THE ANIMAL PARASITES OF MAN

BY

H. B. FANTHAM, M.A.CANTAB., D.SC.LOND.

Lecturer on Parasitology, Liverpool School of Tropical Medicine; Sectional Editor in Protozoology, "Tropical Diseases Bulletin," London, etc.

J. W. W. STEPHENS, M.D.CANTAB., D.P.H.

Sir Alfred Jones Professor of Tropical Medicine, Liverpool University, etc.

AND

F. V. THEOBALD, M.A.CANTAB., F.E.S., HON. F.R.H.S.

Professor of Agricultural Zoology, London University; Vice-Principal and Zoologist of the South-eastern Agricultural College; Mary Kingsley Medallist; Grande Médaille Geoffroy St. Hilaire, Soc. Nat. d'Acclim. de France, etc.

PARTLY ADAPTED FROM

Dr. MAX BRAUN'S "Die Tierischen Parasiten des Menschen" (4th Edition, 1908) and an Appendix by Dr. OTTO SEIFERT.

NEW YORK

WILLIAM WOOD AND COMPANY

MCMXX.

PREFACE.

THE English edition of Braun's "Die Tierischen Parasiten des Menschen," produced in 1906, being out of print, the publishers decided to issue another edition based on the translation of Braun's fourth German edition, which appeared in 1908, to which had been added an appendix by Dr. Otto Seifert on Treatment, etc.

When the work was considered with a view to a new edition, it was found that a vast amount of new matter had to be incorporated, numerous alterations essential for bringing it up to date were necessitated, and many omissions were inevitable. The result is that parts of the book have been rewritten, and, apart from early historical references, the work of Braun has disappeared. This is more particularly the case with the Protozoa section of the present work. The numerous additions, due to the great output of scientific literature and other delays in publication, have led to the book being somewhat less homogeneous than we desired, and have necessitated the use of appendices to allow of the presentation of new facts only recently ascertained. Many new illustrations have been added or substituted for older, less detailed ones. Some of these new figures were drawn specially for this book.

The first section, on the Protozoa, has been written by Dr. Fantham, there being little of the original text left except parts of the historical portions, and thus the section on Protozoa must be considered as new. The second section, on Worms (except the Acanthocephala, Gordiidæ and Hirudinea), has been remodelled by Professor Stephens to such an extent that this, too, must not be looked upon as a translation of Braun's book. With regard to the Arthropoda, much remains as in the last English edition, but some new matter added by Braun in his fourth German edition is included, and much new matter by Mr. Theobald has been incorporated. As regards the Appendix by Dr. Seifert, the first section has been remodelled, but the sections on the Helminthes and the Arthropoda are practically translations of the original.

The authors desire to express their thanks to Miss A. Porter, D.Sc., J. P. Sharples, Esq., B.A., M.R.C.S., and H. F. Carter, Esq., F.E.S., for valuable help. They also wish to thank the authors, editors, and publishers of several manuals and journals for their courtesy in allowing the reproduction of certain of their illustrations. In this connection mention must be made more particularly of Professor Castellani, Dr. Chalmers, Professor Doflein, Dr. Leiper, the late Professor Minchin, Professor Nuttall, Dr. Wenyon, Mr. Edw. Arnold, Messrs. Baillière, Tindall and Cox, Messrs. Black, Messrs. Cassell, Dr. Gustav Fischer, Messrs. Heinemann, the Cambridge University Press, the Editors of the *Annals of Tropical Medicine and Parasitology*, the Editors of the *Journal of Experimental Medicine*, and the Editor of the *Tropical Diseases Bulletin*.

H. B. F.
J. W. W. S.
F. V. T.

December, 1915.

CONTENTS.

THE ANIMAL PARASITES OF MAN—*contd.*

Protozoa—*contd.*

THE ANIMAL PARASITES OF MAN—*contd.*

Platyhelminthes—*contd.*

PAGE

CLASSIFICATION OF THE TREMATODES OF MAN.

THE ANIMAL PARASITES OF MAN—*contd.*

CLASSIFICATION OF THE CESTODA OF MAN.

THE ANIMAL PARASITES OF MAN—*contd.*

THE ANIMAL PARASITES OF MAN—*contd.*

THE ANIMAL PARASITES OF MAN—*contd.*

Arthropoda—*contd.* PAGE

LIST OF ILLUSTRATIONS.

We regret to have taken without permission from the "Transactions of The Society of Tropical Medicine and Hygiene," London, the following diagrams :—

Pages				Figures
268	...	...	...	No. 169
269	...	...	...	,, 170
391	. .	...	...	,, 281
411	...	...	...	,, 295 and 296
414	...	...	...	,, 298
460	...	...	...	,, 337 and 338

and tender our regret to the Society in question for having done so.

PAGE

ERRATA.

P. 31, line 6 from bottom : *delete* "human," as Leidy really worked with *Endamœba blattæ*, parasitic in the gut of the cockroach.

P. 43, line 12 from bottom : *for* "John's" *read* "Johns."

P. 44, line 13 from bottom : *for* "*Amœba buccalis*, Sternberg," *read* "*Amœba buccalis*, Steinberg."

P. 46, line 13 from top : *for* "breath" *read* "breadth."

P. 53, In footnote [1], line 6 from bottom : *insert* "see" before *Arch. f. Protistenk.*

P. 75 : To paragraph regarding development of the parasite in the fly's salivary glands, *add* that the crithidial phase takes two to five days.

P. 111, line 8 from top : the date of Sangiorgi should be 1911.

P. 142, line 7 from top : *insert* "Genus." before Eimeria.

P. 252, *Insert* heading "Family. Opisthorchiidæ, Braun, 1901," *above* "Sub-family. Opisthorchiinæ, Looss, 1899."

P. 351, description of fig. 255, line 3 : *for* "Thoma" *read* "Thomas."

P. 471, line 15 from bottom : *for* "alcohol 100 parts" *read* "alcohol 100 c.c."

P. 472, line 11 from bottom : *for* "Or (2) 10 *per cent. formalin*," *read* "Or (2) *fix in hot* 10 *per cent. formalin*."

P. 493, line 21 from top : *for* "Conoy" *read* "Couvy."

P. 589, line 2 from top : *for* "carnosa" *read* "carnaria."

P. 620, line 15 from top : *for* "fo" *read* "of."

P. 622, line 12 from bottom : *delete* comma after quantity.

P. 626, line 6 from bottom : *delete* comma after Mackie (1915).

P. 638 : *insert* title "**TREMATODES**" above that of "Fascioliasis."

P. 709, line 9 from bottom : *omit* second Pediculus capitis.

P. 748, line 8 from top : *for* "cytologica" *read* "cytological."

P. 753, line 4 from bottom : *for* "Fercocercous" *read* "Furcocercous."

P. 755, line 7 : *for* "Oncocerca" *read* "Onchocerca."

ON PARASITES IN GENERAL.

By the term PARASITES is understood living organisms which, for the purpose of procuring food, take up their abode, temporarily or permanently, on or within other living organisms. There are both plants and animals (Phytoparasites and Zoöparasites) which lead a parasitic life in or upon other plants and other animals.

Phytoparasites are not included in the following descriptions of the forms of parasitism, but a very large number of animal parasites (zoöparasites) are described. The number of the latter, as a rule, is very much underrated. How great a number of animal parasites exists may be gathered from the fact that all classes of animals are subject to them. Some of the larger groups, such as *Sporozoa*, *Cestoda*, *Trematoda* and *Acanthocephala*, consist entirely of parasitic species, and parasitism even occurs among the vertebrates (*Myxine*). It therefore follows that the characteristics of parasites lie, not in their structure, but in the manner of their existence.

Parasitism itself occurs in various ways and degrees. According to R. Leuckart, we should distinguish between OCCASIONAL (temporary) and PERMANENT (stationary) PARASITISM. Occasional parasites, such as the flea (*Pulex irritans*), the bed-bug (*Cimex lectularius*), the leech (*Hirudo medicinalis*), and others, only seek their "host" to obtain nourishment and find shelter while thus occupied. Without being bound to the host, they usually abandon the latter soon after the attainment of their object (*Cimex*, *Hirudo*), or they may remain on the body of their host throughout their entire development from the hatching of the egg (*Pediculus*). It follows from this mode of living that the occasional parasites become sometimes distinguishable from their free-living relatives, though only to a slight extent. It is, therefore, seldom difficult to determine the systematic position of temporary parasites from their structure.

In consequence of their mode of life, all these temporary parasites live on the external surface of the body of their host, though more rarely they take up their abode in cavities easily accessible from the exterior, such as the mouth, nose and gills. They are therefore frequently called EPIZOA or ECTOPARASITES; but these designations do not cover only the temporary parasites, because numerous epizoa (as for instance the louse) are parasitic during their entire life.

In contradistinction to these temporary parasites, the permanent parasites obtain shelter as well as food from their host for a long period, sometimes during the entire course of their life. They do not seek their host only when requiring nourishment, but always remain with it, thus acquiring substantial protection. The permanent parasites, as a rule, live within the internal organs, preferably in those which are easily accessible from the exterior, such as the intestine, with its appendages. Nevertheless, permanent parasites are also found in separate organs and systems, such as the muscular and vascular systems, hollow bones and brain, while some live on the outer skin. Here again, the terms ENTOZOA and ENDOPARASITES do not include all stationary parasites; to the latter, for instance, the lice belong, which pass all their life on the surface of the body of their host, where they find shelter and food and go through their entire development. The ectoparasitic trematodes, numerous insects, crustacea, and other animals live in the same manner.

All "HELMINTHES," however, belong to the group of permanent parasites. This term is now applied to designate certain lowly worms which lead a parasitic life (intestinal worms); but they are not all so termed. For instance, the few parasitic TURBELLARIA are never classed with the helminthes, although closely related to them. The turbellarians, in fact, belong to a group of animals of which only a few members are parasitic, whereas the helminthes comprise those groups of worms of which all species (*Cestoda*, *Trematoda*, *Acanthocephala*), or at least the majority of species (*Nematoda*), are parasitic. Formerly the Linguatulidæ (*Pentastoma*) were classed with the helminthes because their existence is also endoparasitic, and because the shape of their body exhibits a great similarity to that of the true helminthes. Since the study of the development of the Linguatulidæ (P. J. van Beneden, 1848, and R. Leuckart, 1858) has demonstrated that they are really degenerate arachnoids, they have been separated from the helminthes.

It is hardly necessary to emphasize the fact that the helminthes or intestinal worms do not represent a systematic group of animals, but only a biological one, and that the helminthes can only be discussed in the same sense as land and water animals are mentioned, *i.e.*, without conveying the idea of a classification in such a grouping. It is true that formerly this was universally done, but very soon the error of such a classification was recognized. Still, until the middle of last century, the helminthes were regarded as a systematic group, although C. E. v. Baer (1827) and F. S. Leuckart (1827) strenuously opposed this view. Under the active leadership of J. A. E. Goeze,

J. G. H. Zeder, J. G. Bremser, K. A. Rudolphi and F. Dujardin, the knowledge of the helminthes (helminthology) developed into a special study, but unfortunately it lost all connection with zoology. It required the intervention of Carl Vogt to disestablish the helminthes as one class of animals, by uniting the various groups with those of the free-living animals most closely related to them (*Platyhelminthes*, *Nemathelminthes*).

PERMANENT PARASITISM in the course of time has caused animals adopting this mode of life to undergo considerable, sometimes even striking, bodily changes, permanent ectoparasites having as yet undergone least alteration. The latter sometimes bear so unmistakably the likeness to the group to which they belong, that even a superficial knowledge of their structure and appearance often suffices for the recognition of their systematic position. For instance, though the louse, like many decidedly temporary parasites, has lost its wings—a characteristic of insects—in consequence of parasitism, yet nobody would deny its insect nature; such also occurs in other temporary parasites (*Cimex*, *Pulex*). On the other hand, the changes in a number of permanent ectoparasites (such as parasitic Crustacea) are far more considerable, and correspond with those that have occurred in permanent endoparasites.

These alterations depend partly on retrogression and partly on the acquisition of new peculiarities. In the former case, the change consists in the loss of those organs which have become useless in a permanent parasitic condition of existence, such as wings in the louse, and the articulated extremities seen in the larval stage of parasitic Crustacea. The loss of these organs goes hand in hand with the cohesion of segments of the body that were originally separate, and alterations in the muscular and nervous systems. In the same manner another means of locomotion is lost—the ciliated coat—which is possessed by many permanent parasites during their larval period. To all appearances, this character is not secondary and recently acquired, but represents a primary character inherited from free-living progenitors, and still transmitted to the altered descendants, because of its use during the larval stage (*e.g.*, the larvæ of a great many Trematodes, the oncospheres of some Cestodes). Amongst the retrogressions, the loss of the organs of sense may be mentioned, particularly the eyes, which are still present, not only in the nearest free-living forms but also in the free-living larvæ of true parasites. It is only quite exceptionally that the eyes are subsequently retained, as a rule they are lost. Lastly, in a great many cases the digestive system also disappears, as in parasitic Crustacea, in a few nematodes and trematodes, in all cestodes and Acanthocephala. There remain at most the rudiments of the muscles of the fore-gut, but these are adapted to entirely different uses.

The new characters which permanent parasites may acquire are, first of all, the remarkably manifold CLASPING and CLINGING ORGANS, which are seldom (as in parasitic Crustacea) directly joined on to already existing structures. In those instances in which organs for the conveyance of food are retained, these likewise frequently undergo transformation, in consequence of the altered food and manner of feeding. Such alterations consist, for instance, in the transformation of a masticating mouth apparatus into the piercing and sucking organs of parasitic insects.

HERMAPHRODITISM (as in Trematodes, Cestodes, and a few Nematodes) is a further peculiarity of many permanent parasites ; moreover, the association in couples that occurs, especially in trematodes, may lead to complete cohesion and, exceptionally, also to re-separation of the sexes. In many cases the females only are parasitic, while the males live a free life, or there may be in addition the so-called complementary males. Occasionally the male alone is parasitic, and in that case lives within the female of the same species, which may live free, like certain Gephyrea (*Bonellia*) ; or the female also may be parasitic, as *Trichosoma crassicaudum*, which lives in the bladder of the sewer rat (*Mus decumanus*).

We have numerous proofs that demonstrate how considerably the original features of many parasites have become changed. We need only draw attention to the aforementioned Linguatulidæ, also to many of the parasitic Crustacea belonging to various orders. In all of these a knowledge of the larval stages—in which there is no alteration, or at most only a slight degree of change—serves to determine their systematic position, *i.e.*, the nearest conditions of relationship.

The most remarkable changes are observed in those groups that contain only a few parasitic members, the majority leading a free life. A striking instance is afforded by a snail, the well-known *Entoconcha mirabilis*, Müller. This mollusc consists merely of an elongated sac living in a Holothurian (*Synapta digitata*). It possesses none of the characteristics of either the Gastropoda or any molluscs, and in its interior there is nothing to be observed but the organs of generation and the embryos. Nevertheless, the *Entoconcha* is decidedly a parasitic snail, as is clearly proved by its larvæ, but it is a snail which, in consequence of parasitism, has lost all the characteristics of molluscs in its mature condition, but still exhibits them in the early stages of development.

Certain nematodes show very clearly to what devious courses parasitism may lead. The *Atractonema gibbosum*, the life-history of which has been described by R. Leuckart, and which lives in the larvæ and pupæ of a dipterous insect (*Cecidomyia*), exhibits, in its early stage, the ordinary characteristics of other threadworms. A few weeks later—the males having died off immediately after copulation—the females are transformed into spindle-shaped bodies, the mouth and anus of which are closed. They carry with them an irregularly shaped appendage, in which the segmenting ova are situated, and in which the further conditions of life of the *Atractonema* are accomplished. A minute examination has demonstrated that this appendage is the prolapsed and enlarged vagina of the animal which has become merely a supplementary attachment. The conditions present in the *Sphærularia*, the nematoid nature of which was long undiscovered, are still more remarkable. It was only when Siebold proved that typical nematodes were hatched from their eggs that their nature was recognized. The nematodes thus produced have not the slightest resemblance to the parent.

The researches of Lubbock, A. Schneider, and more particularly of R. Leuckart, have shown that what we call *Sphærularia bombi* is not an animal but merely an organ—the vagina—of a nematode worm. This vagina at first grows, sac-like, from the body of the tiny nematode; it gradually assumes enormous dimensions (2 cm. in length); it contains the sexual organs and parts of the intestine. The remaining portion of the actual animal then becomes small and shrivelled; it may be easily overlooked, being but an appendage to the vagina with its independent existence, and it finally disappears altogether.

The GREAT FERTILITY of parasites is another of their peculiarities, though this may be also the case to a certain degree with some of the free-living animals, the progeny of which are likewise exposed to enormous destruction.

More remarkable, however, is the fact that the young of the endoparasites only very exceptionally grow to maturity by the side of their parents. Sooner or later they leave the organ inhabited by the parents, frequently reach the open, and after a shorter or longer period of free existence seek new hosts. During their free period, moreover, a considerable growth may be attained, or metamorphosis may take place, or even multiplication. In the exceptional cases in which the young remain within the same host, they nevertheless usually quit the organ inhabited by the parents. They likewise rarely attain maturity within the host inhabited by the parents, but only, as in other cases, after having gained access to fresh hosts.

These transmigrations play a very important *rôle* in the natural history of the internal parasites, but they frequently conceal the cycle of development, for sometimes there are INTERMEDIATE GENERATIONS, which themselves invade intermediate hosts. Even when there are no intermediate generations, THE SYSTEM OF INTERMEDIATE HOSTS is frequently maintained by the endoparasites.

According to the kind of food ingested by parasites, it has recently become usual to separate the true parasites from those animals that feed on the superfluity of the food of the host, or on products which are no longer necessary to him, and to call the latter MESSMATES or COMMENSALS. As examples, the Ricinidæ are thus designated, because, like actual lice, they dwell among the fur of mammals or the plumage of birds. They do not, however, suck blood, for which their mouth apparatus is unsuited, but subsist on useless epidermic scales. These epizoa, according to J. P. van Beneden, are, to a certain extent, useful to their hosts by removing deciduous materials which under certain circumstances might become harmful to them.[1] This investigator, who has contributed so greatly to our knowledge of parasites, assigns the Ricines to the MUTUALISTS, under which term he comprises animals of various species which live in common, and confer certain benefits on one another. The mutualists are usually intimately connected in a mutually advantageous association known as "symbiosis."[2]

Incidental and Pseudo Parasites.—In many cases the parasites are confined to certain hosts, and may therefore be designated as *specific* to such hosts. Thus, hitherto, *Tænia solium* and *Tænia saginata* in their adult condition have only been found in man ; *Tænia crassicollis* only in the cat ; *Brandesia* (*Distoma*) *turgida* and *Halipegus* (*Distoma*) *ovocaudatus* only in *Rana esculenta*, and so forth. In many other cases, however, certain species of parasites are common to several, and sometimes many, species of hosts ; *Dipylidium caninum* is found in the domestic cat as well as in the dog; *Fasciola hepatica* is found in a large number of herbivorous mammals (nineteen species), *Diplodiscus* (*Amphistomum*) *subclavatus* in numerous urodele and ecaudate amphibia, *Holostomum variabile* in about twenty-four species of birds, and so on. In these cases the hosts are almost invariably closely related, belonging, as a rule, to the same family or order, or at any rate to the same class. *Trichinella spiralis*, which is found in man, and in the pig, bear, rat, mouse, cat, fox, badger, polecat and marten, and is capable of being artificially cultivated in the dog, rabbit, sheep, horse, in other mammals, and even in birds, is one of the most striking exceptions.

Some parasites are so strictly confined to one species of host that, even when artificially introduced into animals very closely related

---

[1] According to Sambon, the Ricinidæ are by no means advantageous to their hosts. These Hemipterous parasites give rise to an intolerable itching which may cause loss of rest, emaciation, and sometimes even death. Birds suffering from phthiriasis of the Ricines are usually in bad health.

[2] For further information on these conditions, see "Die Schmarotzer des Thierreichs," by P. J. van Beneden, Leipzig, 1876 ; and "Die Symbiose," by O. Hertwig.

to their normal host, they do not thrive, but sooner or later, often very quickly, die off, and very rarely establish themselves. For example, repeated attempts have been made to rear the adult *Tænia solium* in the dog, or to rear *Cysticercus cellulosæ* in the ox, or the *Cysticercus* of *Tænia saginata* in the pig, but they have always proved unsuccessful. Only exceptionally has it been possible to transfer *Cœnurus cerebralis*, the larval stage of a tapeworm (*Tænia cœnurus*) of the dog from the brain of the sheep to that of the domestic goat. On the other hand, in the case of the Trichinellæ transference to a different host is easily accomplished.

Under natural conditions, it is not uncommon for certain kinds of specific parasites to occur occasionally in unusual hosts. Their relationship to the latter is that of INCIDENTAL PARASITES. Thus *Echinorhynchus gigas*, a specific parasite of the pig, is only an incidental parasite of man; *Fasciola hepatica* and *Dicrocœlium lanceatum* are specific to numerous kinds of mammals, but may be found incidentally in man. On the other hand, *Dibothriocephalus latus*, a specific parasite of man, may occasionally take up its abode in the dog, cat and fox. As a rule, all those parasites of man that are only rarely met with, notwithstanding that human beings are constantly being observed and examined by medical men, are termed INCIDENTAL PARASITES OF MAN. In many cases we are acquainted with the normal or specific host of these parasites. Thus we know the specific host of *Balantidium coli*, *Eimeria stiedæ*, *Fasciola hepatica*, *Dipylidium caninum*, etc.; in others the host is as yet unknown. In the latter case the question partly relates to such forms as have been so deficiently described that their recognition is impossible, partly to parasites of man in various regions of the earth, the Helminthes and parasites of which are totally unknown or only slightly known, or finally to early developmental stages that are difficult to identify. Animals that usually live free, and exceptionally become parasitic, may likewise be called incidental parasites. In this category are included a few *Anguillulidæ* that have been observed in man; also *Leptodera appendiculata*, which usually lives free, but may occasionally become parasitic in black slugs (*Arion empiricorum*): when parasitic it attains a larger size, and produces far more eggs than when living a free life. In order to avoid errors, the term "incidental parasites" should be confined to true parasites which, besides living in their normal host, may also live in other hosts. Leuckart speaks of FACULTATIVE PARASITISM in such forms as *Leptodera*. L. Oerley[1] succeeded in artificially causing *Leptodera* (*Rhabditis*) *pellio* to assume facultative parasitism by introducing these

---

[1] Oerley, L., "Der Rhabditiden und ihre medizinische Bedeutung," Berlin, 1886, p. 65.

worms into the vagina of mice, where the parasites remained alive and multiplied. *Leptodera pellio* dies in the intestines of mammals and man; it remains alive in frogs, but always escapes into the open with the fæces.

Recently the incidental parasites of man have also been called "PSEUDO-PARASITES" or "PSEUDO-HELMINTHES." Formerly, however, these terms were applied not only to living organisms that do not and cannot live parasitically, and that only exceptionally and incidentally get into man, but also to any foreign bodies, portions of animals and plants, or even pathological formations that left the human system through the natural channels, and the true nature of which was misunderstood. Frequently these bodies were described as living or dead parasites and labelled with scientific names, as if they were true parasites. A study of these errors, which formerly occurred very frequently, would be as interesting as it would be instructive. It is better not to use the expression pseudo-parasites for incidental parasites, but to keep to the original meaning, for it is not at all certain that pseudo-parasites are not described, even nowadays.

The Influence of Parasites on the Host.—In a great many cases, we are not in a position to state anything regarding any marked influence exercised by the parasite on the organism, and on the conditions of life, of the host. Most animals and many persons exhibit few signs of such influence, an exception being infestation with helminthes and certain other parasites which produce eosinophilia in the blood. As a general rule, the parasite, which is always smaller and weaker than its host, does not attempt to endanger the life of the latter, as simultaneously its own existence would be threatened. The parasite, of course, robs its host, but usually in a scanty and sparing manner, and the injuries it inflicts can hardly be taken into account. There are, however, numerous cases[1] in which the situation of the parasites or the nature of their food, added to their number and movements, may cause more or less injury, and even threaten the life of the host. It stands to reason that a *Cysticercus cellulosæ* situated in the skin is of but slight importance, whereas one that has penetrated the eye or the brain must give rise to serious disorders. A cuticular or intestinal parasite is, as a rule, less harmful than a blood parasite. A helminth, such as an *Ascaris lumbricoides* or a tapeworm, that feeds on the residues of foodstuffs within the intestine, will hardly

---

[1] Lühe, M., "Ueber d. Fix. d. Helm. a. d. Darmwand ihrer Wirthe u. die dadurch verursachten path-anat. Veränderungen d. Wirthsdarmes," *Trans. of IVth Intern. Zool. Cong.*, Berlin, 1901; Mingazzini, P., "Ric. sul var. modo di fiss. delle tenie alla par. int. e sul loro assorbimento," *Ric. Lab. Anat. Roma e altri Lab. biol.*, vol. x, 1904; Shipley, A. E., and E. G. Fearnsides, "The Effects of Metazoan Parasites on their Hosts," *Journ. Econ. Biol.*, 1906, i, 2.

affect its host by depriving it of this material. The case is different when the parasites are very numerous, especially when the heavily infested host happens to be a young individual needing all it ingests for its own requirements, and therefore unable to sustain the drain of numerous intruders in the intestine. Disturbances also set in more rapidly when the intestinal helminthes are blood-suckers, the injury to the host resulting from the kind of food taken by the parasite.

Generally, the disorders caused by loss of chyle are insignificant when compared with those induced by the GROWTH and agglomeration of the helminthes. The latter may cause chiefly obstructions of small vessels or symptoms of pressure in affected or contiguous organs, with all those complications which may arise secondarily, or they may even lead to the complete obliteration of the organ invaded. Of course the symptoms will vary according to the nature of the organ attacked.

In consequence also of the MOVEMENTS of the parasites, disorders are set up that may tend to serious pathological changes of the affected organs. The collective migrations, undertaken chiefly by the embryos of certain parasites (as in trichinosis, acute cestode tuberculosis), are still more harmful, as are also the unusual migrations of other parasites, which, incidentally, may lead to the formation of so-called worm abscesses or to abnormal communications (fistulæ) between organs that are contiguous but possess no direct connection.

Recently, several authors have called attention to the fact that the helminthes produce substances that are TOXIC to their host; and the effects of such poisons explain the pathology of helminthiasis far more satisfactorily than the theory of reflex action.

In a number of cases these toxic materials (leucomaines) have been isolated and their effects on living organisms demonstrated by actual experiments. It also appears that the absorption of materials formed by the decomposition of dead helminthes may likewise cause toxic effects. However, our knowledge of these conditions is as yet in its initial stage.[1]

Nearly all the symptoms caused directly or indirectly by parasites are of such a nature that the presence of the parasites cannot be diagnosed with any certainty, or only very rarely. The most that can be done is to deduce the presence of parasites by the exclusion of other causes. Fortunately, however, there are sufficient means

---

[1] Moursson et Schlagdenhauffen, "Nouv. rech. clin. et phys. sur quelq. liquides organ.," *C. R. Acad. Sci.*, Paris, 1882, p. 791; Debove, "De l'intox. hydat.," *Bull. et Mém. Soc. méd. des Hôpit.*, 1888; Linstow, v., "Ueb. d. Giftgehalt d. helm.," *Internat. Monatsschr. f. Anat. u. Phys.*, xiii, 1896; Peiper, "Z. Symptomatol. der thier. Paras.," *Deutsche med. Wochenschr.*, 1897, No. 40; Mingazzini, P., "Ric. sul veleno d. elm. int.," *Rass. intern. d. med. modern. Ann.*, 1901, ii, No. 6; Vaullegeard, A., "Etud. exp. et crit. sur l'action d. helm.," *Bull. Soc. Linn. de Normandie*, 1901, 5, Ser. T, vii, p. 84, and others.

by which we may confirm the diagnosis in a great many cases. Such means consist not only in a minute examination of the patient by palpation, percussion and local inspection, but also in the microscopical examination of the natural secretions and excretions of the body, such as sputum, nasal mucus, urine and fæces. Though such examinations may entail loss of time, they are necessary in the interest of the patient. It appears, moreover, that quackery, which has gained considerable ground even in the treatment of the helminthic diseases of man, can thus be considerably limited.

Origin of Parasites.[1]—In former times, when the only correct views that existed related to the origin of the higher animals, the mode of multiplication of parasites as well as of other lowly animals was ascribed to SPONTANEOUS GENERATION (*generatio æquivoca*), and this opinion prevailed throughout the middle ages. The writers on natural science merely devoted their time to the interpretation of the views of the old authors, and perpetuated the opinions of the ancients on questions, which, even in those days, could have been correctly explained merely by observation.

It was only when observations were again recommenced, and the microscope was invented, that the idea of spontaneous generation became limited. Not only did the microscope reveal the organs of generation or their products (eggs) in numerous animals, but Redi succeeded in proving that the so-called *Helcophagi* (flesh maggots) are only the progeny of flies, and never appear in the flesh of slaughtered animals when fully developed flies are prevented from approaching and depositing their eggs on it. Swammerdam likewise knew that the "worms" living in the caterpillars of butterflies were the larvæ of other insects (ichneumon flies) which had laid their eggs in their bodies; he also discovered the ova of lice. The two authors mentioned were, however, unwilling to see that the experience they had gained regarding insects applied to the helminthes. Leeuwenhoek also vehemently opposed the theory of a spontaneous generation, maintaining that, on a basis of common-sense, eggs, or at all events germs, must exist, even though they could not be seen.

The use of the microscope also revealed a large number of very small organisms in the water and moist soil, some of which undoubtedly resembled helminthes. Considering the wide dissemination of these minute organisms, it was natural to conjecture that after their almost unavoidable introduction into the human system they should grow into helminthes (Boerhave, Hoffmann). Linnæus went even further, for he traced the descent of the liver-fluke of sheep from

---

[1] Die Geschichte der "Klinisch wichtigen Parasiten," behandelt H. Vierordt im "Handb. d. Gesch. d. Med. hrsg." v. M. Neuburger u. J. Pagel, Bd. ii, 1903.

a free-living planaria (*Dendrocœlum lacteum*), the *Oxyuris vermicularis* from free-living nematodes, and the *Tænia lata* (*i.e.*, *Dibothriocephalus latus*) from a tapeworm (*Schistocephalus solidus*) found free in the water. Linnæus' statements met with general approval. However, we must bear in mind that at that time the number of helminthes known was very small, and many of the forms that we have long ago learned to differentiate as specific were then regarded as belonging to one species. Linnæus' statements were partly supported by similar discoveries by other investigators, such as Unzer, and partly also by the discovery of eggs in many helminthes. It was believed that the eggs hatched in the outside world gave rise to free-living creatures, and that these, after their introduction into the intestine, were transformed into helminthes. By means of these eggs the old investigators tried to explain the HEREDITARY TRANSMISSION of the intestinal worms, which was universally believed until the commencement of the last century. Some authors went so far as to regard the intestinal worms as congenital or inherited ; they maintained the possibility of direct transmission, as in suckling, and denied that the eggs reaching the external world had anything to do with the propagation of the parasites.

The more minute comparison between the supposed free-living stages of the helminthes and their adult forms, and the impossibility of finding corresponding free forms for the ever-increasing number of parasitic species, revealed the improbability of Linnæus' statements (O. Fr. Müller). It was the latter author also who recognized the origin of the tapeworms (*Schistocephalus, Ligula*) found free in the water. They originate from fishes which they quit spontaneously.

However, in spite of the fact that van Doeveren and Pallas correctly recognized the significance of the eggs in the transmission of intestinal worms, these statements remained disregarded, as did Abildgaard's observation, experimentally confirmed, that the (immature) cestodes from the abdominal cavity of sticklebacks became mature in the intestines of aquatic birds. Moreover, at the end of the eighteenth and the commencement of the nineteenth centuries, after helminthology had been raised to a special branch of study by the successful results of the investigations of numerous authors (Goeze, Bloch, Pallas, Müller, Batsch, Rudolphi, Bremser), many of whom experienced a "divine joy" in searching the intestines of animals for helminthes, some authors reverted to *generatio æquivoca*, without, however, entirely denying the existence of organs of generation and eggs. The fact that a few nematodes bore living progeny—a fact of which Goeze was already aware—had no influence on the erroneous opinion, as in such cases it was considered that the young continued to develop beside the old forms. There were also many helminthes known that never developed sexual organs and never produced eggs, and which therefore were referred to *generatio æquivoca*. People were convinced that the intestinal mucous membrane or an intestinal villus could transform itself into a worm, either in a general morbid condition of the body, or in pathological changes of a more local character. The appearance of helminthes was even regarded as useful and as a means for the expulsion of injurious matter.

These views, firmly rooted and supported by such eminent authorities as Rudolphi and Bremser, could not easily be overthrown. First, a change took place in the knowledge of the trematodes. In 1773, O. Fr. Müller discovered *Cercariæ* living free in water. He regarded them as independent creatures and gave them the name that is still used at the present time. Nitzsch, who also minutely studied these organisms and who recognized the resemblance of the anterior part of their bodies to a *Fasciola*, did not, however, arrive at a correct conclusion. He regarded the combination rather as that of a *Fasciola* with a *Vibrio*, for which he mistook the characteristic tail of the cercaria. He also noticed the encystment (transformation into the "pupa") on foreign bodies of many species of these animals, but was of opinion that this process signified only the termination of life.

Considerable attention was attracted to the matter when Bojanus first published a paper entitled "A Short Note on Cercaria and their Place of Origin." He pointed out that the cercariæ creep out of the "royal yellow worms," which occur in freshwater snails (*Limnæa, Paludina*), and are probably generated in these worms.

Oken, in whose journal, *Isis* (1818, p. 729), Bojanus published his discovery, remarks in an annotation, "One might lay a wager that these Cercariæ are the embryos of Distomes." Soon after (1827), C. E. v. Baer was able to confirm Bojanus' hypothesis that the cercariæ as a "heterogeneous brood" originated from spores in parasitic tubes in snails (germinating tubes). Moreover, Mehlis (*Isis*, 1831, p. 190) not only discovered the opercula of the ova of *Distoma*, but likewise saw the infusorian-like embryo emerge from the eggs of *Typhlocœlum* (*Monostomum*) *flavum* and *Cathæmasia* (*Distoma*) *hians*. A few years later (1835) v. Siebold observed the embryos (miracidia) of the *Cyclocœlum* (*Monostomum*) *mutabile*, and discovered in their interior a cylindrical body that behaved like an independent being ("necessary parasite"), and was so similar in appearance to the "royal yellow worms" (Bojanus) that Siebold considered the origin of the latter from the embryos of trematodes as, at all events, possible. Meanwhile, v. Nordmann of Helsingfors had in 1832 seen the miracidia of flukes provided with eyes swimming in water; v. Siebold (1835) had observed the embryos, or oncospheres, of tapeworms furnished with six hooklets in the so-called eggs of the Tænia; while Creplin (1837) had discovered the "infusorial" young of the *Diphyllobothrium* (*Bothriocephalus*) *ditremum*, and conjectured that similar embryos were to be found in other cestodes with operculated eggs. At all events, the fact was established that the progeny of the helminthes appeared in various forms and was partly free living. The researches of Eschricht (1841) were likewise of influence, as they elucidated the structure of the Bothriocephali, and proved that the encysted and sexless helminthes were merely immature stages.

J. I. Steenstrup (1842) was, however, the first to furnish explanations for the numerous isolated and uncomprehended discoveries. Commencing with the remarkable development of the Cœlenterata, he established the fact that the Helminthes, especially the endoparasitic trematodes, multiply by means of alternating and differently formed generations. Just as the polyp originating from the egg of a medusa represents a generation of medusæ, so does the germinal tube ("royal yellow worm") originating from the ciliated embryo of a Distoma, etc., represent the cercaria. These were consequently regarded as the progeny of trematodes, and Steenstrup, guided by his observations, conjectured that the cercaria, whose entrance into the snails he had observed accompanied by the simultaneous loss of the propelling tail, finally penetrated into other animals, in which they became flukes.

Part of this hypothetical cycle of development was erroneous, and in other particulars positive observation was lacking, but the path pursued was in the right direction. Immediately after the appearance of Steenstrup's celebrated work, v. Siebold expressed his opinion that the encapsuled flukes certainly had to travel, *i.e.*, to be transmitted with their bearers into other hosts, before becoming mature. This view was experimentally confirmed by de Filippi, La Valette St. George (1855), as well as by Pagenstecher (1857), while the metamorphosis of the ciliated embryo of Distoma into a germinal tube was first seen by G. Wagener (1857) in *Gorgodera* (*Distoma*) *cygnoides* of frogs. All that we have subsequently learned from the works of numerous investigators about the development of endoparasitic trematodes has certainly increased our knowledge in various directions, and, apart from the deviating development of the *Holostomidæ* has, as a whole, confirmed the briefly sketched cycle of development.

Steenstrup's work on the cestodes did not attract the same attention as his work on trematodes. Steenstrup always insisted on the "nurse" nature of the cysticerci and other bladder-worms. Abildgaard (1790), as well as Creplin (1829 and 1839), had already furnished the information that certain sexless cestodes (*Schistocephalus* and

Ligula) from the abdomen of fishes only become mature after their transference to the intestine of aquatic birds. These passive migrations were confirmed in an entire series of other cestodes, particularly by v. Siebold (1844, 1848, 1850) and E. J. van Beneden (1849), not by actual experiment, but by undoubted observation.

It was correctly believed that the ova or oncospheres penetrate into certain intermediate hosts, in which they develop into unsegmented larvæ. Here they remain until, with their host, they are swallowed by some predacious animal. They then reach the intestine, being freed from the surrounding membranes through the process of digestion, and settle themselves there to form the adult chain of proglottides. Though some few scientists, such as P. J. van Beneden and Em. Blanchard, deduced from these observations that the bladder-worms (Cysticerci), which had hitherto been regarded as a separate class of helminthes, were only larval Tæniæ, this correct view was not at first universally accepted. The foundation was too slight, and van Beneden was of opinion that the Cysticerci were not necessary, but only appeared incidentally.

v. Siebold was a strenuous opponent to this theory, notwithstanding his experiences on the change of hosts of the Tetrarhynchus. Together with Dujardin (1850) he conjectured that the Tæniæ underwent a deviating cycle of development. He was of opinion that the six-hooked oncospheres left the intestine, in which the older generation lived, and were scattered about with the fæces, and finally re-entered *per os* (*i.e.*, with water and food) a host similar to the one they had left, in the intestine of which they were directly transformed into tapeworms. A change of host such as occurred in other cestodes was not supposed to take place (the history of the cestodes was at this time not entirely established). As the oncospheres of the Tænia are enveloped in one calcareous or several softer coverings which they cannot leave actively, and as, in consequence of this condition, innumerable oncospheres cannot penetrate into an animal, and others cannot reach the proper animal, v. Siebold conceded, at least for the latter, the possibility of a further development. But this was only supposed to occur because they had either invaded wrong hosts, or, having reached the right hosts, had penetrated organs unsuitable to their development, and had thus gone astray in their travels, and had become hydropically degenerated tæniæ. This was v. Siebold's explanation of bladder-worms. Naturally, v. Siebold himself conjectured that a recovery of the diseased tapeworm might occur, in a few exceptional cases, after transmission into the correct host, as, for instance, in the *Cysticercus fasciolaris* of mice, the host of which is the domestic cat, and in which there is a seemingly normally developed piece of tapeworm situated between the caudal vesicle and the cysticercus head.

Guided by correct views, F. Küchenmeister undertook in Zittau the task of confirming the metamorphosis of *Cysticercus pisiformis* of hares and rabbits, into tapeworms in the intestine of the dog by means of feeding experiments. The first reports on the subject, published in 1851, were not likely to meet with universal approval, because Küchenmeister first diagnosed the actual tapeworm he had been rearing as *Tænia crassiceps*, afterwards as *Tænia serrata*, and finally as *Tænia pisiformis* n. sp. However, in any case, Küchenmeister, by means of the reintroduction of experimental investigation, rendered a great service to helminthology.

The publication of Küchenmeister's works induced v. Siebold to undertake similar experiments (1852 and 1853), which were partly published by his pupil Lewald in 1852. But the positive results obtained hardly changed Siebold's opinion, for although he no longer considered the bladder-worms as hydropically degenerated tapeworms, he still regarded them as tæniæ that had strayed. The change of opinion was partly due to an important work of the Prague zoologist, v. Stein (1853). He was able to examine the development of a small bladder-worm in the larvæ of the well-known meal-worm (*Tenebrio molitor*) and to demonstrate that, as Goeze had already proved in the case of *Cysticercus fasciolaris* of mice, first the caudal vesicle is formed and then the scolex, whereas Siebold believed that in bladder-worms the posterior end of the scolex was formed first, and that this posterior end underwent a secondary hydropic degeneration.

In opposition to v. Siebold, Küchenmeister successfully proved the necessity of the bladder-worm stage by rearing tapeworms in dogs from the *Cysticercus tenuicollis* of domestic mammals and from the *Cœnurus cerebralis* of sheep. He, and simultaneously several other investigators independently, succeeded, with material provided by Küchenmeister, in rearing the *Cœnurus cerebralis* in sheep from the oncospheres of the *Tænia cœnurus* of the dog (1854). R. Leuckart obtained similar results in mice by feeding them with the mature proglottides of the *Tænia crassicollis* of cats (1854).

Küchenmeister also repeatedly reared the *Tænia solium* of man from the *Cysticercus cellulosæ* of pigs (1855), and from the embryos of this parasite P. J. van Beneden succeeded in obtaining the same *Cysticercus* in the pig (1854). As Küchenmeister distinguished the *Tænia mediocanellata*, known to Goeze as *Tænia saginata*, amongst the large tæniæ of man (1851), so it was not long before R. Leuckart (1862) succeeded in rearing the cysticercus of the hookless tapeworm in the ox. It is particularly to this last-named investigator that helminthology is indebted more than to any other author. He followed the gradual metamorphosis from oncospheres to cystic worms in all its details.

In view of all the researches that were made, and which are too numerous to mention individually, the idea that bladder-worms are abnormal or only incidental forms had to be abandoned. Everything pointed to the fact that in all cestodes the development is divided between two kinds of animals; in one—the host, the adult tapeworm is found; while in the other, the intermediate host, we find some form or other of an intermediate stage (cysticercus in the broadest sense). The practical application of this knowledge is self-evident. If no infected pork or beef is ingested, no tapeworm can be acquired, and also the rearing of cysticerci in the human body is prevented by avoiding the introduction of the eggs of tapeworms.

Though these results were definitely proved by numerous researches, yet they have been repeatedly challenged, notably by J. Knoch (1862) in Petrograd, who, on the basis of experiments, sought to confirm a direct development without an intermediate host and ciliated stage, at all events as regards *Dibothriocephalus latus*. However, the repeated communications of this author met with but little favour from competent persons, partly because the experiments were conducted very carelessly, and partly because their repetition on dog and man (R. Leuckart) had no results (1863). It was only in 1883 that Braun was able to prove that the developmental cycle of *Dibothriocephalus latus* is similar to that of other Cestodes. The results obtained in other places by Parona, Grassi, Ijima and Zschokke render any discussion of Küchenmeister's conclusions unnecessary.[1] Long after Knoch, a French author, P. Mégnin, also pleaded for the direct development of some cestodes, and especially some tæniæ. He (1879) also sought to prove a genetic connection between the hookless and armed tapeworms of mammals, but the arguments he adduced, so far as they rest on observations, can be easily refuted or attributed to misinterpretation. Only one of these arguments is correct, namely, that the number of the species of tæniæ with which we are acquainted is far larger than that of the corresponding cystic forms; but this disparity alone cannot be taken as a proof of direct development. It can only be said that our knowledge in this respect is deficient. As a matter of fact, we have during recent years become acquainted with a large number of cystic forms, hitherto unknown, belonging to tæniæ which have long been familiar. It must also be borne in mind that no man in his lifetime can complete an examination for bladder-worms of the large number of insects, for instance, which

[1] Refer to the collected literature under *Dibothriocephalus latus*, and the reply to Küchenmeister by Braun ("Ueber den Zwischenwirt des breit. Bandw." Würzb.: Stuber, 1886).

may destroy an entire generation of an insectivorous species of bird within a small district.

Naturally it does not follow that direct development in the cestodes is altogether lacking. The researches of Grassi (1889) have furnished an example in *Hymenolepis* (*Tænia*) *murina*, which shows that development may sometimes take place without an intermediate host, notwithstanding the retention of the cystic stage. It was found that the oncospheres of this species, introduced into rats of a certain age, after a time grow into tapeworms without leaving the intestine, but not directly, for they bore into the intestinal wall, where they pass the cystic stage, the cysts afterwards falling into the intestinal lumen, where they develop into tapeworms. The recent experiments of Nicoll (1911) show that the larval stages of *Hymenolepis murina* also occur in the rat-flea, *Ceratophyllus fasciatus*.

Important observations were soon made on the remaining groups of helminthes. The discussion on the origin of parasites soon became confined to the helminthes. Amongst the Nematoda, it had long been known that encapsuled forms existed that had at first been regarded as independent species, but very soon they were pronounced to be immature forms, in consequence of their lack of sexual organs. Though Dujardin and also v. Siebold regarded them as "strayed" animals, v. Stein (1853) very promptly demonstrated that the progeny of the nematodes were destined to travel by discovering a perforating organ in the larval nematodes of the mealworm. This was first experimentally confirmed (1860) by R. Leuckart, R. Virchow and Zenker, all of whom succeeded not only in bringing to maturity the muscle Trichinæ (known since 1830) in the intestine of the animals experimented upon, but were likewise able to follow the migrations of the progeny. Of course, the encapsulating brood remained in the same organism, and in this respect deviated from the broods of other helminthes which escape into the outer world and find their way into other animals, but the encapsuled nematodes could no longer be regarded as the result of straying. Subsequently, R. Leuckart worked out, more or less completely, the history of the development of numerous nematodes, or pointed out the way in which further investigations should be made. It has been found that in nematodes far more frequently than in other helminthes, the typical course of development is subject partly to curtailment and partly to complications, which sometimes considerably increase the difficulties of investigation and have hitherto prevented the attainment of a definite conclusion, though the way to it is now clear.

In a similar manner the works of R. Leuckart have cleared up the development of the *Acanthocephala* and *Linguatulida*. Of

2

course, much still remains to be done. So far, we do not even know all the helminthes of man and of the domestic animals in all their phases of life, and still less is known of those of other animals. We are indebted to the discoveries of the last fifty years for the knowledge arrived at, though comparatively few names are connected with it. The gross framework is revealed, but the gaps have only been filled up here and there. However, we may trustfully leave the completion of the whole to the future, without fear that any essential alterations will take place.

The deductions to be drawn are as follows: That the helminthes like the ectoparasites multiply by sexual processes, that the entire course of development of the helminthes is rarely or never gone through in the same host as is the case with several ectoparasites, that the progeny at an earlier or later stage of development, as eggs, embryos, or larvæ, quit the host inhabited by the older generation, and almost always attain the outer world: only in *Trichinella* does the development take place directly in the definite host. Where the eggs have not yet developed they go through the embryonic evolution in the outer world. The young larvæ are transmitted, either still enclosed within the egg or embryonic covering, to the intermediate host or more rarely they are transferred straight to the final host. In other cases they may hatch out from their envelopes, and after a longer or shorter period of free life, during which they may partake of food and grow, they, as before, penetrate, usually in an active way, into an intermediate host, or at once invade the final host. Exceptionally (*e.g.*, *Rhabdonema*), during the free life there may be a propagation of the parasitic generation, and in this case only the succeeding generation again becomes parasitic, and then at once reaches its final host. The young forms which have invaded the final host become mature in the latter, or after a longer or shorter period of parasitism again wander forth (as the Œstridæ, Ichneumonidæ, etc.), and reach the adult stage in the outer world. The young stages, during which the parasites undergo metamorphoses or are even capable of producing one or several intermediate generations, are passed in the intermediate hosts until, as a rule, they are passively carried into the final host and there complete their cycle of development by the formation of the organs of generation. This mode of development, the spending of life in two different kinds of animals (intermediate and final host), is typical of the helminthes. This is manifested in the Acanthocephala, the Cestoda, the majority of the endoparasitic Trematoda, a number of the Nematoda, and the Linguatulidæ. There are now and then exceptions, however, in which, for instance, the host and intermediate host change order (*Trichinella*, *Hymenolepis murina*).

Parasites are hardly ever inherited amongst animals.[1] According to a few statements, however, *Trichinella* and *Cœnurus* are supposed to be transmissible from the infected mother to the fœtus. Otherwise most animals acquire their parasites, especially the Entozoa, from without, the parasites penetrating either actively, as in animals living in the water, or passively with food and drink. A particular predisposition to worms is not more likely than a spontaneous origin of parasites.

Derivation of Parasites.—Doubt now no longer exists as to the derivation of the temporary and of many of the stationary ectoparasites from free-living forms. This conclusion is founded on the circumstance that not only are there numerous intermediate degrees in the manner of living and feeding between predacious and parasitic animals, but that there is more or less uniformity in their structure. The differences that exist are easily explained as consequences of altered conditions of life. The case is more difficult in regard to groups that are exclusively parasitic (*Cestoda, Trematoda, Acanthocephala, Linguatulidæ,* and *Sporozoa*), or groups that are chiefly parasitic (*Nematoda*), because in these cases the gulf that divides these forms from free-living animals is wider. It is true that we know that the nearest relatives of the *Linguatulidæ* are found amongst the *Arachnoidea*, and indeed in the *Acarina*; that, moreover, the structure and development of the *Sporozoa* refers them to the *Protozoa*, and allows some of them to be regarded as the descendants of the lowest *Rhizopoda.* We know that the *Trematoda*, and through these the *Cestoda*, are closely related to the *Turbellaria*, from which they may be traced. The *Nematoda*, and still more the *Acanthocephala*, stand apart. This is less evident, however, in the Nematoda, for there are numerous free-living members of these from which it is possible that the parasitic species may be descended. Indeed, this seems more than probable if such examples as *Leptodera*, *Rhabdonema* and *Strongyloides* are taken into consideration, as well as the conditions of life of free-living nematodes. These mostly, if not exclusively, spend their lives in places where decomposing organic substances are present in quantities; some species attain maturity only in such localities, and there propagate very rapidly. Should the favourable conditions for feeding be changed, the animals seek out other localities, or they remain in the larval form for some time until more favourable conditions set in. It is comprehensible that such forms are very likely to adopt a parasitic manner of life which at first is facultative (*Leptodera, Anguillula*), but may be regarded as the tran-

[1] However, in the Protozoa there are examples of hereditary transmission of parasites, *e.g.*, in the case of *Babesia* (*Piroplasma*) *bovis* and *Babesia canis* in their invertebrate hosts (ticks); in *Crithidia melophagia* and *Crithidia hyalommæ*; and in the case of *Spirochæta duttoni* in its invertebrate host (a tick).

sition to true parasitism. The great advantages attached to a parasitic life consist not only in protection, but also in the supply of suitable food, and consequently in the easier and greater production of eggs, and thus fully account for the gradual passage of facultative parasitism into true parasitism. In many forms the young stages live free for some time (*Strongylidæ*), in others, as is the case in *Rhabdonema*, parasitic and free-living generations alternate; in others, again, the free period is limited to the egg stage or entirely suppressed.

Though it is possible thus to connect the parasitic with the free-living nematodes, by taking their manner of life into account, this matter presents greater difficulties in regard to other helminthes. It is true that the segmented Cestoda may be connected with and traced from the less known and interesting single-jointed Cestoda (*Amphilina*, *Archigetes*, *Caryophyllæus*, *Gyrocotyle*). Trematodes are all parasites, with the exception of one group, *Temnocephalidæ*, several genera and species of which live on the surface of the bodies of Crustacea and turtles of tropical and sub-tropical freshwaters. *Temnocephalidæ* are, nevertheless, predacious. They feed on Infusoria, the larvæ of small insects and Crustacea. So far as is known they do not nourish themselves on part of the host. They belong to the group of commensals, or more correctly, to that of the SPACE PARASITES, which simply dwell with their host and do not even take a portion of the superfluity of its food. However, space parasitism may still be regarded as the first stage of commensalism, which is again to be regarded as a sort of transition to true parasitism.

It is possible that parasitism came about in this way in the trematodes, in which connection we must first consider the turbellaria-like ancestors of the trematodes. Much can be said in favour of such a genetic relationship between turbellaria and trematodes, and hardly anything against it. It should also be remembered that amongst the few parasitic turbellaria there are some that possess clinging discs or suctorial pores, and these are only differentiated from ectoparasitic trematodes by the possession of a ciliated integument, which is found only in the larval stages of the latter.

The Acanthocephala occupy an isolated position. Most authors certainly regard them as related to the nematodes; in any case, the connection is not a close one, and the far-reaching alterations which must have occurred prevent a clear view. Perhaps the free original forms of Acanthocephala are no longer in existence, but that such must have existed is a foregone conclusion.

An explanation of the CHANGE OF HOST so frequent in parasites is more difficult than that of their descent. R. Leuckart is of opinion that the present intermediate hosts, which belong principally to the lower animals, were the original hosts of the parasites, and fostered both their larval and adult stages. It was only in course of time that the original hosts sank to the position of intermediate hosts, the cause for this alteration being that the development of parasites, especially of the helminthes, through further development and differentiation extended over a larger number of stages. The earlier stages remained in their original hosts, but the later stages sought out other hosts (higher animals). To prove this, Leuckart points out that the mature stages of the helminthes, with but few exceptions, occur only in the vertebrates which appeared later in the development of the animal kingdom, while the great majority of intestinal worms of the lower animals only represent young stages, which require transmission into a vertebrate animal before they can become mature. The few helminthes that attain maturity in the lower animals (*Aspidogaster, Archigetes*) are therefore regarded by Leuckart as primitive forms, and he compares them with the developmental stages of helminthes, *Aspidogaster* with rediæ, *Archigetes* with cysticercoids. He classes the nematodes that become mature in the invertebrates with *Anguillulidæ, i.e.*, with saprophagous nematodes from which the parasitic species descend.

Leuckart therefore regards the change of hosts as secondary, so does Sabatier. The latter, however, adduces other reasons for this (lack of clinging organs and the necessity to develop them in an intermediary stage) ; but in this connection he only considers the Cestoda. In opposition to Leuckart, R. Moniez, however, is convinced that the migrations of the helminthes, as well as the system of intermediate hosts, represent the original order of things. Moniez traces all Entozoa from saprophytes, but only a few of these were able to settle directly in the intestine and there continue their development. These are forms that at the present day still lack an intermediate host, such as *Trichocephalus, Ascaris*, and *Oxyuris*. In most other cases the embryos, however, consisted of such saprophytes as were, in other respects, suitable to become parasites, but were incapable of resisting the mechanical and chemical influences of the intestinal contents. They were therefore obliged to leave the intestine at once, and accomplished this by penetrating the intestinal walls and burrowing in the tissues of their carriers. In this position, assisted by the favourable conditions of nutrition, they could attain a relatively high degree of development. Mechanical reasons prevented a return to the intestines, where the eggs could be deposited. Most of them doubtless died off as parasites, as also their young stages do at present when they penetrate wrong hosts. Some of them, nevertheless, passively reached the intestine of beasts of prey. Many were destroyed in the process of mastication; for a small part, however, there was the chance of reaching the intestine of a beast of prey undamaged, and there, having become larger and more capable of resistance, maturity was attained. By means of this incidental coincidence of various favourable circumstances, these processes, according to Moniez, have been established by heredity and have become normal.

This is not the place to express an opinion either for or against the various hypotheses advanced, but the existence of these diametrically opposed views alone will show the great difficulty of the question. Independently, however, it appears more natural to come to the conclusion that parasitism, as well as change of hosts, were gradual transitions.

As a conclusion to this introductory chapter, a list of some of the most important works on the parasitology of man and animals is appended.

LITERATURE.

GOEZE, J. A. E. Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper. Blankenburg, 1782. 4to, 471 pp., with 44 plates.

ZEDER, J. G. H. Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer, von J. A. E. Goeze. Leipzig, 1800. 4to, with 6 tables.

RUDOLPHI, C. A. Entozoorum sive vermium intestinalium historia naturalis. I, Amstelod., 1808; ii, 1809. 8vo, with 18 plates.

RUDOLPHI, C. A. Entozoorum synopsis. Berol., 1819. 8vo, with 3 plates.

BREMSER, J. G. Ueber lebende Würmer im lebenden Menschen. Wien, 1819. 8vo, with 4 plates.

BREMSER, J. G. Icones helminthum, systema Rudolphii entozoologicum illustrantes. Viennae, 1824. Fol. (Paris, 1837).

DUJARDIN, F. Histoire naturelle des helminthes ou vers intestinaux. Paris, 1845. 8vo, with 12 plates.

DIESING, C. M. Systema helminthum. 2 vols. Vindobonnae, 1850, 1851. 8vo. Supplements by the same author: Revision der Myzhelminthen (Report of the Session of the Imp. Acad. of Science. Wien, xxxii, 1858); with addendum (ibid., xxxv, 1859); Revision der Cephalocotyleen (ibid., xlix, 1864, and xlviii, 1864); Revision der Nematoden (ibid., xlii, 1861); Supplements (ibid., xliii, 1862).

BENEDEN, P. J. VAN. Mémoire sur les Vers intestinaux. Paris, 1858. 4to, with 12 plates.

KÜCHENMEISTER, F. Die in und an dem Körper des lebenden Menschen vorkommenden Parasiten. Leipzig, 1855. 8vo, with 14 plates.

LEUCKART, R. Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten. I, Leipzig, 1863; II, Leipzig, 1876. 8vo.

COBBOLD, T. SP. Entozoa; an Introduction to the Study of Helminthology. London, 1864. 8vo. Supplement, London, 1869.

DAVAINE, C. Traité des entozoaires et des maladies vermineuses de l'homme et des animaux domestiques. 2nd edit. Paris, 1877. 8vo.

LINSTOW, O. V. Compendium der Helminthologie, ein Verzeichniss der bekannten Helminthen, die frei oder in thierischen Körpern leben, geordnet nach ihren Wohnthieren, unter Angabe der Organe, in denen sie gefunden sind, und mit Beifügung der Litteraturquellen. Hanov., 1878. 8vo. Supplement, including the years 1878-1888, Hanov., 1888.

COBBOLD, T. SP. Parasites; a Treatise on the Entozoa of Man and Animals, including some Account of the Entozoa. London, 1879. 8vo.

LEUCKART, R. Die Parasiten des Menschen und die von ihnen herrührenden Krankheiten. 2nd edit. Leipzig, 1879-1886. The Protozoa, Cestodes, Trematodes and Hirudinea have hitherto appeared (continued by Brandes).

BÜTSCHLI, O. Protozoa in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. i, Leipzig, 1880-1889. 8vo, with 79 plates.

BRAUN, M. Trematodes in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. iv, 1, Leipzig, 1879-1893. 8vo, with 33 tables. (The first thirteen sheets, comprising the history of the worms up to 1830, were compiled by H. Pagenstecher.)

ZÜRN, F. A. Die thierischen Parasiten auf und in dem Körper unserer Haussäugethiere, sowie die durch erstere veranlassten Krankheiten, deren Behandlung und Verhütung. 2nd edit. Weimar, 1882. 8vo, with 4 plates.

COBBOLD, T. SP. Human Parasites; a Manual of Reference to all the Known Species of Entozoa and Ectozoa. London, 1882. 8vo.

KÜCHENMEISTER, F., and F. A. ZÜRN. Die Parasiten des Menschen. 2nd edit. Leipzig, 1888. 8vo, with 15 plates.

BLANCHARD, R. Traité de zoologie médicale. I, Paris, 1889; II, 1890. 8vo.

NEUMANN, L. G. Traité des maladies parasitaires non microbiennes des animaux domestiques. 2nd edit. Paris, 1892. 8vo. English edit., translated by G. Fleming. 2nd edit., revised by J. Macqueen. 1905. London: Baillière, Tindall and Cox.

LOOSS, A. Schmarotzerthum in der Thierwelt. Leipzig, 1892. 8vo.

RAILLIET, A. Traité de zoologie médicale et agricole. 2nd edit. I, Paris, 1895. 8vo.

PARONA, C. L'elmintologia italiana da' suoi primi tempi all' anno 1890. Genova, 1894. 8vo.

BRAUN, M. Cestoda in Bronn's Klass. u. Ordn. d. Thierreichs. Vol. iv, 2, Leipzig, 1894-1900. 8vo, with 24 plates.

MOSLER, F., and E. PEIPER. Thier Parasit. (Spec. Path. u. Ther. v. H. Nothnagel. Vol. vi.) Wien, 1894. 8vo, with 124 illustrations.

LAVERAN, A., et R. BLANCHARD. Les hématozoaires de l'homme et des anim. Paris, 1895. 12mo, with 30 figs.

SLUITER, C. R. De dierl. paras. v. d. mensch en van onze huisdier. Haag, 1895. 8vo.

BLANCHARD, R. Malad. parasit., paras. animaux, paras. végét. à l'exclus. des bacter. (Traité de pathol. gén. de Ch. Bouchard, vol. ii.) Paris, 1895. 8vo, with 70 figs.

HUBER, J. CH. Bibliographie der klin. Helminthol. München, 1895. 8vo. With Supplement, 1898, and continued as Bibl. d. klin. Entomol. München, 1899-1900.

MONIEZ, R. Traité de parasitol. anim. et veget. appl. à la médecine. Paris, 1896. 8vo, with 116 figs.

WEICHSELBAUM. Parasitologie (Weil's Handb. d. Hyg.). Jena, 1898. 8vo, with 78 illustrations.

KRAEMER, A. Die thierischen Schmarotzer des Auges (Gräfe and Sämische's Handb. d. ges Augenheilk.). Leipzig, 1899. 8vo, with 16 illustrations.

CHOLODKOWSKY, N. A. Icones helm. hominis. St. Petersburg, 1898-99. Fol. (atlas with 15 plates).

PERRONCITO, E. I parassiti dell' uomo e degli animali utili e le più comuni malattie da essi prodotti. IIa ed. Milano 1902. 8°. con 276 fig. e 25 tav.

STILES, CH. W. and A. HASSALL. Index Catalogue of Medicine and Veterinary Zoology. Washington, 1902 (U.S. Dept. of Agric., Bur. of Anim. Ind., Bull. No. 39).

NEVEU-LEMAIRE, M. Précis de parasitologie humaine, parasites végétaux et animaux. 4e édit. Paris, 1911.

HOFER, B. Handbuch der Fischkrankheiten. München, 1904. 8°. 18 Taf. 222 Abb.

GUIART, J., and L. GRIMBERT. Précis de Diagnostic chimique, microscopique et parasitologique. Paris, 1906. With 500 figs.

OSTERTAG, R. Handbuch der Fleischbeschau. V. Aufl. mit 265 Abb. Stuttgart, 1904.

STILES, CH. W. The International Code of Zoological Nomenclature as applied to Medicine (Hygienic Lab., Bull. No. 24, Washington, 1905).

STILES, C. W., and HASSALL, A. Trematoda and Trematode Diseases. (Index Catalogue of Med. and Vet. Zoology.) Hygienic Lab., Bull. No. 37, Washington, 1908.

STILES, C. W., and HASSALL, A. Cestoda and Cestodaria. Hygienic Lab., Bull. No. 85, Washington, 1912.

LALOY, L. Parasitisme et mutualisme dans la nature. Paris, 1906. 8vo, 284 pp., 82 figs.

THEOBALD, F. V. A Monograph of the Culicidæ of the World. 5 vols. and plates. 1901-1910. London: Brit. Museum, Nat. Hist.

JAMES, S. P., and LISTON, W. G. The Anopheline Mosquitoes of India. 2nd edit. 1911. Calcutta: Thacker, Spink and Co.

HOWARD, L. O., DYAR, H. G., and KNAB, F. The Mosquitoes of North and Central America and the West Indies. 2 vols. 1912. Washington: Carnegie Institution.

AUSTEN, E. E. African Blood-sucking Flies. 1909. London: Brit. Museum, Nat. History.

AUSTEN, E. E. A Handbook of Tsetse-flies. 1911. London: Brit. Museum, Nat. History.

CASTELLANI, A., and CHALMERS, A. J. Manual of Tropical Medicine. 2nd edit. 1,747 pp. 1913. London: Baillière, Tindall and Cox.

KOLLE and WASSERMANN. Handbuch der pathogenen mikroorganismen. Jena: Gustav Fischer.

MINCHIN, E. A. An Introduction to the Study of the Protozoa. 1912. London: Arnold.

LAVERAN, A., et MESNIL, F. Trypanosomes et Trypanosomiases. 2nd edit. 1912. Paris: Masson and Co.

DOFLEIN, F. Lehrbuch der Protozoenkunde. 3rd edit. 1911. Jena: Gustav Fischer.

NUTTALL, G. H. F., WARBURTON, C., COOPER, W. F., and ROBINSON, L. E. Ticks—a Monograph of the Ixodoidea. Pt. I (1908). Pt. II. (1911). University Press, Cambridge, England.

BRUMPT, E. Précis de Parasitologie. 2nd edit. 1913. Paris: Masson and Co.

PATTON, W. S., and CRAGG, F. W. A Text-book of Medical Entomology. 1913. Christian Literature Society of India: London, Madras, and Calcutta.

JOURNALS.

For current researches the following, among others, should be consulted :—

Annals of Tropical Medicine and Parasitology, Liverpool.
Annales de l'Institut Pasteur, Paris.
Archives de Parasitologie, Paris.
Archives de Zoologie Expérimentale et Générale, Paris.
Archiv für Protistenkunde, Jena.
Archiv für Schiffs- und Tropen-Hygiene, Leipzig.
Bulletin of Entomological Research, London.
Bulletin de l'Institut Pasteur, Paris.
Bulletin de la Société de Pathologie Exotique, Paris.
Bulletins of the Bureau of Animal Industry, Washington.
Centralblatt für Bakteriologie und Parasitenkunde, Jena.
Compt. Rend. Acad. Sci., Paris.
Compt. Rend. Soc. Biol., Paris.
Indian Journal of Medical Research, Calcutta.
Journal of Experimental Medicine, New York.
Journal of Medical Research, Boston.
Memorias do Instituto Oswaldo Cruz, Rio de Janeiro.
Parasitology, Cambridge.
Proceedings of the Royal Society, London.
Quarterly Journal of Microscopical Science, London.
Review of Applied Entomology, London.
Tropical Diseases Bulletin (London: Tropical Diseases Bureau).
Zeitschrift für Infektionskrankheiten, Berlin.

THE ANIMAL PARASITES OF MAN.

MAN is one of those organisms in or on which a whole host of parasites find conditions suitable for their existence: Protozoa, Platyhelminthes, Nematoda, Acanthocephala, Hirudinea, and a large number of Arthropoda (Arachnida as well as Insects) all include members which are parasites of man. These animals either live on the external surface of the body or within the intestine and its appendages. Other organs and systems are not quite free from foreign organisms—we are acquainted with parasites in the skeletal system, in the circulatory system, in the brain, in the muscles, in the excretory and genital organs, and even in the organs of sense.

It is possible, and perhaps might be advantageous, to arrange and describe the parasites of man according to the situations in which they are found (parasites of the skin, intestinal parasites, etc.). Their description in the various stages of development would, however, be disturbed when, as is generally the case, the different stages are passed in different organs, and a work which treats more fully of the natural history of the parasites than of the local disorders to which they give rise would suffer thereby. It is, therefore, preferable to describe the parasites of man in their systematic order, and to mention their different situations in man in describing each species.

A. PROTOZOA,

BY

H. B. FANTHAM, M.A., D.Sc.

All those animal organisms which throughout their entire life never rise above the unicellular stage, or merely form simple, loose colonies of similar unicellular animals, are grouped under the term *Protozoa* (Goldfuss, 1820), as the simplest types of animal life. All the vital functions of these, the lowest forms of animals, are carried out by their body substance, the protoplasm (sarcode). Often particular parts possess special functions, but the limits of a cell are never over-stepped thereby. These special parts of the cell are called "cell-organs"; recently they have been termed "organellæ."

The living protoplasm has the appearance of a finely granular, viscid substance which, as a rule, when not surrounded by dense investing membranes or skeletons, exhibits a distinct kind of movement, which has been termed amœboid. According to the species, processes of different forms and varying numbers called pseudopodia are protruded and withdrawn, and with their assistance these tiny organisms glide along—it might almost be said flow along—over the surface. In most Protozoa two layers of cytoplasm may be recognised, and distinguished by their appearance and structure, namely, the superficially situated, viscid, and quite hyaline ectosarc or ectoplasm, and the more fluid and always granular endosarc or endoplasm, which is entirely enveloped by the ectoplasm. The two layers have different functions; the movements originate from the ectoplasm, which also undoubtedly fulfils the functions of breathing, introduction of food and excretion. The endoplasm, which in some forms (Radiolaria) is separated from the ectoplasm by a membrane, undertakes the digestion of the food. To this distribution of functions between the various layers of cytoplasm is due the development of particular cellular organs, such as the appearance of cilia, flagella, suctorial tubules (in the Suctoria) and the myophan striations, which are contractile parts of the ectoplasm in Infusoria and Gregarines. In many cases (Flagellata, Ciliata), an area is differentiated for the ingestion of food (oral part, cytostome) to which there is often added a straight or curved opening (cytopharynx), through which the food reaches the endoplasm. The indigestible residue is either cast off through the oral part or excreted by a special anal part (cytopyge). In rare cases, structures sensitive to light, the so-called pigment or eye spots are developed, *e.g.*, *Euglena*. In the case of Infusoria the endoplasm circulates slowly, and agglomerations of fluids (food vacuoles) sometimes appear around each bolus of food ; in these vacuoles the food is digested under the action of certain materials (ferments). Even in the lowliest Protozoa fluids to be excreted are, as a rule, gathered into one, or, more rarely, several contractile vacuoles, which regularly discharge their contents. This action, however, is to a certain extent governed by the temperature of the surrounding medium. In some Infusoria a tube-like channel in the cytoplasm is joined to the contractile vacuole which usually occupies a certain position; this forms a sort of excretory duct, and there are also supply-canals leading to these organellæ.

Very frequently various substances are deposited in the endoplasm, such as fatty granules, drops of oil, pigment granules, bubbles of gas or crystals. More solid skeletal substances are secreted in or on the ectoplasm. To the latter belong the cuticle of the Sporozoa and Infusoria, the chalky shells containing one or several chambers of the Foraminifera, the siliceous and very ornamental framework of the Radiolaria, and the chitinous coat of many Flagellata, Infusoria, etc. Some forms make use of foreign bodies found in their surroundings, such as grains of sand, to construct their protective coverings.

The food often consists of small animal or vegetable organisms and of organic waste ; it is usually introduced *in toto* into the endoplasm. On the other hand, the Suctoria extract nourishment from their prey by means of their tentacles. Many parasitic species also ingest solid food, others feed by endosmosis.

In all cases one nucleus at least is present. It is true that the existence of non-nucleated Protozoa, the so-called *Monera*, is still insisted upon, but some of these have already proved to be nucleated, and the presence of nuclei in the others will no doubt be established. Very often the number of nuclei increases considerably, but these multinucleate stages are always preceded by uninucleate stages. In the Infusoria, in addition to the larger or principal nucleus (macronucleus) there is usually a smaller reproductive nucleus (micronucleus). This dualism of the nuclear apparatus is considered by some to be general, and usually to appear first at the onset of reproduction.

The form and structure of the nucleus vary greatly in different species. There are elongate, kidney-shaped, or even branched nuclei as well as spherical or oval ones. In addition to vesicular nuclei with a distinct karyosome and incidentally also with a nuclear membrane, homogeneous and more solid formations are frequently encountered. The nuclei are always differentiated from the protoplasm by their reactions, particularly in regard to certain stains.

In many Protozoa an extra-nuclear mass, sometimes compact, sometimes diffuse, arises from or near the nucleus. This mass, whose staining reactions resemble those of the nucleus, is termed the chromidial apparatus. On the dualistic hypothesis, two varieties of chromidia occur, one originating from the vegetative nucleus (macronucleus), being chromidia in the restricted sense, the other derived from the reproductive or micronucleus being termed sporetia. Chromidia consist of altered (? katabolic) nuclear material.

The nucleus plays the same part in the life of the single celled organisms as it does in the cells of the Metazoa and Metaphyta. It appears to influence in a certain manner all, or at least most, of the processes of life, such as motility, regeneration, growth, and generally also digestion. Its principal influence, however, is exercised in the propagation of the cells, as this is always brought about by the nucleus.

The PROPAGATION of the Protozoa is effected either by division or by means of direct budding. In division, which is preceded by direct or indirect (mitotic) division of the nucleus, the body separates into two, several, or even a great many segments. In this process the entire substance of the body is involved, or a small residual fragment may be left, which does not undergo further division and finally perishes. In the budding method of multiplication a large number of buds are formed, either on the surface or in the interior of the organism. Where divisions or buddings follow one another rapidly, without the segments separating immediately after their production, numerous forms develop, which are often unlike the parental forms, and these are termed swarm spores or spores. Divisions imperfectly accomplished lead to the formation of protozoal colonies.

Sometimes encystment[1] takes place previous to division. Frequently, also, sexual processes appear, such as the union of two similar (isogamous) or dissimilar (anisogamous) individuals. In the latter case sexual dimorphism occurs, with the formation of males (microgametes) and of females (macrogametes). The union may be permanent (copulation), the process being comparable with the fertilisation of the ovum by a spermatozoon. On the other hand, attachment may be transient (conjugation) when, after the exchange of portions of the nucleus, the couple separate, to multiply independently of each other. Sometimes there is an ALTERNATION OF GENERATIONS, as there may be several methods of propagation combined in the same species, either direct multiplication, conjugation, or copulation being practised; the different generations may thus, in certain cases, be unlike morphologically.

Protozoa inhabit salt water as well as fresh water; they are also found on land in very damp places, and invade animals as parasites.

CLASSIFICATION OF THE PROTOZOA.

Class I.—**Sarcodina** (*Rhizopoda*). Protozoa, the body substance of which forms pseudopodia; many of them are capable of developing chitinous, chalky, or siliceous coverings or skeletal structures, which, however, permit the protrusion of the pseudopodia either over the entire periphery or at certain points. They possess one nucleus or several.

Order 1.—*Amœbina* (Lobosa) naked or with a simple shell, sometimes formed of a foreign substance; the pseudopodia may be lobose or finger-shaped; there may be a contractile vacuole; generally only one nucleus. They live in fresh or salt water, in the soil, and also parasitically.

Order 2.—*Foraminifera* (Reticularia). Mostly provided with a calcareous shell, usually consisting of several chambers, and allowing the protrusion of the pseudopodia either at the periphery or only at the opening. The pseudopodia are filamentous and frequently anastomosed; there is no contractile vacuole; there are usually several nuclei. Mostly marine.

Order 3.—*Heliozoa.* Naked, or with a chitinous or simple radial siliceous skeleton; the pseudopodia are filamentous, and are frequently supported

[1] Independently of propagation, many protozoa protect themselves from death by encystment when the water in which they are living dries up; in this condition the wind may carry them over wide tracts of land.

by firmer axes, which exhibit no tendency to anastomosis; there is a contractile vacuole; one or several nuclei. Live in fresh water.

Order 4.—*Radiolaria.* The body has radially-disposed filamentous pseudopodia, and the nucleus is hidden in the central capsule; there is almost always a siliceous framework, consisting of pieces arranged radially, tangentially, or lattice-like; there is no contractile vacuole, but fluid-containing hydrostatic vacuoles are present in the peripheral protoplasm. Marine.

Class II.—**Mastigophora** (*Flagellata*). Protozoa with one or several long flagella used for locomotion and for acquiring food; in stationary forms their only function is to take in food. Cytostome and contractile vacuole may be present. May be either naked or provided with protective coverings; one or more nuclei. They live either in fresh or salt water, or may be parasitic.

This class is again divided into several sub-classes and orders, of which only the Euflagellata, with the Protomonadina and Polymastigoda are of interest here.

Class III.—**Sporozoa**. Protozoa that only live parasitically in the cells, tissues, or organs of other animals. They ingest liquid food by osmosis; the surface of the body is covered with an ectoplasmic layer, or cuticle; they have no cilia in the adult state, but may form pseudopodia. Flagella occur, but only on the male propagating individuals. There may be one or numerous nuclei, but no contractile vacuole. Propagation by means of spores, mostly provided with sporocysts, is characteristic.

Sub-class 1.—**Telosporidia.** These are usually of constant form, rarely amœboid; they are uninucleate in the mature state; they live within host cells in the first stage. Spore-formation occurs at the end of the life-cycle.

Order 1.—*Gregarinida.* Body of a constant, usually elongate form, surrounded by a cuticle. In the early stage they lead an intracellular existence; in the mature stage they live within the intestine or body cavity of invertebrate animals, especially the Arthropoda, and, like intestinal parasites, are provided with clinging organs. Copulation usually isogamous; the spores have coats (chlamydospores) and usually contain several minute germs (sporozoites).

Order 2.—*Coccidiidea.* Body of uniform spherical or oval shape: they lead an intracellular life, but are not freely motile in cavities of the body. Fertilization is anisogamous; the spores have coats or shells (sporocysts), and usually contain several sporozoites. Exhibit alternation of generations.

Order 3.—*Hæmosporidia.* Parasites of the blood corpuscles of vertebrate animals; they exhibit amœboid movement; fertilization is anisogamous; many present alternation of generations and hosts; spores naked.

Sub-class 2.—**Neosporidia.** They are multinucleate when adult, and the form of the body varies exceedingly (often amœboid); spore-formation commences before the completion of growth.

Order 1.—*Myxosporidia.* The spores have valvular coats, with or without caudal appendages, with two, rarely four, polar capsules. They live free in such organs as the gall or urinary bladder, but are chiefly found in connective tissue. They occur especially in fishes.

Order 2.—*Microsporidia.* Spores with coats or sporocysts; no caudal appendage, with one polar capsule. They usually live in the tissues of Arthropoda.

Order 3.—*Sarcosporidia.* Elongate parasites of the muscular fibres of amniotic vertebrates, on rare occasions they occur also in the connective tissue; the spores, which are kidney or sickle-shaped, are naked and apparently have no obvious polar capsule.

Order 4.—*Haplosporidia.* Simple organisms, forming simple spores; they occur in Rotifers, Polychætes, Fish and Man.

Class IV.—**Infusoria** (*Ciliata*). The body is generally uniform in shape, with cilia and contractile vacuole, frequently also with cytostome; usually has macro- and micro-nucleus; live free in water and also parasitically.

The orders *Holotricha*, *Heterotricha*, *Oligotricha*, *Hypotricha* and *Peritricha* are classified according to the arrangement of the cilia.

Class V.—**Suctoria**. Bodies with suctorial tubes, contractile vacuoles, macro- and micro-nucleus, no cytostome. They generally invade aquatic animals as cavity parasites, yet also attack plants; early stage ciliated. Live sometimes as parasites on Infusoria. [The Suctoria are frequently regarded as a sub-class of the Infusoria.]

The Protozoa and Protophyta are sometimes united under the term *Protista* (Haeckel, 1866). The Spirochætes are Protists (see pp. 114—128).

Class I. SARCODINA, Bütschli, 1882.

Order. Amœbina, Ehrenberg.

A. Human Intestinal Amœbæ.

The first record of the occurrence of amœba-like organisms in the human intestine, that is, in intestinal evacuations, was that of Lambl (1859); nevertheless, the case was not quite conclusive, as the occurrence of testaceous amœbæ of fresh water (*Arcella*, *Difflugia*) was also reported. In 1870 Lewis found amœbæ associated with disorders of the large intestine in patients in Calcutta. A year later Cunningham reported from the same locality that he had observed on eighteen occasions, in one hundred examinations of dejecta from cholera patients, colourless bodies with amœboid

FIG. 1.—*Amœba coli*, Lösch, in the intestinal mucus. (After Lösch.)

movements, which became encysted and multiplied by fission. The daughter forms were said to be capable of dividing again, but they might also remain in contact. Contractile vacuoles were not noticed. The same bodies were observed also in simple diarrhœa (twenty-eight cases out of one hundred.)

The case reported by Lösch in 1875 attracted more attention. It was that of a peasant, aged 24, who came from the province of Archangel. He was admitted into Eichwald's clinic at Petrograd with symptoms of dysentery. In the discharges containing blood and pus, Lösch found amœbæ in large numbers. When at rest these amœbæ measured from 20 μ to 35 μ; in a state of movement their length might extend up to 60 μ (fig. 1). The pseudopodia appeared only singly, and, since they were hyaline (ectoplasmic), were thus distinguished from the markedly granular endoplasm that enclosed a spherical nucleus of from 5 μ to 7 μ in diameter. One or more non-contractile vacuoles were present. Quinine enemata had the effect of making the amœbæ disappear from the fæces and thus causing the diarrhœa to abate. Four months after admission the patient died from the results of intercurrent pneumonia. At the autopsy ulceration of the large intestine was found, especially in the lower parts. Lösch connected the amœbæ with the ulcerations by experiments made on four dogs by injecting them with recently passed stools (*per os et anum*). Eight days after the last injection numerous amœbæ were found in the fæces of one of these dogs; eighteen days after the injection the animal was killed. The mucosa of the rectum was inflamed, covered with blood-stained mucus and ulcerated in three places. Numbers of amœbæ were found both in the pus of the ulcers and in the mucus. The three other dogs remained healthy. From these observations Lösch concluded that the species of amœba described by him as *Amœba coli* could not be regarded as the primary cause of the disease, but that it was certainly capable of increasing a lesion of the large intestine already present, or at least of preventing its healing.

B. Grassi (1879) found in the stools of healthy as well as in those of diarrhœic patients from various localities in Northern Italy, amœbæ similar to those discovered by Lösch. As this was of frequent occurrence, the pathogenicity could not be definitely established. Normand, formerly naval surgeon at Hong-Kong, observed numerous amœbæ in the dejecta of two patients suffering from colitis.

Many further investigations, which cannot be quoted in detail, showed not only that intestinal amœbæ were widely distributed in man, but indicated with greater certainty their rôle as agents of dysentery. The Commission sent out by the German Government in the year 1883 to investigate cholera in India and Egypt—whose members discovered the cholera bacillus—also collected information with regard to dysentery. In five cases of dysentery examined *post mortem* at Alexandria, with the exception of one case in which ulceration of the colon had already cicatrized or was approaching cicatrization, R. Koch found amœbæ as well as bacteria in sections from the base of the ulcers, although such had previously escaped notice in examination of the dejecta. Encouraged by these results, Kartulis (1885), who had discovered amœba-like bodies in the stools of patients suffering from intestinal complaints at Alexandria, continued his investigations. The results, obtained from more than 500 cases, gave rise to the theory that typical dysentery was caused by amœbæ as were also the liver-abscesses that often accompany it. Kartulis supported his theory not only by the regular occurrence of amœbæ in the stools of dysenteric patients and their absence in other diseases, and by the occurrence of the parasites in ulcers of the large intestine and in the pus from liver-abscesses, but also by experiments which he performed on cats. These were infected by injection *per anum* of stool material rich in amœbæ from subjects of dysentery. The infection took place also when amœba-containing, but bacteria-free, pus from liver-abscesses was used. It has been objected that the infection of man with *Amœba coli*, as the dysenteric amœbæ were then generally designated, does not take place *per anum* but *per os*. This difficulty, however, diminished in proportion as the encysted states of amœbæ (fig. 2), long known in the case of other Protozoa, became understood. The infection of man (Calandruccio, 1890) and of cats (Quincke and Roos) succeeded solely when material containing such stages was used. Amœbæ introduced into the intestine multiply there by fission (Harris, 1894). However, this theory, to which various other authors gave support on the grounds of their own observations, encountered opposition. Thus it was established that amœbæ were not found in patients in every place where dysentery was endemic, or else they were much rarer than was expected. Further, amœbæ were present in the most varied kinds of intestinal diseases, both of infective and non-infective characters. Also they were present in quite healthy persons.

Moreover, for various reasons, infection experiments on animals failed to supply proof, and finally a bacterium was discovered (Shiga, 1898) to be the excitant of one form of dysentery. Agglutination attested the specific part played by this organism, as it was produced by the blood serum of a person suffering from or recovered from dysentery, but not by the serum of one who was uninfected. Bacillary dysentery consequently was a distinct entity. The final step to be taken was to decide whether there was a specific amœbic enteritis (amœbic dysentery or amœbiasis, according to Musgrave).

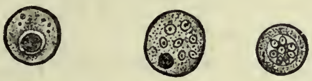


FIG. 2.—Encysted intestinal amœbæ showing nuclear multiplication. (After B. Grassi.)

This question should decidedly be regarded from the positive point of view. It is intimately connected with another, namely, whether there are not several species of intestinal amœbæ. The possibility of this had already been recognized. In addition to the *Amœba coli* Lösch, R. Blanchard distinguished yet another, *Amœba intestinalis*, and designated thereby the large amœbæ described in the first communication made by Kartulis ; later on he stated the distinction between the species. Councilman and Lafleur[1] (1891) considered the amœba of dysentery to be *Amœba coli* Lösch and so re-named the species *Amœba dysenteriæ*. Kruse and Pasquale (1893) employed the same nomenclature, but retained the old name *Amœba coli* Lösch for the non-infectious species. Quincke and Roos (1893) set forth three species : a smaller species (25 μ) finely granular, pathogenic for men and cats (*Amœba coli* Lösch) ; a larger species (40 μ) coarsely granular, pathogenic for men but not for cats (*A. coli mitis*) ; and a similar species non-pathogenic either for man or cat (*A. intestini vulgaris*). Celli and Fiocca (1894-6) went still further, they distinguished :

(1) *Amœba lobosa* variety *guttula* (=*A. guttula* Duj), variety *oblonga* (= *A. oblonga* Schm.) and variety *coli* (= *A. coli* Lösch).

(2) *Amœba spinosa* n. sp. occurring in the vagina as well as in the intestine of human patients suffering from diarrhœa and dysentery.

(3) *Amœba diaphana* n. sp. found in the human intestine in cases of dysentery.

(4) *Amœba vermicularis* Weisse, present in the vagina and in dysentery ; and

(5) *Amœba reticularis* n. sp. in dysentery.

Shiga distinguished two species; a larger pathogenic species with a somewhat active movement, and a small harmless species with a somewhat sluggish movement. Bowman mentions two varieties, Strong and Musgrave (1900) two species—the pathogenic *Amœba dysenteriæ* and the non-pathogenic *Amœba coli;* Jäger (1902) and Jürgens (1902) mention at least two species. In the following year (1903) a work by Schaudinn was published which marked a real advance. This, in conjunction with the establishing of a special genus (*Endamœba* or *Entamœba*) for human intestinal amœbæ first by Leidy[2] and then by Casagrandi and Barbagallo,[3] for the time cleared up the confused nomenclature, the old name *Amœba coli* being retained for the

---

[1] "Amœbic Dysentery," *Johns Hopkins Hosp. Repts.*, ii, pp. 395-548, 7 plates.

[2] "On *Amœba blattae*," *Proc. Acad. Nat. Sci.*, Philadelphia (1879), xxxi, p. 204.

[3] "*Entamœba hominis* s. *Amœba coli* (Lösch). *Annali d'Igiene speriment.* (1897), vii, p. 103. See also further remarks on p. 34.

harmless intestinal amœbæ of man, whereas the pathogenic species was designated *Entamœba histolytica*. The history of more recent work is incorporated in the accounts of the entamœbæ given below.

Entamœba coli, Lösch, 1875, emend. Schaudinn, 1903.

Syn.: *Amœba coli*, Lösch, 1875. *Entamœba hominis*, Casagr. et Barbag. 1897.

The amœboid trophozoite, according to Lösch, measures 26 μ to 30 μ and upwards; according to Grassi 8 μ to 22 μ; according to Schuberg 12 μ to 26 μ. A separation of the body substance into ectoplasm and endoplasm is only perceived during movement. The pseudopodia, which are generally only protruded singly, are broad

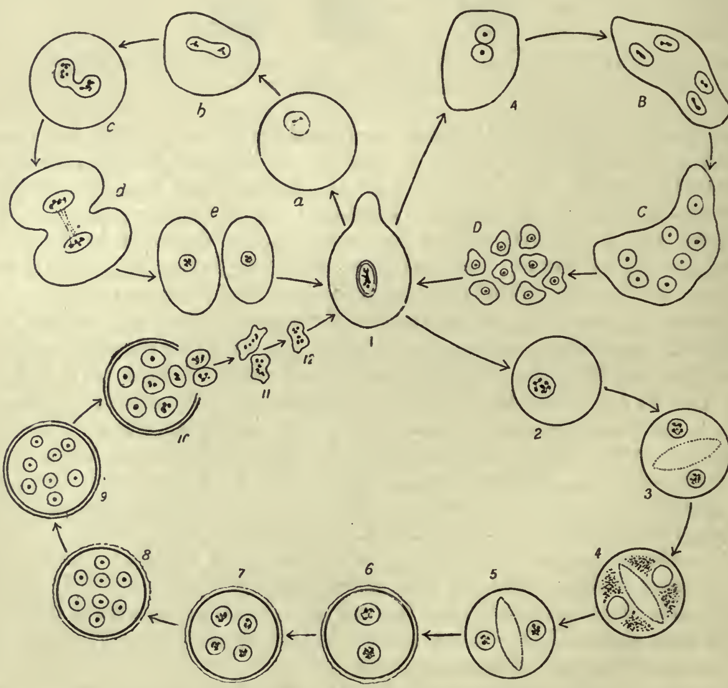


FIG. 3.—*Entamœba coli:* life-cycle, *a—e*, stages in binary fission; *A—D*, schizogony, with formation of eight merozoites; 2—10, cyst formation or sporogony, with formation of eight nucleate cysts. (After Castellani and Chalmers).

and rounded at the end (lobopodia) and are hyaline, while the remainder of the body is granular. The ectoplasm is less refractile than the rest of the cytoplasm; it also stains less intensely (fig. 1), and is best seen on protrusion of a pseudopodium. Red blood corpuscles are rarely, if ever, found ingested in the cytoplasm.

The nucleus is vesicular, and is spherical when inactive, measuring 5 μ to 7 μ, with a thick nuclear membrane. In the centre of the nucleus is a chromatinic body or karyosome or sometimes several small nuclear bodies formed of plastin and chromatin ; the remaining chromatin is arranged on the achromatic network in the form of fine granules, especially thickly deposited on the nuclear membrane.

Entamœba coli lives as a commensal in the upper portion of the large intestine, where the fæces still possess a pulpy consistency. With their concentration and change in reaction lower in the bowel, the parasites either die or else if they are at a suitable stage of development form resistant cysts. These cysts (fig. 2) can be found in great abundance in normal fæces, as Grassi first observed. Slight laxantia or intestinal diseases of any kind producing increased peristalsis, however, show amœbæ even in the unencysted condition, provided that the person harbours intestinal amœbæ generally. The intensity of infection varies according to the locality; thus Schaudinn found that 50 per cent. of the persons examined were infected with harmless amœbæ in East Prussia, 20 per cent. in Berlin and about 66 per cent. on the Austrian littoral.

The life-history (fig. 3) of the parasite exhibits two phases: (*a*) asexual multiplication in the intestine, either by binary fission or by schizogony with formation of eight merozoites, and (*b*) sporogony leading to the production of eight-nucleate cysts. Infection results from ingestion of cysts. Only cysts with eight nuclei are infective. The diameter of such cysts is about 15 μ to 20 μ.

There are varying accounts of the details of the life-cycle of *Entamœba coli* in its different stages. Thus, regarding schizogony or multiple fission it was formerly stated that the nucleus of the parent amœba divided into eight portions, which after dissolution of the nuclear membrane, passed outwards into the cytoplasm, which segregated around each. Eight merozoites were thus produced. More recently the process of schizogony has been considered to consist in the repeated division of the nucleus into two, four, and finally eight nuclei (fig. 3, A—D), and the formation of eight merozoites or amœbulæ.

The process of encystment is initiated by the extrusion of all liquid and foreign bodies from the protoplasm, which assumes a spherical form (fig. 4, A). The rounded uninucleate amœba then secretes a soft gelatinous coat, which finally differentiates into a double contoured cyst wall in older cysts. According to Casagrandi and Barbagallo, the size of the cyst varies from 8 μ to 30 μ, and averages about 15 μ. According to Schaudinn (1903) the cytological changes during cyst formation are as follows. The nucleus of a rounded uninucleate form divides into two (fig. 4, B). Each of these nuclei fragments into chromidia (fig. 4, C), some of which are absorbed, while others reunite so that the cell becomes binucleate again. Each of these nuclei, by a twice repeated division, produces three nuclei (fig. 4, D), the smaller two of which degenerate and were regarded as reduction nuclei. There is a clear zone or vacuole in the middle of the cyst during these maturation processes, dividing the cyst into two halves. After the nuclear reduction the clear space disappears, and each nucleus (termed by some a gamete nucleus) divides into two pronuclei (fig. 4, E). The pronuclei of the pairs were said by Schaudinn to differ slightly. Copulation occurs between pairs of unlike pronuclei, and is an example of autogamy (fig. 4, F). When complete, each of the fusion nuclei (synkarya) divides twice, giving rise first to four and finally to eight nuclei. Eight amœbulæ are thus formed within the cyst.

According to Hartmann and Whitmore (1911)[1], however, autogamy does not occur within the cysts of *E. coli*. They consider that eight small amœbulæ are formed (fig. 3, *2—10*) which escape from the cyst and then conjugate in pairs (fig. 3, *10—12*), afterwards growing into a new generation of trophozoites.

Only some 10 to 20 per cent. of the cysts evacuated with the fæces undergo the full course of development, the majority perish previously. In old dry fæces, only cysts with eight nuclei are found, and it is these alone that cause the infection.

Entamœba williamsi, *E. bütschlii*, *E. hartmanni* and *E. poleki* (Prowazek) are probably only varieties of *E. coli*.

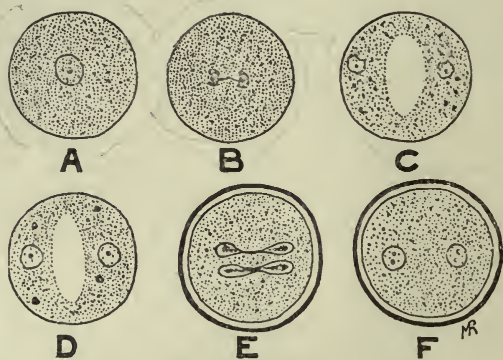


FIG. 4.—So-called autogamy of *Entamœba coli*. A, rounded amœba; B, nucleus dividing; C, the two daughter-nuclei giving off chromidia; D, each nucleus has formed two reduction nuclei; E, cyst membrane formed, and gamete nuclei are dividing; F, cyst with two synkarya.

The principal feature distinguishing *Entamœba coli* from *E. histolytica* is the formation of eight-nucleate cysts by the former as contrasted with the tetra-nucleate cysts of the latter. The cyst-wall of *E. coli* is thicker than that of *E. histolytica* (*tetragena*). Further, *E. coli* does not usually ingest red blood corpuscles, nor are "chromidial blocks" present inside its cyst (see p. 40).

According to Chatton and Lalung-Bonnaire[2] (1912) the entamœbæ of vertebrates should be placed in a separate genus *Löschia*, as they differ in their life-history from *E. blattæ*, the type species of *Entamœba*. Leidy (1879), however, named the genus *Endamœba*, but further researches are necessary on biological variation among these organisms.

Entamœba histolytica, Schaudinn, 1903.

Syn.: *Amœba coli*, autt. p. p. *Amœba dysenteriæ*, autt. p. p.

The average size of the amœboid trophozoite is 25 μ to 30 μ. In fæces diluted with salt solution the amœbæ swell to 40 μ and more. There is sometimes separation of the body substance into a strongly refractile vitreous ectoplasm and a corneous endoplasm, pronounced

---

[1] *Archiv f. Protistenkunde*, xxiv, p. 182.
[2] *Bull. Soc. Path. Exotique*, v, p. 135.

even in repose, although the former is not equally thick at all parts of the periphery. In the endoplasm generally there are numerous foreign bodies (bacteria, epithelial cells, colourless and red blood corpuscles (fig. 6), and occasionally living flagellates of the intestine). The nucleus is 4 μ to 6 μ in diameter, and may be difficult to recognize because it is sometimes weakly refractile and poor in chromatin. Its shape is slightly variable; it is usually excentric, sometimes wholly peripheral at the limit of the two parts of the body. Vacuoles are not present in quite fresh specimens, but appear later. In the study of *E. histolytica*, the morphological characters of the trophozoite or vegetative stage of the organism formerly separated as *E. tetragena* (figs. 5, 6, 8*a*) must be considered (see p. 38).

FIG. 5.—*Entamœba histolytica* (*tetragena* form), showing three successive changes of form due to movement. × 1100. (After Hartmann.)

The history of the development of these species, which give rise to amœbic enteritis as distinguished from bacillary dysentery, was formerly not so well known as that of *E. coli*. Upon being introduced into cats (*per anum*) dysenteric amœbæ provoke symptoms similar to those in man. In the latter, besides metastatic liver abscesses, abscesses of the lungs, and, according to Kartulis, cerebral abscesses are occasionally produced. Marchoux (1899) states that when the disease has lasted for some time liver abscesses are produced in cats also.

FIG. 6.—*Entamœba histolytica* which has ingested many red blood corpuscles. × 1100. (After Hartmann.)

In the large intestine of infected cats the amœbæ creep over the epithelium, and here and there they force the epithelial cells apart, as well as removing them or pushing them in front of them; the amœbæ thus insert themselves into the narrowest fissures. They penetrate also into the glands through the epithelium, and thence into the connective tissue of the mucosa. Intestinal and glandular epithelia perish under the influence of these parasites: the cells are pushed aside, fall to pieces or are absorbed by the amœbæ. In the connective tissue of the mucosa the amœbæ migrate further, and often accumulate above the muscles. Finally they rupture this and force their way into the submucosa. In cats, apparently, the penetration is not so great as in men, according to Kruse and Pasquale. During their migration the parasites also gain access to the lymph-follicles of the wall of the intestine, which become swollen and commence to suppurate; follicular abscesses arise and after their rupture follicular ulcers. The diseased patches in the mucosa are markedly hyperæmic and numerous hæmorrhages are set up. Roos and Harris state that the amœbæ also penetrate into the blood-vessels (fig. 7) and this explains the occurrence of metastatic abscesses.[1] The whole submucosa is severely swollen at the diseased spot and undergoes small-celled infiltration in the neighbourhood of the colonies of amœbæ. From these findings Jürgens (1902) draws the conclusion[2] which is followed here, that the amœbæ

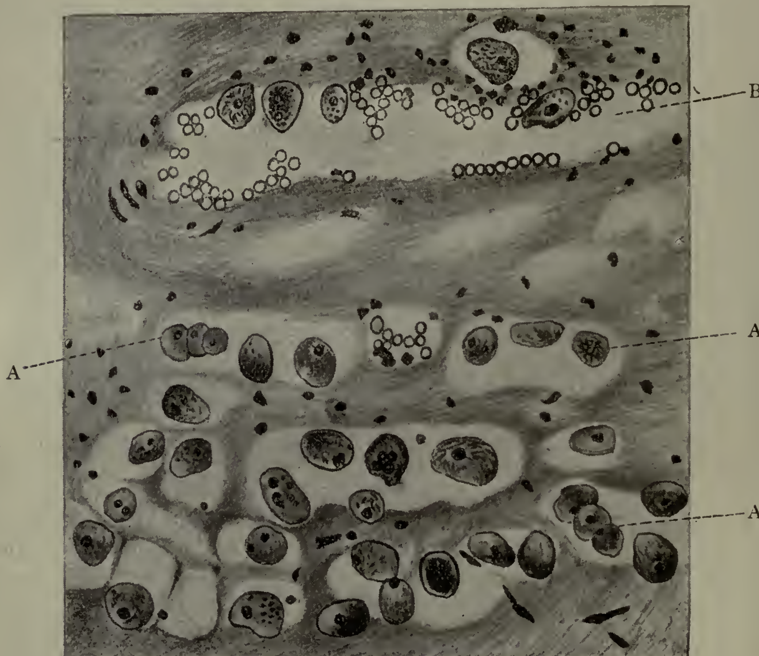


FIG. 7.—Section through wall of large intestine (of a man) close under an ulcer caused by *Entamœba histolytica*. A, amœbæ that have penetrated partly in blood-vessels (Bv), partly in tissue of submucosa to the muscularis. Magnified. (After Harris.)

are causative agents of the enteritis of cats, which disease is well defined, both pathologically and anatomically. Subsequent researches confirm the experience of earlier authors; great precautions were taken to exclude errors, hence, as with Gross and Harris, no exception can be taken to their results. The inoculation material was derived from soldiers who suffered from amœbic enteritis in China and who were admitted into the garrison hospital at Berlin. In order to be

[1] Lung abscesses generally arise by the bursting of a liver abscess through the diaphragm into the right lower lobe of the lung, sometimes also through conveyance of amœbæ by means of the blood-stream (Banting).

[2] These findings were confirmed by Schaudinn by means of investigations on cats and men. *Cf.* also Alfred Gross, Marchoux, P. G. Woolley, W. E. Musgrave, H. F. Harris and others.

independent of the patients themselves, transmission experiments from cat to cat were performed, after the first experiments on cats yielded positive results. This was also effected by rectal feeding as employed by earlier workers. Such appeared necessary in order to prevent the evacuation of the inoculation material *per anum*, as well as to avoid the employment of morphia and ether narcosis. Forty-six cats were used for the experiments. Ten cats received tested stools containing motile amœbæ from soldiers suffering from amœbic enteritis contracted in China. Sixteen other cats received stools from cats infected by inoculation. All the animals sickened and suffered from the disease. Five cats received dejecta from human amœbic enteritis in which, however, no *motile* amœbæ were present. Thirteen cats received stools from soldiers who suffered from bacillary dysentery. None of the latter cats took the complaint and none showed changes in the large intestine upon sectioning. The injection of various bacteria, obtained from a stool of amœbic enteritis pathogenic to cats, remained without result in both the cats employed for this experiment. Lastly, two cats, which had been kept with those artificially infected, were taken ill spontaneously and suffered from the disease. In the opinion of Harris, who ascertained the harmless nature of bacteria derived from the intestinal flora containing dysenteric amœbæ, young dogs are capable of being infected.

Within the large intestine an active increase of *Entamœba histolytica* must occur. Nevertheless, Jürgens did not definitely find changes that might be interpreted in this sense. Schaudinn (1903) observed division and gemmation *in vivo*. Both processes, in which the nucleus divides by amitosis, can only be distinguished by the fact that the daughter individuals are similar in binary fission but dissimilar in gemmation, whether they make their appearance singly or in greater numbers. Schizogony, resulting in the formation of eight individuals, which is so characteristic for *Entamœba coli*, was not observed. (But schizogony, into four merozoites, is now known to occur. Gemmation processes are apparently degenerative.)

Resistant stages, which serve for transmission to other hosts, are according to Schaudinn[1] first formed when the diseased portions commence to heal, or more accurately, the recovery commences when the vegetative increase of the amœbæ in the intestine discontinues. The so-called spores of *E. histolytica* were distinguished very definitely from those of *E. coli;* they were said to consist of spheres of only 3 to 7 μ in diameter, which were surrounded by a double membrane, at first colourless, but becoming a light brownish yellow colour after a few hours, and possessing a protoplasmic content containing chromidia. They were said to arise by fragments of chromatin passing outwards from the nucleus of the amœba into the surrounding cytoplasm (fig. 9, *a*) and undergoing so marked an increase that finally the whole cytoplasm became filled with chromidia. The remainder of the nucleus underwent degeneration and became extruded. On the surface of the cytoplasm there then arose small protuberances containing chromidia. These processes had been observed in the living organisms. They gradually divided and separated from membranes which later became yellow. The remainder of the amœba perished. Craig[2] had also seen phases of this process of development. It must be remarked that, according to recent researches, these processes of exogenous sporulation are degenerative in character (see p. 41). The small spores may be fungi. The "sporulation" processes are only mentioned here as a warning. They are now only of historic interest. By means of an experiment made on a cat, Schaudinn ascertained that ingestion of permanent cysts, which resist desiccation, is the cause of the infection. The animal took food containing dry fæces with amœba cysts ; these fæces came from a patient suffering from amœbic

[1] *Arb. a. d. kaiserl. Gesundheitsamte*, xix, pp. 547-576.

[2] "Life cycle of *Amœba coli* in Human Body," *American Medicine*, 1904, vii, p. 299 ; viii, p. 185.

enteritis in China. On the evening of the third day the cat evacuated blood-stained mucous fæces which contained large numbers of typical *Entamœba histolytica*. On the fourth day after the infection the animal experimented upon died, and the large intestine showed the changes previously stated.

E histolytica also is found in the large intestine. This was originally shown to be the case by Kartulis, and the fact has recently been confirmed from many quarters. It is also present in the metastatic abscesses of which it is the cause (*cf.* among other authors, Rogers, *Brit. Med. Journ.*, 1902, ii, No. 2,177, p. 844; and 1903, i, No. 2,214, p. 1315).

It should lastly be pointed out in this connection that mixed infections also take place. For instance, in addition to *E. histolytica*, *E. coli*, and, under certain circumstances, flagellates may be found together. In the same way *E. coli* may come under observation even in bacillary dysentery. On the other hand, Schaudinn stated that in cases of dysentery endemic in Istria, *Entamœba coli*, if it had hitherto been present, disappeared, to return again after recovery from the illness.

FIG. 8.—*Entamœba histolytica*. *a*, trophozoite (*tetragena* type) containing red blood corpuscles, × 1,300; *b* and *c*, two isolated nuclei showing different appearances of karyosome, centriole and nuclear membrane, × 2,600. (After Hartmann.)

(*Entamœba tetragena*, Viereck, 1907.)

This amœba must now be considered to be a part of the life-cycle of *Entamœba histolytica*, in fact a very important part of that cycle, especially in its tetranucleate cystic stages.

This organism, the so-called *Entamœba tetragena*, may occur in the human intestine in cases of amœbic dysentery, especially in mild or chronic cases. It was discovered by Viereck in 1907 in patients suffering from dysentery contracted in Africa. Soon afterwards an independent description was published by Hartmann, who called the amœba *E. africana*. It was also studied by Bensen and Werner. Recently (1912-13) much work has been published on this amœba by Darling and others; in this way its relationship to Schaudinn's *E. histolytica* has been made known.

In general morphology it somewhat resembles *Entamœba coli*, and its discoverer at first mistook it for a variety of that species. According to Hartmann, a distinct ectoplasm is only clearly visible when a pseudopodium is protruded (fig. 5). The granular endoplasm may contain ingested red blood corpuscles (fig. 6). The large, round nucleus is visible in the fresh state (fig. 8, *a*). So-called chromidial masses (? crystalloidal substances) may occur in the cytoplasm.

Some investigators, as Hartmann,[1] lay stress on the internal structure of the nucleus (fig. 8, *b*, *c*), best seen in preparations fixed wet and stained with iron-hæmatoxylin. The nucleus is limited by a well-marked nuclear membrane, on the inside of which granules or nodules of chromatin may occur. There is a karyosome, which, in successfully stained specimens, shows, at times, a central dot called a centriole. (The nucleus of *Entamœba coli* does not contain such a centriole.) However, the structure of the nucleus varies at different periods during the life-cycle.

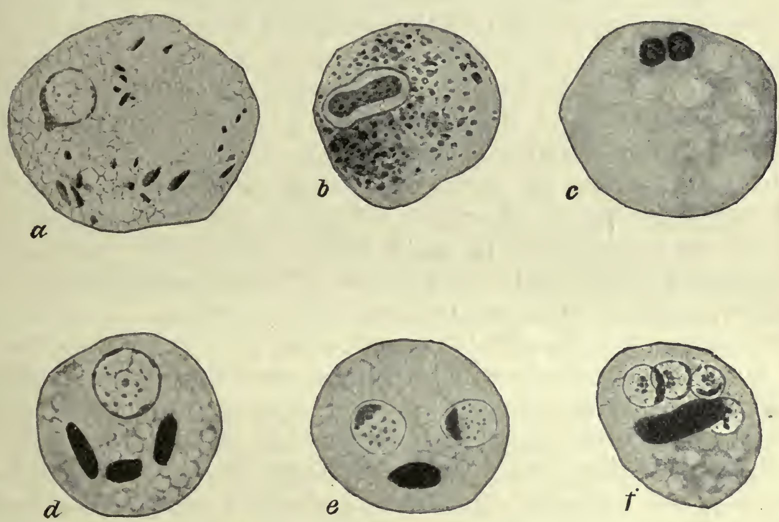


FIG. 9.—*Entamœba histolytica* (*tetragena* form). *a*, emission of chromatin from nucleus; *b*, nuclear division; *c*, degenerating form with two nuclei; *d*, *e*, *f*, cysts containing one, two and four nuclei respectively, and showing chromidial blocks. × 2,000. (After Hartmann.)

The diameter of the trophozoites or vegetative forms (fig. 8, *a*) is variously given as from 20 μ to 40 μ. Multiplication proceeds by binary fission and also by schizogony into four merozoites.[2]

Reproduction takes place by endogenous encystment (fig. 9, *d*-*f*), which is preceded by nuclear division into two, reduction and then autogamy. The interpretation of the latter phenomenon as autogamy

[1] *Arch. f. Protistenkunde* (1911), xxiv, p. 163.

[2] *See* Darling, 1913, *Arch. Intern. Med.*, vol. ii, pl. i, fig. 3.

is disputed by some authors. The round cysts, which may measure 12 μ to 15 μ in diameter, contain four nuclei, together with darkly staining masses of various shapes, the so-called "chromidial blocks" (fig. 9, *f*). The cyst-wall of *E. histolytica* (*tetragena*) is thinner than that of *E. coli*, and the diameter of the cyst is rather less. *E. histolytica* has not yet been cultivated.

Infection in man occurs by way of the mouth by the ingestion of cysts. A patient showing acute symptoms of dysentery is not usually infective, for he is merely harbouring the large trophozoites, which, by experiment, have been shown not to be infective to animals (kittens) when administered by the mouth. The stools of recovered patients may still contain cysts, and they may thus act as cyst-carriers or reservoirs of disease by infecting water and soil. The stools of such cyst-carriers are often solid, and so cysts of *E. histolytica* (*tetragena*) are easily overlooked. Mathis (1913)[1] points out that healthy carriers of *E. histolytica* may be found; 8 per cent. of the natives of Tonkin examined by him were healthy carriers of cysts.

In return cases, or prolonged untreated cases of entamœbic dysentery, a generation of smaller trophozoites is associated with, or replaces the larger ones. In stools they are frequently refractile and consequently stain slowly *intra vitam*. These trophozoites are the "smaller, senile, or pre-cyst generation" of Darling. This pre-cyst generation is characterized by the presence of blocks of crystalloidal substance in the cytoplasm, and by the possession of a prominent, densely stainable karyosome. Darling believes this generation to be the same as that described by Elmassian as *Entamœba minuta*.[2]

Walker,[3] Darling,[4] Wenyon[5] and others believe that *Entamœba histolytica*, which was only seen by Schaudinn in a single case, that of a Chinaman, is really *E. tetragena*. Darling states that if the published illustrations of *E. histolytica* and of *E. tetragena* are collected from the literature and compared, it will be seen that the writers have been calling *E. histolytica* the large trophozoites seen in dysenteric stools. These large trophozoites frequently display no karyosome, but they can be demonstrated as *E. tetragena* by animal inoculation, or by the history of the case. On the other hand, the illustrations of *E. tetragena* show that the authors have been dealing with the small generation or reduced forms ("*E. minuta*"), which are the direct descendants of the large trophozoites. If kittens are inoculated rectally with dysenteric material containing large trophozoites, the strain may be carried in successive kittens for four to six transfers. If, on the other hand,

---

[1] *Bull. Soc. Med. et Chirurg. Indo-Chine*, iv, p. 474.
[2] *Centralbl. f. Bakter.*, Orig., lii, p. 335. [3] *Philip. Journ. Sc.* (1911), B, vi, p. 259.
[4] *Annals Trop. Med. and Parasitol.* (1913), vii, p. 321.
[5] *Brit. Med. Journ.*, Nov. 15, 1913, p. 1287, and *Journ. Lond. School Trop. Med.*, ii, p. 27.

kittens are inoculated rectally with small trophozoites of the pre-cyst generation, the transmission cannot be carried through more than one or two kittens. Wenyon has succeeded in maintaining *E. tetragena* in kittens for several generations.

In some of the preparations from the last remove, pathological forms of the trophozoites may be seen. These show abnormal forms of budding, especially peripherally, such as have been described by Schaudinn and by Craig as characteristic of *E. histolytica*. Schaudinn's small peripheral, exogenous buds and cysts are thus explained. Craig has latterly changed his views.

Further, Darling states that *tetragena* cysts fed by the mouth to kittens produce bowel lesions in which trophozoites having the characters of *E. tetragena*, *E. histolytica* and *E. nipponica* (Koidzumi) occur.

In view of the work of recent observers, the peculiar exogenous encystment which Schaudinn made characteristic of *Entamœba histolytica* has been shown to be due to degenerative changes in senile races of the amœba. *E. histolytica* and *E. tetragena* are one and the same species, and its trophozoite is subject to variation. According to some observers the *histolytica* type of nucleus—described by Schaudinn as being poor in chromatin and not easily seen in the fresh state—occurs frequently in patients with severe symptoms of dysentery; on the other hand, the *tetragena* type of nucleus—round and easily seen in the fresh state—may occur in cases presenting slight dysenteric symptoms. Intermediate types of nuclei are seen. The name of this species, the principal pathogenic amœba of man, must then be *E. histolytica* by priority. The cystic stages of *E. histolytica* are those first recorded by Viereck and formerly described as *E. tetragena*. The geographical distribution of *E. histolytica* is wide.

Noc's Entamœba (1909).

A species of Entamœba was cultivated by Noc[1] in 1909 from cysts derived from liver abscesses, from dysenteric stools and from the water supply of Saigon, Cochin China. He cultivated it in association with bacteria. It is pathogenic. It has been considered allied to *E. histolytica*, and shows internal segmentation or schizogony. It exhibits polymorphism. This amœba has been found by Greig and Wells (1911) in cases of dysentery in India. It is an important organism and requires further investigation.

Certain other Entamœbæ[2] have been described at various times from the intestinal tract of man. Probably most, if not all, of these are not good species and in some cases much more information is needed.

Entamœba tropicalis (Lesage, 1908). This parasite is said to be

[1] Noc, F. (1909), *Ann. Inst. Pasteur*, xxiii, p. 177.

[2] See Fantham, H. B. (1911), *Annals Trop. Med. and Parasitol.*, v, p. 111.

non-pathogenic, and to occur in the intestine of man in the tropics. It has a general resemblance to *E. coli*, but forms small cysts (6 μ to 10 μ in diameter). The nucleus of the cyst is said to break up into a variable number of daughter nuclei, from three to thirteen having been noted. Lesage states that it is culturable in symbiosis with bacteria. It is probably a variety of *E. coli*, if not a cultural amœba.

Entamœba hominis (Walker, 1908) has a diameter of 6 μ to 15 μ. A contractile vacuole is present. Encystment is total, and small cysts are formed. It is culturable. The original strain, now lost, was obtained from an autopsy in Boston Hospital. This organism is probably a cultural amœba.

Entamœba phagocytoides (Gauducheau, 1908). This parasite was discovered in a case of dysentery at Hanoi, Indo-China. The amœba is small, 2 μ to 15 μ in diameter. It is active. It ingests bacteria and red blood corpuscles, while peculiar spirilla-like bodies are found in its cytoplasm. It multiplies by binary and multiple fission. It can be cultivated. More recently (1912) the author appears to consider the amœba to be a stage of a *Trichomonas*, but abandons the view later (1914). Further researches on this organism are needed.

Entamœba minuta (Elmassian, 1909)[1] was found, in association with *E. coli*, in a case of chronic dysentery in Paraguay. It resembles *E. tetragena* but is smaller, rarely exceeding 14 μ in diameter. Schizogony occurs, four merozoites being produced. The encystment is total and endogenous, giving rise to cysts containing four nuclei. This amœba is considered by Darling and others to be the pre-cyst trophozoite stage of *E. histolytica* (*tetragena*).

Entamœba nipponica (Koidzumi, 1909) was found in the motions of Japanese suffering from dysentery or from diarrhœa, in the former case in company with *Entamœba histolytica*. Its diameter is 15 μ to 30 μ. The endoplasm is phagocytic for red blood corpuscles. The nucleus is well defined, resembling that of *E. coli* and of *E. tetragena*. Multiplication occurs by binary fission and by schizogony. Encystment is total, but has not been completely followed. Darling and others consider that this is an abnormal form of *E. histolytica*, while Akashi (1913) doubts if it is an amœba at all, but rather is to be regarded as shed epithelial cells.

General Remark.—It is now considered by some workers that true Entamœbæ cannot be cultivated on artificial media. Quite recently Williams and Calkins (1913)[2] have somewhat doubted this opinion, and state that certain cultural amœbæ, originally obtained from Musgrave in Manila, exhibit the various morphological variations associated with true entamœbæ of the human digestive tract.

---

[1] *Centralbl. f. Bakter.*, Orig., lii, p. 335.

[2] *Journ. of Med. Research*, xxix, p. 43.

Entamœba buccalis, Prowazek, 1904.

The size varies from 6 μ to 32 μ. Ectoplasm is always present; the endoplasm contains numerous food-vacuoles. The nucleus is vesicular, with a greenish tinted membrane which is poor in chromatin. The size of the nucleus is from 1·5 μ to 4·5 μ. A contractile vacuole is not visible. The pseudopodium is broad. It was discovered in the mouths of persons with dental caries at Rovigno and also at Trieste, being most easily found in dense masses of leucocytes, also among leptothrix and spirochæte clusters. It can be easily distinguished from leucocytes by more intense staining with neutral red. Multiplication proceeds by fission. Transmission may take place through the small spherical cysts. This species (fig. 10) has since been observed in Berlin, and is also occasionally found in carcinoma of various regions of the oral cavity. (Leyden and Löwenthal, 1905).

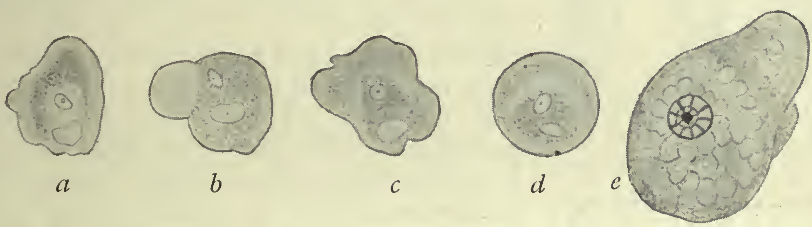


FIG. 10.—*Entamœba buccalis*, Prow. *a-d*, the same specimen observed during five minutes. × 1,000. *e*, amœba fixed and stained with iron-hæmatoxylin. × 1,500. (After Leyden and Löwenthal.)

Entamœba buccalis, Prow., is said to be allied to a protozoön which A. Tietze has found either encysted or free in the lumen of the orifice of the parotid gland of an infant aged 4 months. The gland had undergone pathological change, and had therefore been extirpated. The organisms, which were roundish and three to four times the size of the normal epithelial cells of the gland, were without a membrane and possessed a nucleus in which the chromatic substance appeared to be contained in a karyosome. Bass and John's[1] (Feb. 1915) and Smith, Middleton and Barrett (1914) state that *E. buccalis* is the cause of pyorrhœa alveolaris.

Entamœba undulans, Aldo Castellani, 1905.

Under this name a protozoön is described which A. Castellani found in addition to *Entamœba histolytica* and *Trichomonas intestinalis* in the fæces of an European planter living in Ceylon, who had suffered from amœbic enteritis and liver abscess. The shape of the body was roundish or oval, 25 μ to 30 μ in the greatest diameter. It was without a flagellum, but with an undulating membrane, and capable of protruding a long pseudopodium from different parts of its body at short intervals. The nucleus could not always be recognized in life; it was, however, always demonstrable

[1] *Journ. Amer. Med. Assoc.*, lxiv, p. 553.

by staining. One or two contractile vacuoles were present. The protoplasm was finely granular, showing no differentiation into ecto- and endo-plasm. According to Braun, in spite of the author declaring himself expressly against the flagellate nature of the parasite, such a nature may be assumed to be tolerably certain in view of the description and illustration.

It is now considered that *Entamœba undulans* is a portion of a flagellate, namely, *Trichomonas*.

Entamœba kartulisi, Doflein, 1901.

Doflein gave this name to amœbæ, from 30 μ to 38 μ in diameter, which Kartulis (1893) found on examining the pus of an abscess in the right lower jaw of an Arab, aged 43, and in a portion of bone that had been extracted. The movements of the amœbæ (fig. 11) were more active than those of "dysenteric amœbæ." Their coarsely granular cytoplasm contained blood and pus corpuscles, and a nucleus was generally only recognizable after staining. Vacuoles were not seen with certainty. Flexner reported upon a similar case, and Kartulis published five additional cases. As in these cases dental caries was present the infection is likely to have proceeded from the oral cavity as a result of the carious teeth. Craig[1] (1911) considers that this parasite is probably identical with *Entamœba histolytica*.

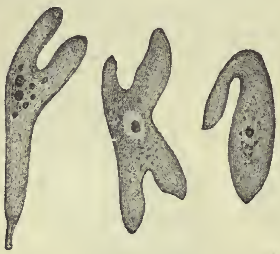


FIG. 11.—*Entamœba kartulisi*, Dofl., from the pus of an abscess in the lower jaw, showing different stages of movement. (After Kartulis.)

In the literature the following species have been reported as occurring in the oral cavity of man :—

Amœba gingivalis, Gros, 1849. [? identical with *Entamœba buccalis.*]
Amœba buccalis, Sternberg, 1862.
Amœba dentalis, Grassi, 1879.

Far too little, however, is known concerning these to regard them as definite species, that is, independent organisms ; Grassi thinks it even possible there may have been a confusion in their case with salivary corpuscles. If they really are amœbæ they are all of them probably identical with *Entamœba buccalis*.

Genus Paramœba, Schaudinn, 1896.

Schaudinn established the genus *Paramœba* for a marine rhizopod which multiplied by division, became encysted at the end of its vegetative life and then segmented into swarm bodies with two flagella. These multiplied by longitudinal fission, and finally passed into the condition of Amœbæ. Whether the human parasite described by C. F. Craig (1906) as

[1] "The Parasitic Amœbæ of Man," Lippincott, Philadelphia.

Paramœba hominis:

belonged to this genus was for a time uncertain. It is now placed in a new genus **Craigia**, Calkins, 1912, since it possesses only one flagellum.[1]

In the amœbic stage it is 15 μ to 25 μ in diameter; ecto- and endo-plasm during rest are indistinguishable. The body substance is granular, with a spherical, sharply contoured nucleus and an accessory nuclear body. No vacuoles are present, but occasionally the endoplasm contains red blood corpuscles. The pseudopodia are hyaline, finger- or lobe-shaped, and are protruded either singly or in twos. Multiplication is by binary fission and by the formation of spherical cysts (15 μ to 20 μ in diameter) in which occurs successive division of the nuclei, ultimately forming ten to twelve roundish bodies each of which soon develops a flagellum. The flagellate stages have similarly a spherical shape and attain a diameter of 10 μ to 15 μ. They also occasionally contain red blood corpuscles and pass either directly or after longitudinal division into the amœboid phase.

Craig found these Amœbæ and the flagellate stage belonging to them in six patients in the military hospital at Manila (Philippine Islands), five of whom were suffering from simple diarrhœa whilst the sixth exhibited an amœbic enteritis and contained also *Paramœba hominis*, with *Entamœba histolytica*, Schaudinn. In one of the other cases, *Trichomonas intestinalis* was present.

B. Amœbæ from other Organs.

Entamœba pulmonalis, Artault, 1898.

Artault[2] discovered a few amœboid forms with nucleus and vacuole in the contents of a lung cavity. In the fresh condition they were distinguishable from leucocytes by their remarkable capacity of light refraction. They were also much slower than the latter in staining with methylene blue or fuchsine. Their movements became more lively in a strong light. Water and other reagents killed them, and then, even when stained, they could not be distinguished from leucocytes. They have also been seen by Brumpt. R. Blanchard found amœbæ which may belong here in the lungs of sheep. *A. pulmonalis* is perhaps the same as *Entamœba buccalis*. Smith and Weidman[3] (1910, 1914) described an entamœba, *E. mortinatalium*, from the lungs and other organs of infants in America.

Amœba urogenitalis, Baelz, 1883.

This species was found in masses in the sanguineous urine as well as in the vagina of a patient in Japan, aged 23. Shortly before the death of the patient, which was caused by pulmonary tuberculosis, hæmaturia with severe tenesmus of the bladder had set in. The amœba, which showed great motility, and had a diameter of about 50 μ when quiescent, exhibited a granular cytoplasm and a vesicular nucleus. Baelz is of opinion that these parasites were introduced into the vulva with the water used for washing the parts, and thence had

[1] See Craig (1913), *Amer. Journ. Trop. Dis. and Prevent. Med.*, i, p. 351.

[2] *Arch. de Parasitologie*, i, p. 275.

[3] *Amer. Journ. Trop. Dis. and Prevent. Med.*, ii, p. 256.

penetrated into the bladder and vagina. Doflein places the organism in the genus *Entamœba*, and it is perhaps identical with *E. histolytica*.

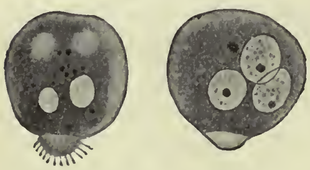
Similar cases are also reported (1892-3) by other authors: Jürgens, Kartulis, Posner, and Wijnhoff. Jürgens found small mucous cysts, filled with amœboid bodies, in the bladder of an old woman suffering from chronic cystitis; they were also found in the vagina. The amœba observed by Kartulis in the sanguineous urine of a woman, aged 58, suffering from a tumour of the bladder, measured 12 μ to 20 μ, and exhibited slow movements by protruding short pseudopodia. The vacuoles and nucleus became visible only after staining with methylene blue.

Posner's case related to a man, aged 37, who had hitherto been quite healthy and had never been out of Berlin. Suddenly, after a rigor, he passed urine tinged with blood. This contained, besides red and white blood corpuscles and hyaline and granular casts, large granular bodies (about 50 μ in length and 28 μ in breath), which slowly altered their shape, and contained red blood corpuscles in addition to other foreign matter. These bodies exhibited one or several nuclei and some vacuoles. From the course of the disease, which extended over a year, and during which similar attacks recurred, Posner came to the conclusion that the amœbæ which had originally invaded the bladder had penetrated into the pelvis of the kidney, where they probably had settled in a cyst, and thence induced the repeated attacks.

Wijnhoff observed four cases of amœburia in Utrecht.

Amœba miurai, Ijima, 1898.

Under this term the author describes protoplasmic bodies which Miura, in Tokyo, found in the serous fluid of a woman, aged 26, who had died from pleuritis and peritonitis endotheliomatosa. Two days before death these same forms had also appeared in the hæmorrhagic fæces of the patient. The bodies were usually spherical or ellipsoidal, and at one pole carried a small protuberance (fig. 12) beset with filamentous short "pseudopodia" (really a pseudopodium covered with cilia). Their size varied between 15 μ and 38 μ. The cytoplasm was finely granular, and no difference was observable in the ecto- and endo-plasm, only the villous appendage was clearer. The cytoplasm contained vacuoles more or less numerous, none of which was contractile. After the addition of acetic acid one to three nuclei could be distinguished, 8 μ to 15 μ in size. Actual movements were not observed. Taking everything into consideration, the independent nature of these bodies is, to say the least, doubtful, although it cannot be denied that they possess a certain similarity to the marine *Amœba fluida*, Grüber or Greeff, and to a few other species. (It is likely that cells present in serous exudation were mistaken for amœbæ.)



a *b*

FIG. 12.—*Amœba miurai*, Ij. × 500. *a*, fresh; *b*, after treatment with dilute acetic acid. (After Ijima.)

APPENDIX.

"*Rhizopods in Poliomyelitis acuta.*"

In three cases of poliomyelitis acuta which were investigated by Ellermann, the spinal fluid obtained by puncture of the cord contained bodies, from 10 μ to 15 μ in size, which had amœboid movements and exhibited variously shaped pseudopodia in large numbers. After staining, a usually excentric nucleus, about 1·5 μ in size, was demonstrated in them.

Order. **Foraminifera**, d'Orbigny.

The order is divided by Max Schultze into Monothalamia and Polythalamia. Only a few of the former can be considered here.

Sub-Order. **Monothalamia.** (Testaceous Amœbæ).

These forms occur frequently in fresh water, rarely in sea water. They possess a shell which is either pseudo-chitinous in character, or consists of foreign particles, or in a few cases is composed of siliceous lamellæ. There is usually an orifice for the protrusion of pseudopodia. The only representative of the order of interest here is :—

Genus. **Chlamydophrys**, Cienkowski, 1876.

The genus is based on a form which A. Schneider carefully investigated and considered to be the *Difflugia enchelys* of Ehrenberg. L. Cienkowski rediscovered this same form and created for it the genus *Chlamydophrys*. We agree with this view, but not with the renaming of the organism (so common at the time). If the parasite in dung, *Chlamydophrys stercorea* Cienk: is identical with *Difflugia enchelys* of Ehrenberg, the old specific name should be retained.

The genus is characterized by the possession of a hyaline, structureless, slightly flexible shell which is ovoid or reniform. At the more pointed pole there is an orifice situated terminally or somewhat laterally, serving for the emergence of the filiform pseudopodia (fig. 13, *a*). The protoplasm does not entirely fill the interior of the shell. An equatorial zone bearing excretory granules divides the shell internally into two almost equal portions. The anterior portion is rich in vacuoles and serves for the reception of nutriment and for digestion. The posterior part is vitreous, and contains the nucleus. One to three contractile vacuoles are situated in the equatorial zone.

Chlamydophrys enchelys, Ehrbg.

Syn.: *Chlamydophrys stercorea*, L. Cienkowski.

This species (fig. 13) is found in the fæces of various animals (cattle, rabbits, mice, and lizards), and also in quite fresh human fæces. According to Schaudinn, the parasite occurs so frequently in the human fæces that it must be considered of wide distribution. The species must traverse the intestine of man and animals during one stage of its life cycle, as Schaudinn showed by experiments on himself and on mice. He infected himself with cysts (fig. 14) by swallowing them, and evacuated the first *Chlamydophrys* as early as the following day. After the evacuation of numerous specimens on one of the following days the infection ceased.

The nucleus of a living specimen is surrounded by a hyaline, strongly refractile chromidial mass, arranged in the form of a ring. Chromatin stains colour it darkly.

Asexual multiplication (fig. 13, *b*), which takes place in fæces, follows a similar course to that of allied forms (*e.g.*, *Euglypha*, *Centropyxis*). It commences by the cytoplasm issuing from the orifice of the shell and assuming the shape characteristic of the mother organism, but in a reverse position. The nucleus then divides by mitosis, when the daughter nuclei move apart from one another. The chromidial ring also divides into two portions by a process of dumb-bell like constriction. The one daughter nucleus remains in the mother organism, the other moves towards the daughter individual, which then separates from the parent.

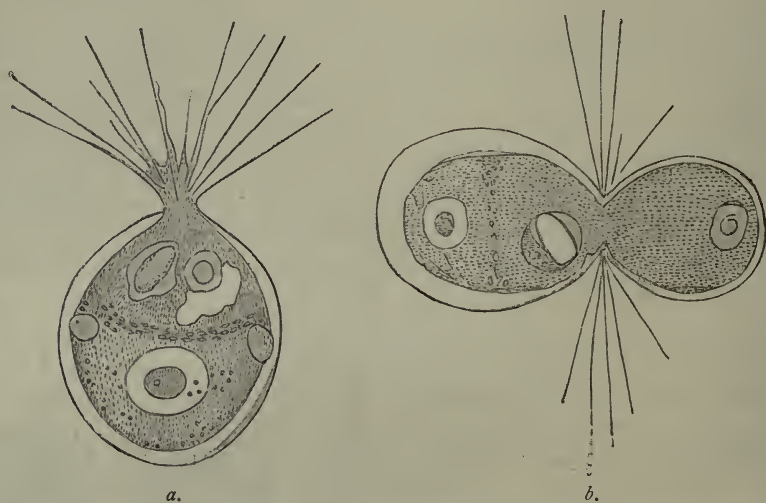


FIG. 13.—*Chlamydophrys enchelys.* *a*, free, motile form, showing nucleus, equatorial granules, vacuoles and pseudopodia ; *b*, dividing organism. × 760. (After Cienkowski.)

In this species plasmogamic union of two or more individuals (up to twenty) is frequently observed. Such colonies may similarly divide, and in this way monstrosities frequently arise. When drying of the fæces, or deficiency of food occurs, encystment takes place apparently spontaneously. The whole body, as stated by Cienkowski, issues from the shell, assumes a spherical shape (probably with discharge of water) and becomes surrounded with a thick membrane (fig. 14). After the addition of water and the escape of the encysted *Chlamydophrys*, a new shell must be formed. Schaudinn, who has not given a more detailed description of the process of encystment in this species, but refers to Cienkowski and to similar observations made on *Centropyxis*, states of the latter that the encystment takes place within the shell.

The *sexual multiplication* is accompanied by shedding of all the foreign bodies and of the degenerating nucleus. The protoplasm, now contracting into a sphere, remains behind in the shell with the chromidial mass. From the latter several new nuclei arise (sexual nuclei) often eight in number. The cytoplasmic sphere then segregates into as many spherical portions as there are nuclei present. When they have assumed an oval form, two flagella develop at one pole and the flagellispores swarm out of the shell.[1] The biflagellate swarm-spores, or gametes, copulate in pairs and apparently the individuals of the pairs of gametes arise from different mother organisms. The zygote secretes a thick covering which soon becomes brown and rough. These zygote cysts or resistant spores must now pass from the intestine of an animal in order to complete their development. The escape of the cyst contents does not always take place in the intestine; often it does not occur until after defæcation. These shell-less individuals (amœbulæ) soon become invested with a shell. But in the alkaline intestinal contents, shell formation may proceed even while the organism is in the intestine, and multiplication may take place.

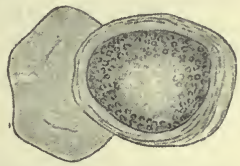


FIG. 14. — *Chlamydophrys enchelys*, encysted; on the left the old capsule. × 760. (After Cienkowski.)

Schaudinn's further communication was of special interest; it was to the effect that *Chlamydophrys* was related to

Leydenia gemmipara, Schaudinn, 1896.

In the fluid removed by puncture from two patients suffering from ascites in the first medical clinic in Berlin, cellular bodies with spontaneous movement were found, which Leyden and Schaudinn regard as distinct organisms. They remained alive without the use of the warm stage for four or five hours, the external temperature being 24° to 25° C. In a quiescent condition they were of a spherical or irregular polygonal form. Their surface was rarely smooth, being beset with protuberances and excrescences (fig. 15). The substance of the body was thickly permeated with light refractile granules with a yellowish shimmer. The hyaline ectoplasm was rarely seen distinctly. All sizes from 3 μ to 36 μ in diameter were observed. The movements were rather sluggish, the ectoplasm in the meantime appearing in the form of one or several lamellæ, in which also strings of the granular endoplasm occurred, and frequently protruded over the border of the hyaline pseudopodia. The tendency for the joining of several individuals by means of their pseudopodia was so marked that associations ensued similar to those known in free-living Rhizopoda.

The cytoplasm enclosed blood corpuscles as well as numerous vacuoles, one of which pulsated slowly about every quarter of an hour. A vesicular nucleus the diameter of which was about equal to one-fifth of the body was present.

[1] Schaudinn (1903), *Arb. a. d. Kaiserl. Gesundh.*, xix, p. 547.

Multiplication took place by means of division and budding (fig. 15, *c*), after previous direct division of the nucleus. The buds were supposed to divide repeatedly soon after their appearance, thus giving rise to minute forms of 3 μ.

There was a suspicion in both cases that the ascites was associated with malignant neoplasms in the abdomen, and autopsy confirmed this view in one case.

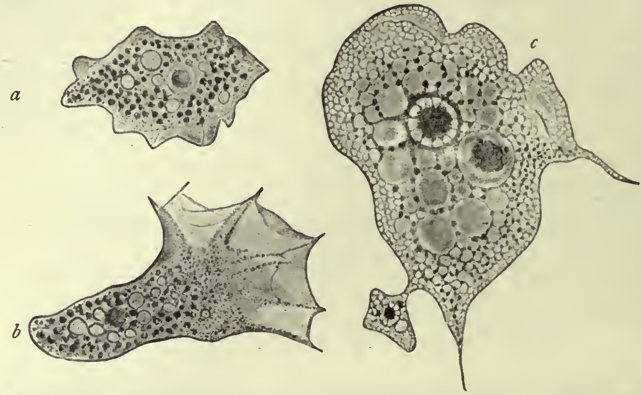


FIG. 15.—*Leydenia gemmipara*, Schaud. *a*, in a quiescent condition, × 1000; *b*, in the act of moving, × 1000; *c*, from a fixed preparation, showing a bud, × 1500.

The parasite, which has seldom been observed, has been variously interpreted; for example, it has been regarded merely as altered tissue cells. It is now known, from Schaudinn's researches, that *Leydenia gemmipara* is connected with abnormal conditions of *Chlamydophrys*, occasionally occurring as a commensal in the ascitic fluid. The form is produced when pathological conditions of the large intestine create an alkaline reaction of its whole contents. The formation of shells then often ceases, and these naked *Chlamydophrys* are enabled to multiply atypically by division and gemmation. Such stages, which are no longer capable of a normal development, are the *Leydenia*, as Schaudinn has demonstrated.

Class II. **MASTIGOPHORA**, Diesing.

Sub-Class. FLAGELLATA, Cohn emend. Bütschli.

During the motile part of their life the Flagellata possess one or more flagella which serve for locomotion, and in many cases also for the capture of food. A few groups (*Euglenoidinæ*, *Choanoflagellata*) have only one flagellum, others two or several of about equal length (*Isomastigoda*), or of various lengths (*Monadina*, *Heteromastigoda*, *Dinoflagellata*). The long flagellum is the principal one; the smaller ones on the same organism are accessory flagella. The flagella directed backwards, which occur in the Heteromastigoda and are used for clinging, are termed trailing flagella or tractella. At the base of the flagellum, which is almost always at the anterior end, a Choanoflagellate possesses a cytoplasmic funnel-shaped neck or collar. In the parasitic forms an undulating membrane is often present.

The body of the Flagellata is usually small, generally elongate and of unchangeable form. It is frequently covered by a distinct cuticle, and, in certain groups, by a hard envelope, or it may be more or less loosely enveloped by a gelatinous or membranous covering. An ectoplasmic layer is thin and not always obvious. The granular cytoplasm contains a varying number of vacuoles, one of which may be contractile, and is generally situated near the area from which the flagella arise, that is, at the anterior extremity. The cytoplasm, moreover, contains the nucleus, which is nearly always single; and in many species there are also yellow, brown, or green chromatophores of various shapes, such as occur in plants. Some species feed after the manner of green plants (holophytic), or of plants devoid of chlorophyll (saprophytic); others, again, ingest solid food, and for this purpose usually possess a cytostome; the latter, however, in a few forms is not used for its original function, but is connected with the contractile vacuole. Many parasitic forms feed by endosmosis. A few species possess eye-spots with or without light-refracting bodies.

Variation in the form of the nuclear apparatus occurs. One nucleus only, which may be compact or vesicular, is known in many species. This nucleus is situated either centrally or sometimes near the flagellar end of the body, but its position is subject to variation. The flagella may arise near the nucleus. Other structures, such as an axial filament and a rhizoplast, may be present. Some flagellates are binucleate, the two nuclei—which often differ in size and shape—being separated from each other. One of these nuclei is the principal, vegetative or trophic nucleus; the other is an accessory nucleus, frequently termed the blepharoplast, flagellar or kinetic nucleus. One or more small basal granules are often present at or very near the origin of the flagella.

Multiplication is by fission, usually longitudinal, which may occur in either the free or encysted forms. Division is initiated by that of the nucleus or nuclei (especially the kinetic nucleus). The basal granule divides also. Collars and chromatophores, if present, likewise separate into two. Variation in the method of doubling the original number of flagella occurs. In most organisms, especially uniflagellate forms, the flagellum splits lengthwise, after division of the basal granule, blepharoplast and nucleus. The daughter flagella may be of the same or different lengths and thicknesses. Other flagellates at division are said to produce new flagella in the neighbourhood of the original ones. The daughter organisms in such cases are provided with one or more parental flagella in addition to newly formed ones. It has been stated that in certain cases the parent flagellate retains all its flagella, while new ones arise *ab initio* in the cytoplasm of the daughter forms.

Multiplication by longitudinal fission may be interrupted sooner or later by the production of gametes, which form zygotes, from which new generations of individuals arise. In many flagellates gamete formation and sporogony are unknown, and asexual reproduction by fission alone prevails.

Incomplete division results in the formation of colonies of individuals. These colonies must not be confused with the aggregation rosettes of flagellates found among the parasitic Mastigophora. The individuals of aggregation rosettes are capable of immediate separation from the rosette at will.

A number of parasitic Flagellata produce non-flagellate stages which are very resistant to external conditions, the assumption of which forms serves to protect the organisms during their transference from one host to another. Such non-flagellate forms possess one or more nuclei, are usually of an oval or rounded contour, and are capable of developing into the full flagellate on the return of more favourable conditions. These forms are often known as the post-flagellate stage of the organism. When ingested by a new host, the post-flagellate coat becomes more flexible, and the phase of the organism which now recommences growth is known as the pre-flagellate stage ; it gradually develops into the typical flagellate organism.

Many Flagellata live free in fresh and salt water. They prefer stagnant water, rich in organic products of decomposition, such as puddles, swamps and pools. Those forms developing shells and colonies are, as a rule, adherent. A number of species are parasitic in man and animals, living mostly within the intestine or in the blood.

It is usual to classify the Flagellata in four orders : *Euflagellata*, *Dinoflagellata*, *Choanoflagellata*, and *Cystoflagellata*, of which only the *Euflagellata* are of interest to us. This is a group comprising numerous species, for the further classification of which the number and position of the flagella are utilised.

The Euflagellata observed in man belong to the Protomonadina as well as to the Polymastigina. The former possess either only one or two similar flagella, or one principal and one or two accessory flagella. The Polymastigina possess at least three flagella of equal size, or four to eight of unequal size, inserted at different points. An undulating membrane may be present in members of both groups.

It must also be pointed out that unicellular organisms with one or several flagella are not always classified with flagellates, for such forms occur in Rhizopods as well as temporarily in the lower plants. In addition, the examination of the flagellates, especially the parasitic species, is very difficult on account of their diminutive size and great activity ; thus it happens that certain forms cannot with certainty be included in the group because their description is insufficient.

Order. **Polymastigina,** Blochmann.

The Polymastigina contains flagellates with three to eight flagella. Some of the Flagellata parasitic in man belong to the Polymastigina, and to two or three genera that are easily distinguishable.

Genus. **Trichomonas,** Donné, 1837.

The body is generally pyriform, the anterior part usually rounded, the posterior part pointed. There are at the anterior extremity three (? four) equally long flagella that are sometimes matted together. A blepharoplast (kinetic nucleus) and basal granule are present, together with a supporting structure known as an axial filament or axostyle. In addition there is an undulating membrane, bordered by a trailing flagellum, that commences at the anterior extremity and proceeds obliquely backwards. The nucleus, which is vesicular, is situated near the anterior extremity, and behind it are one or more vacuoles, none of which seems to be contractile. These flagellates are parasitic in vertebrate animals, and live chiefly in the intestine.

Trichomonas vaginalis, Donné.

The form of the body is very variable, and is elongate, fusiform or pear-shaped, also amœboid. The length varies between 15 μ and 25 μ, and the breadth between 7 μ and 12 μ. The posterior extremity is drawn out to a point and is about half the length of the remainder of the body. The cuticle is very thin and the body substance finely granular. At the anterior extremity there are three—some say four[1]—flagella of equal length which are frequently united together, at least at the base, and are easily detached.

There is an undulating membrane (fig. 16) which runs spirally across the body, arising from the place of insertion of the flagella, and terminating at the base of the caudal process. A cytostome seldom is recognizable in fresh specimens, but is apparently present. The nucleus is vesicular, elliptical and situated near the anterior extremity.[2]

Multiplication takes place by division (Marchand). Encysted forms are almost unknown.

FIG. 16.—*Trichomonas vaginalis*, Donné. × 2,000 approx. (After Künstler.) Four flagella are represented, but usually only three are present.

Trichomonas vaginalis lives in the vaginal mucus of women of various ages, not in normal mucus, but in mucus of acid reaction. It is found in menstruating females as well as in females who have passed the menopause. It occurs in pregnant and non-pregnant women, even in very young girls, provided always that they have a vaginal catarrh with acid reaction of the secretion. Should the acid reaction change, as, for instance, during menstruation, the parasites disappear, as they do likewise on injection of any alkaline fluid into the vagina. A low temperature (below + 15° C.) is also fatal to the parasites. These flagellates can pass from the vagina through the urethra into the bladder, and produce severe catarrh, and are not easily removed.

T. vaginalis appeared to be a parasite specific to the female organs and not transmissible to man. However, several observations have since been made that confirm the occurrence of this species in the urethra of the male. The infection apparently takes place through coitus when changes are present in the urethral mucous membrane. At any rate, three cases observed point to this circumstance.

Attempts at experimental transmission to rabbits, guinea-pigs and dogs failed (Blochmann, Dock). So far, the manner in which women become infected is unknown.

---

[1] To explain this discrepancy it is stated that the border of the undulating membrane can be detached in the form of an independent flagellum. But Parisi (1910) places such quadriflagellate forms in the sub-genus *Tetratrichomonas*, *Arch. f. Protistenk.*, xix, p. 232.

[2] According to Marchand, the nucleus is connected with a line, which becomes visible on addition of acetic acid, terminates at the posterior extremity, and does not correspond to the line of insertion of the undulating membrane. This formation probably is the same as the axostyle in *Trichomonas batrachorum*, Perty. Blochmann (1884) also mentions two longitudinal rows of granules, which commence at the same place as the nucleus and converge posteriorly.

Trichomonas intestinalis, R. Leuckart, 1879 = Trichomonas hominis, Davaine, 1854.

Some authors believe that a second trichomonad inhabiting man, *Trichomonas intestinalis*, R. Lkt., is identical with *Trichomonas vaginalis*, Donné. Leuckart's species was based on the discoveries of Marchand (1875) and Zunker (1878), who stated that according to all appearances, and in their opinion, it was the same as *Cercomonas intestinalis*, Lambl, 1875 (*nec* 1859), which they found in the fæces of patients suffering from intestinal disorders. The organism is described by them as being pear-shaped and 10 μ to 15 μ in length and 3 μ to 4 μ in breadth. The posterior extremity terminated in a point (fig. 17).

FIG. 17.—*Trichomonas intestinalis*, Lkt. (After Grassi.)

A row of twelve or more cilia was said to commence at the anterior end and extend over the body. Leuckart stated that this parasite, placed by the two authors in the genus *Cercomonas*, was a *Trichomonas*, and that they mistook the undulating membrane for cilia, and overlooked the flagella. Notwithstanding its striking similarity with *T. vaginalis*, it was said to be distinguishable from that species by differences in the undulating membrane. Lambl's *C. intestinalis*[1] (of 1875) which corresponds with *C. hominis*, Davaine[2] (1854), is regarded by Leuckart as a true Cercomonad (characterized by a flagellum and the absence of an undulating membrane, see p. 61), and is thus generically distinct from *Trichomonas*.

The correctness of Leuckart's judgment in regard to Marchand-Zunker's flagellate was demonstrated by Grassi's researches, accounts of which were published soon after. In about 100 cases of bowel complaints in North Italy and Sicily, Grassi found Flagellata in the stools, which he first named *Monocercomonas* and *Cimænomonas*, but later termed *Trichomonas*. However, in opposition to Leuckart, Grassi has also classified Davaine's *C. hominis* (= *C. intestinalis*, Lambl, 1875) as *Trichomonas*, and most authors have followed his example. Hence arose the use of the name *Trichomonas hominis*. It was through Janowski (1896) that the former view was again taken up. After a review of the literature, the occurrence of Cercomonads in the intestine of human beings in addition to Trichomonads was considered by the author to have been proved, and he added a description of the Trichomonads. According to this, all morphological distinction

---

[1] Under the term *Cercomonas intestinalis*, Lambl in different years has described two entirely distinct Flagellata, namely, in 1859 ("Mikr. Unters. d. Darm- Excrete," *Prag. Vierteljahrsschr. f. prakt. Hlkde.*, lxi, p. 51; and Lambl, *A. d. Franz-Josephs-Kinderspitale in Prag*, Prag, 1860, i, p. 360), a form that at the present day is termed *Lamblia intestinalis;* and in 1875 (in the *Russian Medical Report*, No. 33), a species identical with *Cercomonas hominis*, Dav.

[2] Davaine, C., "Sur les anim. infus. trouv. dans les selles d. malad. atteints du cholera et d'autr. malad.," *C. R. Soc. Biol.*, 1854, ii, p. 129.

between *T. vaginalis*, Donné, and *T. intestinalis*, Leuckart, disappeared. On the other hand, it is worthy of note that the smaller size, the more pear-shaped form, and the longer flagella differentiate *T. intestinalis* (= *T. hominis*) from *T. vaginalis*.[1]

The easily deformed pear-shaped body has three free flagella anteriorly, and an undulating membrane with its flagellar border terminating in a short free flagellum posteriorly (figs. 17, 18). The undulating membrane may coil itself spirally round the body. A supporting rod or axostyle projects as a posterior spine. It appears to begin near the nucleus and blepharoplast, which are situated near the more rounded, anterior end of the body. There may be a chromatoid basal supporting line along the body for the undulating membrane. Rows of chromatoid granules are sometimes situated along one side of the axostyle. A cytostome may sometimes be seen. In mice, Wenyon (1907) found these parasites to vary in length from 3 μ to 20 μ. They occur in the cæcum and intestine of mice, where their internal structure seems more obvious than in man. The flagellates divide by longitudinal fission.

FIG. 18.—*Trichomonas intestinalis* from man, showing anterior flagella, cytostomic depression anteriorly, undulating membrane, nuclei, and axostyle. ×2,500. Original.

T. intestinalis, R. Leuckart, appears to be capable of settling in all parts of the human intestine in which the contents have an alkaline reaction. Trichomonads have been cited as occurring in the oral cavity by Steinberg, Zunker, Rappin and Prowazek; in the œsophagus by Cohnheim, and in the stomach by Strube, Cohnheim, Zabel, Hensen and Rosenfeld. The normal situation seems to be the small intestine. The parasites then appear in the dejecta, especially in various intestinal diseases the course of which is connected with an increased peristalsis. They are also found in healthy persons, from whom they are obtained after the administration of laxatives. They have been regarded by some workers as commensals, which, however, have the power of accelerating

[1] For the present the following should be regarded as synonymous: *Protoryxomyces coprinarius*, Cunningham (*Quart. Journ. Micr. Sci.* [2] 1880, xxi, p. 234), (*Zeitschr. f. Biol.*, 1882, viii, p. 251). *Monocercomonas hominis*, Grassi, 1882. *Cimænomonas hominis*, Grassi, 1882. *Trichomonas hominis*, Grassi, 1888. *Cercomonas coli hominis*, May (*Deutsches Archiv. f. klin. med.*, 1891, xlix, p. 51). *Monocercomonas hominis*, Epstein (*Prag. med. Wochenschr.* 1893, Nos. 38-40). *Trichomonas confusa*, Stiles (*Zool. Anz.*, 1902, xxv, p. 689). *Trichomonas elongata*, *Trichomonas elliptica*, Cohnheim (*Deutsche med. Wochenschr.*, 1903 xxix, Nos. 12-14). *Trichomonas elongata*, *Trichomonas caudata*, *Trichomonas flagellata*, Steinberg (*Kiewer Zeitschr. f. neuere Medicin*, 1862). *Trichomonas pulmonalis*, A. Schmidt, (*Münch. med. Wochenschr.*, 1895, No. 51), and St. Artault (*Arch. de parasit.* 1898, i, p. 279).

the onset of intestinal complaints, or at least of adding to them. They have been found in cases of carcinoma of the stomach, and in other diseases of that organ in which the acid reaction ceased.

Naturally, whether all the reports relate to the same species of Trichomonas must remain undecided. Certain authors (Steinberg, Cohnheim, van Emden) accept several species. Prowazek speaks of a variety of *T. intestinalis* inhabiting the oral cavity. This was distinguished by a posterior process exceeding the length of the body fourfold, and by a somewhat unusual course of the undulating membrane. The food of this form, which was found in the whitish deposit present, especially in the cavities of carious teeth, consisted almost exclusively of micrococci. Schmidt and St. Artault named the Trichomonads found in pathological products (*e.g.*, gangrene, putrid bronchitis, phthisis) of the lungs of man, as *Trichomonas pulmonalis*. Trichomonads have also been found by Wieting in lobular pneumonia in the lungs of pigs.

It is still uncertain in what way the infection takes place. Experiments in the transmission of free trichomonads to mammals (*per os*), in which the same or allied species occur (guinea-pigs, rats, apes), have been without result. Probably encystment is necessary. Such conditions are mentioned by May, Künstler, Roos, Schurmayer, van Emden, Prowazek, Galli-Valerio and Schaudinn. According to Prowazek, intestinal trichomonads of rats become encysted for conjugation. In the cyst an accumulation of reserve food material occurs, causing distension. The nuclei of the conjugants each give off a reduction body and, after fusion, produce the nuclei for the daughter individuals. According to Schaudinn the intestinal trichomonads lose their flagella before conjugation, become amœboid and encyst in twos, the formation of a large agglomeration of reserve substance accompanying this. Galli-Valerio found double-contoured cysts in the fæces of trichomonad-infected guinea-pigs, after the fæces had been kept for a month in a damp chamber. When exposed to heat small flagellates escaped from them. Administration of such material containing cysts resulted in severe infection with trichomonads, and death of the experimental guinea-pigs followed. The cyst wall is clearly a protection against the deleterious acid reaction of the stomach contents. Alexeieff (1911) and Brumpt (1912) think that the trichomonad cysts of man are really fungi, while other workers also doubt encystment among trichomonads. Wenyon (1907) states that *T. intestinalis* in mice produces spherical contracted forms which escape from the body in the fæces.

Air, water, and under certain circumstances even food may be regarded as vectors for the trichomonads. The occurrence of the organisms in the oral cavity, and still more so in the lungs, is in favour of the air being the transmitting agent. An observation made by Epstein supports the idea of water transmission. Multiplication of the trichomonads, once they have gained access to the body, is effected by longitudinal division commencing at the anterior end (Künstler). "Cercomonads" with several flagella and an undulating membrane, as well as trichomonads, have been observed by Ross in some cases of cutaneous ulcers.

Mello-Leitao (1913)[1] has described flagellate dysentery in children in Rio de Janeiro. He states that it is due to *T. intestinalis* and *Lamblia intestinalis* either separately or together. Flagellate dysentery, he thinks, is benign and is the most frequent form of dysentery in infants. The flagellates are pathogenic to infants under three years of age. Escomel (1913)[2] found 152 cases of dysentery in Peru due solely to Trichomonas. Such cases are probably widespread

[1] *Brit. Journ. Children's Diseases*, x, p. 60. [2] *Bull. Soc. Path. Exot.*, vi, p. 120.

Genus. **Tetramitus**, Perty, 1852.

Tetramitus mesnili, Wenyon, 1910.

Syn.: *Macrostoma mesnili*, *Chilomastix mesnili*, *Fanapapea intestinalis*.

The genus *Tetramitus* differs from *Trichomonas* in possessing an undulating membrane inserted in a deep groove or cytostome. There are three anterior flagella. The pear-shaped organism measures 14 μ by 7 μ, but smaller examples occur. *T. mesnili* occurs in the human intestine, having been described by Wenyon[1] (1910) from a man from the Bahamas in the Seamen's Hospital, London. Its occurrence is widespread. Alexeieff considers that *Macrostoma* and *Tetramitus* are synonymous. The parasite is the same as *Fanapapea intestinalis*, Prowazek, 1911, from Samoa. Brumpt (1912) found *T. mesnili* to be the causal agent of colitis in a Frenchwoman. Nattan-Larrier (1912) considers it of little pathological importance.

Gäbel[2] (1914) described an interesting case of seasonal diarrhœa acquired in Tunis, in which a new Tetramitid was the causal agent. The organism was pear-shaped, without an undulating membrane, and measured 6·5 μ to 8 μ by 5 μ to 6 μ. The cytostome was large, and there was no skeletal support. Encystment occurred. Gäbel named the organism *Difämus tunensis* and considered that it was pathogenic.

Genus. **Lamblia**, R. Blanchard, 1888.

Syn., *Dimorphus*, Grassi, 1879, *nec* Haller, 1878; *Megastoma*, Grassi, 1881, *nec* de Blainville.

The body is pear-shaped, with a hollow on the under surface anteriorly. It has four pairs of flagella directed backwards, of which three pairs lie on the borders of the hollow disc, and the fourth arises from the pointed posterior extremity.

Lamblia intestinalis, Lambl, 1859.

Syn.: *Cercomonas intestinalis*, Lambl, 1859 (*nec* 1875); *Hexamitus duodenalis*, Davaine, 1875; *Dimorphus muris*, Grassi, 1879; *Megastoma entericum*, Grassi, 1881; *Megastoma intestinale*, R. Blanch., 1886; *Lamblia duodenalis*, Stiles, 1902.

The organism is pear-shaped and bilaterally symmetrical. It is from 10 μ to 21 μ long and 5 μ to 12 μ broad and possesses a thin cuticle. Anteriorly an oblique depression is present, which functions as a sucking disc (fig. 19, *s*). Its edges are raised above the general surface and are contractile. It corresponds to a peristome and acts as an adhesive organ (fig. 20, *b*, *c*). No true cytostome is present. A double longitudinal ridge, representing axostyles, extends from the sucking disc to the tapering posterior extremity, which is prolonged as two flagella from 9 μ to 14 μ long.

Lamblia intestinalis possesses eight flagella (fig. 19). The first pair

[1] *Parasitology*, iii, p. 210. [2] *Arch. f. Protistenk.*, xxxiv, p. 1.

of flagella, which cross one another, arise in a groove formed by the anterior edge of the sucking disc. Two pairs of flagella (lateral and median) are inserted on the posterior edge of the disc, while the posterior flagella occur at the tapering posterior extremity of the body. Basal granules are found at the bases of the flagella. The median flagella are most active in movement, the anterior and lateral flagella being less motile, as they are partially united to the body for part of their length.

The nuclear apparatus is situated in the thin, anterior, hollowed part of the body. It is at first dumb-bell shaped, the "handle" of the dumb-bell being formed by a very slight connecting strand, which eventually separates, so that the flagellate becomes binucleate, and thus completes the general bisymmetry of the organism.

There is a karyosome in each nucleus. Other bodies of unknown function, and possibly composed of chromatin, occur on or near the axostyles.

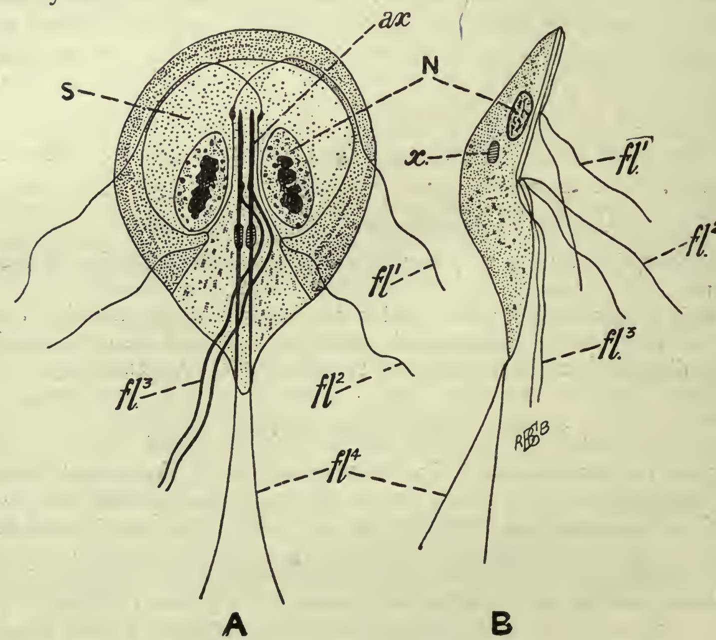


FIG. 19. —*Lamblia intestinalis.* A, ventral view; B, side view; N, one of the two nuclei; *ax.*, axostyles; *fl*1, *fl*2, *fl*3, *fl*4, the four pairs of flagella; *s*, sucker-like depressed area on the ventral surface; *x*, bodies of unknown function. (After Wenyon.)

Division has not been observed in the flagellate stages of the Lamblia, but it occurs within the cysts. The resistant cysts (fig. 20, *e*) are oval and are surrounded by a fairly thick, hyaline cyst wall. They measure 10 μ to 15 μ by 7 μ to 9 μ, and may be tetranucleate. According to Schaudinn, the cysts arise from the conjugation of two individuals, and nuclear rearrangement occurs.

L. intestinalis occurs in its flagellate stage in the duodenum and jejunum, and rarely as such in the other parts of the intestine. Normally it is found in the large intestine as cysts, which are voided with the fæces. The hosts of Lamblia include *Mus musculus, M. rattus, M. decumanus, M. silvestris, Arvicola arvensis* and *A. amphibius* the dog and cat, rabbit, sheep and man. Cysts voided with the fæces of infected animals reach plants or drinking water, and thence are transferred to man.

The flagellate in these different hosts exhibits some variation in size and in the problematic chromatic bodies. Bensen has suggested the species *L. intestinalis* from man, *L. muris* from the mouse and *L. cuniculi* from the rabbit. It is not certain whether these different species are necessary, as the variation may be due to differences of environment.

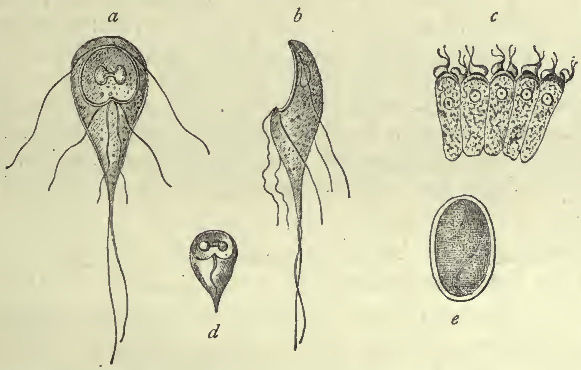


FIG. 20.—*Lamblia intestinalis*. *a*, from the surface; *b*, from the side; *c*, on intestinal epithelium cells; *d*, dead and *e*, encysted. (After Grassi and Schewiakoff.)

Like Trichomonas, Lamblia can multiply under inflammatory conditions of the alimentary tract. Thus they are found in cases of diarrhœa, carcinoma of the stomach, etc. The parasites attach themselves by their sucking discs to the epithelial cells of the gut (fig. 20, *c*), and though their numbers may be very great, their direct pathological significance is not fully known. Their occurrence in cases of diarrhœa has been explained as being due to the increased peristalsis, which has detached the parasites from the epithelium. Free flagellate forms perish in stools if kept, more especially if the temperature falls below 0° C. or rises above 40° C. Lamblia has often been found in dysenteric diseases, especially in the East, and is said to be the causal agent of certain diarrhœas in India. Mathis (1914)[1] found Lamblia in cases of diarrhœa with dysenteriform stools in Tonkin. He also discovered healthy carriers of Lamblia cysts.

[1] *Bull. Soc. Med. Chirurg. Indo-Chine*, v, p. 55.

The parasite under discussion was first observed by Lambl (1859) in the mucous evacuations of children. He regarded the parasite as a Cercomonad and termed it *Cercomonas intestinalis*, which name as a rule is applied to *Cercomonas hominis*, Davaine, although Stein had already pointed out the difference between the two species. Grassi (1879) observed this species first in mice (calling it *Dimorphus muris*), and subsequently in human beings in Upper Italy and named it *Megastoma entericum*. Bütschli and Blanchard then laid stress on the identity of this species with Lambl's *C. intestinalis* (1859), and consequently called it *Megastoma intestinale*. Later, Blanchard drew attention to the circumstance that the generic name *Megastoma* chosen by Grassi had already been used four times for various kinds of animals, and established the genus *Lamblia*. Accordingly, *L. intestinalis* is the valid name, and should be generally adopted.

In Upper Italy the parasite in the encysted condition has also been seen by Perroncito in man. At the same time, Grassi and Schewiakoff began a new investigation of specimens from mice and rats. In Germany, *L. intestinalis* was found by Moritz and Hölzl, Roos, Schuberg and Salomon. Moritz and Hölzl confirmed the relative frequency of the species. In Königsberg, Prussia, a student found encysted *Lamblia* in his fæces. One case was reported from Finland by Sievers, another case from Scandinavia by Müller. Frshezjesski and Ucke reported cases from Russia. Jaksch announced the occurrence of the parasite in Austria; Piccardi mentioned their presence again in Italy. They were reported from Egypt by Kruse and Pasquale, and from North America (Baltimore) by Stiles. Noc stated that 50 per cent. of the population of Tonkin harboured *Lamblia*. Finally, the structure of *L. intestinalis* has been described by Metzner (1901), and by Wenyon[1] (1907) in mice.

In all these cases *L. intestinalis* has been observed in the small intestine, or in the evacuations of patients with intestinal diseases. It has also been found in the intestine of healthy subjects. Just as *Trichomonas intestinalis* may be found inhabiting the stomach in diseases of that organ, in which an alkaline reaction is present (carcinoma), so has *L. intestinalis* been found to occur under similar circumstances (Cohnheim, Zabel). However, in Schmidt's case, 1 per cent. hydrochloric acid was certainly stated to be present. Infection takes place by the ingestion of cysts (fig. 20, *e*), as was established by Grassi, experimentally on himself. Cereal food-stuffs, contaminated with Lamblia cysts from vermin of the locality, such as rats and mice, serve to convey the infection to man. Such cysts may probably be found in street-dust, etc. Stiles induced infection in guinea-pigs, and Perroncito in mice and rabbits, by means of cysts of Lamblia from human beings. Stiles suspected that flies could transport Lamblia cysts. Mathis (1914) found that *L. intestinalis* was not amenable to emetine, at any rate in its cystic stage.

Order. **Protomonadina,** Blochmann.

The smallness of the Protomonadines and their less superficial situation than the Polymastigines, may be the cause that so far as the species occurring in man are concerned, they were formerly less well known. As regards parasitic species, this group may be divided

[1] *Arch. f. Protistenkunde*, Suppl. i, p. 169.

as follows, according to the number of flagella and the presence or absence of an undulating membrane :—

(1) *Cercomonadidæ*, with one flagellum at the anterior extremity, without an undulating membrane.

(2) *Bodonidæ*, with two flagella, without an undulating membrane, except in *Trypanoplasma*.

(3) *Trypanosomidæ*, with one flagellum, and an undulating membrane along the length of the body in some genera.

Family. **Cercomonadidæ**, Kent emend. Bütschli.

Small uniflagellate forms, without cytostome.

Genus. **Cercomonas**, Dujardin emend. Bütschli.

Oval or rounded organisms, with the aflagellar end often drawn out into a tail-like process.

Cercomonas hominis, Davaine, 1854.

Davaine found flagellates in the dejecta of cholera patients. They had pear-shaped bodies, lengthening to a point posteriorly. Their length was from 10 μ to 12 μ, and a flagellum about twice as long as the body projected from one extremity (fig. 21). A nucleus was hardly recognizable. Occasionally a somewhat long structure (cytostome ?) appeared at the anterior extremity. The animals moved with remarkable activity. They also attached themselves by means of their posterior extremities and swung about around the point of attachment. Davaine found a smaller variety, only about 8 μ long, in the dejecta of a typhoid patient (fig. 21, *b*).

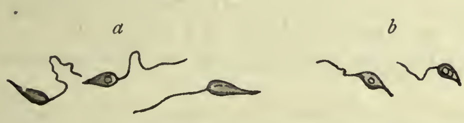


FIG. 21.—*Cercomonas hominis*, Dav. *a*, larger, *b*, smaller variety. Enlarged. (After Davaine.)

FIG. 22.—*Cercomonas hominis*, Dav. From an Echinococcus cyst. (After Lambl.)

The Flagellata observed by Ekeckrantz (1869) in the intestine of man belong to this form—at least to the larger variety—and Tham (1870) reported fresh cases soon after. Lambl's publication of 1875, which was written in Russian, and became known through Leuckart's work on parasites, also alludes to apparently typical Cercomonads, which, however, were discovered, not in the intestine, but in an *Echinococcus* cyst in the liver (fig. 22). The elliptical, fusiform, rarely pear-shaped or cylindrical bodies of the parasites measured 5 μ to 14 μ in length, and were provided with a flagellum at one end, while the other extremity usually terminated in a long point. An oral aperture occurred at the base of the flagellum, and there were one or two vacuoles near the posterior extremity. Longitudinal division was also observed (fig. 22).

As already mentioned, this form, which Lambl termed *Cercomonas intestinalis*, differs considerably from the form found by the same author in 1859, which received the same designation (*cf. Lamblia intestinalis*, p. 60), but it corresponds with *Cercomonas hominis*, Davaine. The latter, as well as *C. intestinalis*, Lambl, 1875, is usually classed with the Trichomonads, but, as has already been remarked (*cf. Trichomonas intestinalis*, p. 54), this cannot be considered correct, as only *one* flagellum is present.

Cercomonas vaginalis (Castellani and Chalmers, 1909) was found in the vagina of native women in Ceylon.

Other species of *Cercomonas* have, at various times, been recorded from man. However, the parasitic species of the genus *Cercomonas* require further investigation.

According to Janowski (1896-7), typical Cercomonads have also been observed in the intestine of man by Escherich, also by Cahen, Massiutin, Fenoglio, Councilman and Lafleur, Dock, Kruse and Pasquale, Zunker, Quincke and Roos, and others. However, it is an open question whether the Flagellata observed by Roos in one of his cases belonged to Davaine's species, the size showing some deviation (14 μ to 16 μ). In his, as in many other cases, doubts have been raised as to whether the flagellates found in the stools had actually lived in the intestine, or had subsequently appeared in the fæces: for this a surprisingly short time only is necessary. Salomon also appears to have observed Cercomonads (*Berl. klin. Wochenschr.*, 1899, No. 46).

As with *T. intestinalis* so with *C. hominis*, it appears that the parasite settles not only in the intestine but also in the air-passages. This is demonstrated by the statements of Kannenberg and Streng of the occurrence of Monads and Cercomonads in the sputum and putrid expectoration in gangrene of the lungs, which no doubt apply to *C. hominis* (*cf.* also Artault). Possibly also the Flagellata observed in the pleural exudation by Litten and Roos may be included here; this is the more probable in Roos's case as the process ensued in the pleura after the breaking through of a vomica.

Perroncito and Piccardi have described encysted stages of Cercomonads.

FIG. 23. — *Monas pyophila*, R. Blanch. (After Grimm.)

Monas pyophila, R. Blanch., 1895.

R. Blanchard thus designates a Flagellate that Grimm found in the sputum, as well as in the pus of a pulmonary and hepatic abscess, in the case of a Japanese woman living in Sapporo. The parasites resemble large spermatozoa (fig. 23). The body, 30 μ to 60 μ, has the shape of a heart or a myrtle leaf, and is surrounded by a thick cuticle which is supposed to extend into the interior of the body, dividing it into three parts. A long appendix at the rounded pole is covered for the greater part of its length by the cuticle; the extremity, however, is free and resembles a flagellum. The parasites were very active, frequently changed their shape, and were able to retract the long appendix within the body, which then assumed a round form.

[This organism requires further investigation.]

Family. **Bodonidæ**, Bütschli.

Protomonadina which are either free-living or parasitic, with two dissimilar flagella, while the possession of an undulating membrane and of a kinetic nucleus or blepharoplast is variable.

There are three genera :—

1. *Bodo*, Stein, 1878, without a kinetic nucleus and undulating membrane.
2. *Prowazekia*, Hartmann and Chagas, 1910, with a kinetic nucleus and without an undulating membrane.
3. *Trypanoplasma*, Laveran and Mesnil, 1901, with a kinetic nucleus and undulating membrane.

Of these genera *Prowazekia* must be discussed. *Bodo* does not occur in man. Species of *Trypanoplasma* occur in the blood and in the gut of various fishes, in the seminal receptacle of certain snails, in the gut and genitalia of a flatworm (*Dendrocœlum lacteum*) and in the vagina of a leech. Closely allied to *Trypanoplasma* is the genus *Trypanophis*, parasitic in the cœlenteric cavity of Siphonophores.

Genus. **Prowazekia**, Hartmann and Chagas, 1910.

The genus was founded for a flagellate parasite, *Prowazekia cruzi*, discovered in a culture of human fæces in Brazil. Various other species have been referred thereto. The genus is separated from *Bodo* by the possession of a second nucleus, the so-called kinetonucleus or blepharoplast. It differs from *Trypanoplasma* in the absence of an undulating membrane. It is heteromastigote, that is, it possesses two dissimilar flagella, one anteriorly directed and the other lateral and trailing.

The principal species are :

Prowazekia urinaria, Hassall, 1859.

Syn. : *Bodo urinarius*, Hassall, 1859; *Trichomonas irregularis*, Salisbury, 1868; *Cystomonas urinaria*, Blanchard, 1885 ; *Plagiomonas urinaria*, Braun, 1895.

Hassall[1] in 1859 first found Bodo-like flagellates in human urine. He examined fifty samples of urine from patients suffering from albuminuria and from cholera. The reaction of the urine was alkaline or sometimes only feebly acid. The flagellates were only seen after the urine had been standing for several days. Hassall named the organism *Bodo urinarius*, and gave a very good description of it with illustrations. The flagellate, which was round or oval, measured 14 μ by 8 μ. The organism had " one, usually two, and sometimes three

[1] *Lancet*, 1859, ii, p. 503.

lashes or cilia." In 1868 Salisbury described a similar flagellate in the urine under the name *Trichomonas irregularis*. Künstler in 1883 described the latter parasite under the name *B. urinarius*. In 1885 Blanchard, considering Künstler's organism a different parasite from Hassall's, called it *Cystomonas urinaria*. Braun, in 1895, gave the name *Plagiomonas urinaria*. Barrois (1894) considered Künstler's and Hassall's organisms to be identical and not to be true parasites of man. Sinton,[1] in 1912, found the flagellate in the deposit, after centrifuging, of a 24-hour old specimen of alkaline urine from a Mexican sailor in the Royal Southern Hospital, Liverpool. Sinton found a kinetic nucleus or blepharoplast in the organism, and therefore placed it in the genus *Prowazekia*.

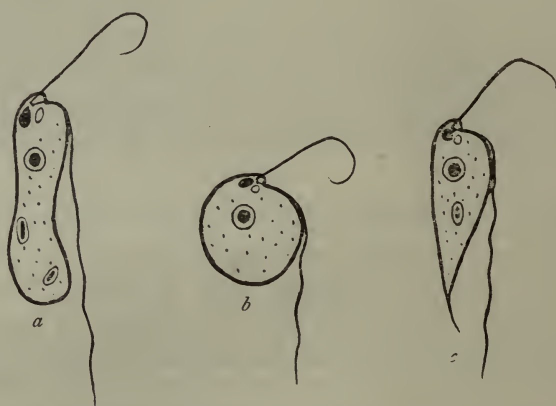


FIG. 24.—Types of *Prowazekia urinaria*. (*a*) sausage-shaped; (*b*) round; (*c*) carrot-shaped form. (After Sinton.)

The flagellate stage (fig. 24) of the organism is polymorphic, and may be either (*a*) sausage-shaped, 10 μ to 25 μ in length by 2·5 μ to 6 μ in breadth; (*b*) round or oval, varying from 4 μ in diameter to oval forms 15 μ by 10 μ; (*c*) a carrot-shaped form, of varying size up to 25 μ by 4 μ. The kinetic nucleus is large and pear-shaped. Near it are basal granules, closely applied to one another, from which the flagella arise. There is a small cytostome near the roots of the flagella. There is a well-marked karyosome in the nucleus. The movement is jerky. The shorter, anterior flagellum may be used in food-capture. In life, bacteria have been seen to be ingested. Food-vacuoles tend to accumulate at the posterior (aflagellar) end. A contractile vacuole may be present, near the base of the cytostome, and may really be the dilated fundus of the latter. Division occurs by

[1] *Annals Trop. Med. and Parasitology*, vi, p. 245.

binary fission. The organism can encyst (fig. 25, *a*), when the flagella are lost, and round or oval cysts are found, 5 μ to 7 μ in diameter. After a time flagella are formed inside the cyst, and the organism emerges therefrom in its typical flagellate form (fig. 25, *b*—*f*).

Sinton's case is interesting. He obtained the flagellate only twice from the same patient, a Mexican then in hospital in Liverpool. The flagellate was not found in the patient's fæces, nor was it found in the urine on later occasions when taken aseptically.

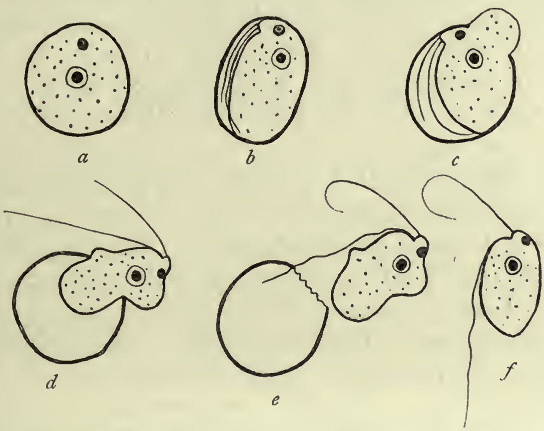


FIG. 25.—*Prowazekia urinaria.* Flagellate emerging from cyst. (After Sinton.)

In cultures *Prowazekia urinaria* was always found in association with bacteria. The cultures died at a temperature of 37° C., but grew well at 20° C. Various media were useful at the lower temperature, such as urine, salt agar, nutrient agar, serum agar, blood agar, peptone salt solution, and diluted blood serum. The flagellate was, then, considered to be an accidental contamination and not a true parasite of human urine.

Prowazekia asiatica, Castellani and Chalmers, 1910.

The flagellate was found by the discoverers in the stools of patients suffering from ankylostomiasis and diarrhœa in Ceylon. It was referred by them to the genus *Bodo*, but in 1911 Whitmore[1] further studied it and placed it in the genus *Prowazekia.* In the stools the flagellate is found either as a long, slender form measuring 10 μ to 16 μ by 5 μ to 8μ or as a rounded form 8 μ to 10 μ in diameter. Its cytoplasm is alveolar. A rhizoplast connects the basal granules to the kinetic

[1] *Arch. f. Protistenk.* xxii, p. 370.

nucleus. There is multiplication and cyst formation as before. The organism is easily cultivated, especially in the condensation water of nutrose agar and maltose agar. The pathogenicity is stated to be nil.

Prowazekia javanensis, Flu, 1912.

Found in agar cultures from the motions of patients at Weltevreden, Dutch East Indies.[1] The flagellates are 12 μ long and 5 μ broad. The lateral flagellum is stated to be attached to the cell body for a short distance. Regarding the karyosome in the nucleus, the author states that the smaller the karyosome the more chromatin is deposited on the nuclear membrane. Flu mentions that the specific name *javanensis* is a temporary one, as in the course of time it may be shown that there is only one species of *Prowazekia*.

Prowazekia cruzi, Hartmann and Chagas, 1910.

Found in a culture from human fæces on an agar plate in Brazil, and considered to be a free-living form.[2] The organism is oval or pear-shaped, 8 μ to 12 μ long and 5 μ to 6 μ broad. In human stools at Tsingtau, China, a *Prowazekia* has been found by Martini which he thinks is the same as *Prowazekia cruzi*. He considers it to be a cause of human diarrhœa and intestinal catarrh.

Prowazekia weinbergi, Mathis and Léger, 1910.

This species was found in the fæces of men, both healthy and diarrhœic, in Tonkin.[3] It is pear-shaped, 8μ to 15 μ long by 4 μ to 6·5 μ broad. The flagella occur at the broad end.

The discoverers think that *Prowazekia weinbergi* is an intestinal inhabitant, but non-pathogenic, since it was found to occur in the fæces even when obtained with aseptic precautions.

Prowazekia parva, Nägler, 1910.

A free-living form found in the slime on the stones at the biological station at Lunz. Another *Prowazekia* was found in 1914 in tap-water in Calcutta.

Family. Trypanosomidæ, Doflein.

The Trypanosomidæ, broadly considered, are uniflagellate organisms, the flagellum being at the anterior end. The flagellum arises near the blepharoplast (kinetic nucleus), which lies anterior, near or posterior to the nucleus.

---

[1] *Geneesk. Tijdschr. v. Nederl. Ind.*, lii, p. 659; *Med. v. d. Burg. Geneesk. d. Nederl. Ind.*, iii, p. 1.

[2] *Mem. Inst. Osw. Cruz.*, ii, p. 64.

[3] *Bull. Soc. Med. Chir. Indo-Chine*, i, p. 471.

The following genera will be considered :—

Trypanosoma—with an undulating membrane along the length of the body.

Crithidia—with a less well-developed undulating membrane anteriorly (see fig. 49).

Herpetomonas—including the so-called *Leptomonas*, with anterior free flagellum only, and no undulating membrane.

Leishmania—non-flagellate forms in mammalian blood, flagellate herpetomonad stages in culture, probably occurring naturally in Arthropods.

Genus. **Trypanosoma**, Gruby, 1843.

The members of the genus possess a single flagellum, which arises posteriorly, adjacent to a blepharoplast or kinetic nucleus. The flagellum forms a margin to an undulating membrane, and may or may not be continued beyond the body as a free flagellum. Many species are parasitic in vertebrate blood and in the digestive tracts of insects.

Historical.

The history of blood flagellates goes back to the year 1841, in which Valentin discovered in the blood of a brook-trout (*Salmo fario* L.) minute bodies, from 7 μ to 13 μ in length, with active movements and presenting marked changes in form. Valentin considered the parasite a new species of the old genus *Proteus* or *Amœba*, Ehrbg. This announcement led Gluge (1842) to publish a similar discovery he had made in frog's blood. The latter forms were called by Mayer (1843) *Amœba rotatoria*, *Paramœcium loricatum* and *P. costatum*, while Gruby (1843) called them *Trypanosoma sanguinis*.[1] Later it was discovered that similar organisms occurred also in the blood of birds (Wedl (1850), Danilewsky) and of mammals. Gros (1845) found them in the mouse and mole, Chaussat (1850) in the house rat, Lewis (1879) in the Indian rat, Wittich (1881) in the hamster. Danilewsky (1886-89) and Chalachnikow (1888) investigated the structure and division of trypanosomes.

In the case of all these forms, there was no discussion as to a pathogenic influence on the host. Opinion, however, as to the action of trypanosomes changed when, in 1880, Evans found flagellates in the blood of horses in India that suffered from a disease endemic there called "surra," and associated the parasites with the disease. Steel and Evans were successful in transmitting the parasites—first known as *Spirochœta evansi*, Steel, then as *Trichomonas evansi*, Crookshank, and finally as *Trypanosoma evansi*—to dogs, mules and horses. They recognized that the above mentioned flagellates in the blood of the experimental animals were the causal agents of the disease.

From that time there was a considerable increase in the literature, the contents of which have been summarized by Laveran and Blanchard. In 1894 Rouget discovered trypanosomes in the blood of African horses that suffer

---

[1] Gruby's generic name is generally accepted. Still others have been used, *e.g.*, *Undulina*, Ray Lankester, *Globularia* Wedl, *Paramecioides* Grassi, *Trypanomonas* Danilewsky, *Hæmatomonas* Mitrophanow.

from "stallion's disease" (dourine). In 1894 Bruce found similar forms (*T. brucei*) in the blood of South African mammals suffering from "nagana," and in consequence attention was drawn to the part which the much dreaded tsetse-fly played in the transmission of "nagana." In 1901 Elmassian discovered trypanosomes in the blood of horses that were stricken with "mal de caderas," which is very common in the Argentine. The disease in cattle named "galziekte" (gall-sickness), occurring in the Transvaal, was also at one time attributed to a trypanosome remarkable for its great size, and like some other species, bearing the name of its discoverer (*T. theileri*).

The study of the species hitherto known has been carried on partly by the above mentioned authors and in part by others, *e.g.*, Rabinowitsch and Kempner, Laveran and Mesnil, Wasiliewski, Senn. It was greatly advanced by the method of double staining (with alkaline methylene blue and eosin) introduced by Romanowsky (1891) and elaborated by Ziemann, Leishman, Giemsa and others. By this means the presence of a terminal flagellum and of an undulating membrane at the side of the flattened and extended body was demonstrated. Laveran and Mesnil (1901) discovered allied flagellates in the blood of the fish, *Scardinius erythrophthalmus*. These flagellates, now placed in the genus *Trypanoplasma*, had a second free flagellum in addition to the one bordering the undulating membrane. Trypanoplasms have since been found in both freshwater and marine fishes. The transmission of trypanoplasms of freshwater fishes is effected by leeches. *Trypanoplasma varium* from *Cobitis* is transmitted by *Hemiclepsis marginata* according to Léger, while the Trypanoplasmata of *Cyprinus carpio* and *Abramis brama* reach new hosts by the agency of *Piscicola* according to Keysselitz.

Another ally of the Trypanosomidæ, *Trypanophis*, lives in the cœlenteric cavity of Siphonophores. It has also an extra terminal flagellum (Poche, Keysselitz). [*Trypanoplasma* and *Trypanophis* belong to the *Bodonidæ*, see p. 63].

Finally it was shown that Trypanosomes occurred in human beings. Although Nepveu's early report of trypanosomes in the blood of malarial patients may be doubtful, subsequent researches by Forde and Dutton demonstrated trypanosomes (fig. 28) in the blood of a European, apparently suffering from malaria, living in the Gambia. Dutton (1902) called the human trypanosome, *T. gambiense*. The expedition despatched by the Liverpool School of Tropical Medicine (1902) to Senegambia found trypanosome infections in six cases among a thousand inhabitants examined.

About the same time attention was devoted to the disease of West African negroes known for a century as "sleeping sickness." Castellani (1903) was the first to succeed in demonstrating the presence of trypanosomes (at first called *T. ugandense*) in centrifugalized cerebro-spinal fluid obtained by puncture from cases of sleeping sickness in Uganda. Similar discoveries were made by Bruce, who also found trypanosomes in the blood of those attacked with sleeping sickness. Sambon regarded a species of *Glossina* as the transmitter. From consideration of the geographical distribution of the disease Christy regarded *Glossina palpalis* as the transmitter. Brumpt first thought it was *G. morsitans*, but, later, supported the view of *G. palpalis*. Bruce, Nabarro and Greig also named the same insect as the transmitter, not only for geographical reasons but also because healthy apes became infected by the bite of certain *G. palpalis*. The inoculation of cerebro-spinal fluid from subjects of sleeping sickness into the spinal canal of apes (*Macacus*) had the same result.

Just as the discovery of the malarial parasites called forth a whole flood of research memoirs which were followed by a second series on the relation of the mosquitoes to malaria, so a similar outpouring occurred after the discovery of the pathogenic trypanosomes of mammals and men. In both cases the inquiry was not limited to the stages in man and other vertebrate hosts, but the fate of the parasites in the intermediate (invertebrate) hosts was investigated, and allied species were obtained from many different hosts.

Novy and MacNeal (1903) were the first to cultivate trypanosomes in artificial media (blood-agar).

In 1910 Stephens and Fantham recorded the presence of another human trypanosome, *T. rhodesiense*, from a case of sleeping sickness in Rhodesia, where *G. palpalis* was absent. Kinghorn has since demonstrated that *T. rhodesiense* is transmitted by *G. morsitans*. Kinghorn and Yorke believe that big game (*e.g.*, antelope) is the reservoir of *T. rhodesiense.*

The output of literature on trypanosomiasis in men and animals is enormous. To cope with it the *Sleeping Sickness Bureau Bulletin* was founded in 1908, and it is now (since November 1912) continued as a section of the *Tropical Diseases Bulletin*, wherein current literature is reviewed.

General.

Trypanosomes occur in the blood of representatives of all the vertebrate classes. Often the trypanosomes occur so scantily in the blood that they are overlooked on examination. A useful aid in detecting the flagellates in such cases consists in the use of cultures of the blood of the host on artificial media. Stimulated by the medium multiplication occurs, and hence the parasites are more easily detected. [For the composition of such culture media see Appendix.]

There is a periodicity in the appearance of the trypanosomes in the peripheral blood of the host, due to alternating phases of multiplication and of rest on the part of the parasites. Such periodicity has been established both by biological and enumerative methods. Again, a seasonal variation has been observed in the occurrence of certain trypanosomes in the peripheral circulation of the hosts; for example, some trypanosomes (*e.g.*, *T. noctuæ* in birds) are found only in the summer in the blood, while in the winter they occur in the internal organs.

Recent cultural researches have established that trypanosomes, *e.g.*, *T. americanum*, may be present in very small numbers in hosts, such as cattle, which are quite unharmed by them, and in which the presence of these flagellates formerly was never suspected ("cryptic trypanosomiasis.") However, the majority of the trypanosomes occurring in domestic animals are usually deleterious or even lethal to their hosts. Many wild animals, such as various species of antelope, harbour trypanosomes without being injured thereby. In such cases it is probable that the vertebrate hosts have been so long parasitized in the past, that they have become tolerant and immune to the effects of the flagellates. Should such trypanosomes of wild animals be transmitted to domesticated stock or man, they may re-acquire their initial virulence and become pathogenic to the new host. As a general statement, the newer a parasite is to its host the greater is its virulence.

For example, *T. gambiense, T. rhodesiense* and *T. brucei* are innocuous to big game in Africa, but are pathogenic to man and domestic animals respectively. Pathogenic trypanosomes appear to have a wider range of hosts, that is, to be less limited to one specific host than non-pathogenic forms. Thus, *T. rhodesiense* is pathogenic to man and all laboratory animals, while it is non-pathogenic to antelopes and their kind.

Morphology.

The general structure of the various trypanosomes shows much uniformity, though variations in size and shape occur. Typically the body is elongate and sinuous. The flagellar end tapers gradually to a point, the aflagellar extremity usually being rounded or more blunt. In some trypanosomes there is much diversity in size, the organisms varying from long, slender forms to short, stumpy ones; in other

FIG. 26.—*Trypanosoma brucei* in division. *n*, nucleus; *bl*, blepharoplast; *fl*, flagellum. × 2,000. (After Laveran and Mesnil.)

species relative constancy of size is maintained. The former are known as polymorphic trypanosomes, the latter as monomorphic forms.

Two nuclei are present. The main or principal nucleus, sometimes termed the trophic nucleus, is often situated towards the centre of the body; it is frequently of the vesicular type, containing a karyosome. The blepharoplast or kinetic nucleus is posterior to the nucleus, and usually is rod-like. The flagellum arises close to the blepharoplast, and forms an edge to the undulating membrane. It may or may not extend beyond the limits of the undulating membrane. If it does so, the unattached part is known as the free flagellum. Sometimes a small granule is found at the origin of the flagellum. This is the basal granule, and is considered by some to function as the centriole of the kinetic nucleus.

The undulating membrane is a lateral extension of the ectoplasm or periplast, and is the main agent in locomotion. It is edged by the flagellum, which forms a deeply stainable border to it. Within the membrane substance, often arranged parallel with its edge, are a number of fine contractile elements, the myonemes. These contractile elements may also occur on the body of the trypanosome. They are easily seen in some large trypanosomes, but are difficult of demonstration in others, owing to their great fineness.

Multiplication of trypanosomes in the blood is brought about by binary longitudinal fission (fig. 26). Division is initiated by that of the blepharoplast and nucleus. The division may be equal or subequal, whereby differences in size of individuals partly arise. Multiple

FIG. 27.—*Trypanosoma lewisi.* Multiplication rosettes. × 1,000. (After Laveran and Mesnil.)

division by repeated binary fission, without complete separation of the daughter forms, is known in some trypanosomes (*e.g., T. lewisi*), and rosettes of parasites thereby are produced (fig. 27).

The classification of trypanosomes is very difficult. Laveran (1911)[1] has suggested the examination of the relative length of the flagellum as a diagnostic character, and so arranged these flagellates in mammals in three groups. The first group included those trypanosomes always having part of the flagellum free (*e.g., T. evansi, T. vivax*); the second group comprised forms without a part of

[1] *Ann. Inst. Pasteur*, xxv, p. 497.

the flagellum free (*e.g.*, *T. congolense*), while the third group included forms some members of which have free flagella, while others have not (*e.g.*, *T. gambiense*). Bruce[1] (1914) and Yorke and Blacklock[2] (1914) have also devised classifications.

Resting stages of some trypanosomes have been found in the internal organs of their vertebrate hosts. The formation of these oval, Leishmania-like bodies will be noted in individual cases later. Similar small oval bodies form an important phase in the life-history of *T. cruzi*, which multiplies normally by multiple fission or schizogony into these oval, daughter elements, and not by binary longitudinal fission in the circulating blood.

Polymorphism in trypanosomes (*e.g.*, *T. gambiense*, *T. rhodesiense*) is now interpreted as a phenomenon resulting from growth and division.[3] Long, thin forms are those about to divide. Fully mature forms are shorter and broader. Various intermediate types occur and represent growth forms. Formerly, polymorphism was interpreted in terms of sex, thin forms being regarded as males, broad forms as females, while the intermediate types were termed indifferent. Conjugation was not observed, and there is no evidence in support of the sexual interpretation.

The transmission of trypanosomes from one vertebrate host to another is usually accomplished by the intermediation of some biting arthropod in the case of terrestrial animals, while leeches are usually considered to act as transmitters in the case of the trypanosomes occurring in aquatic animals. Developmental phases of the life-histories of trypanosomes occur in the invertebrate transmitters, and will be considered in individual cases.

Trypanosoma gambiense, Dutton, 1902.

Syn.: *Trypanosoma hominis*, Manson, 1903. *Trypanosoma nepveui*, Sambon, 1903. *Trypanosoma castellanii*, Kruse, 1903. *Trypanosoma ugandense*, Castellani, 1903. *Trypanosoma fordii*, Maxwell Adams.

In vertebrate blood *Trypanosoma gambiense* is polymorphic, for long, thin forms may be seen in contrast with short, stumpy forms, as well as intermediate forms (fig. 29, *a*—*c*). This polymorphism has been interpreted in terms of sex, especially by German investigators, following Schaudinn (see above). However, there is no evidence of conjugation, and the polymorphic forms are more easily interpreted in terms of growth and division, for the long thin forms are potential dividing organisms, and the stumpy or short parasites, with little or no free flagellum, are the adult individuals.

---

[1] *Trans. Soc. Trop. Med. & Hyg.*, viii, p. 1.

[2] *Annals Trop. Med. and Parasitol.*, viii, p. 1.

[3] Robertson (1912), *Proc. Roy. Soc.*, B, lxxxv, p. 527.

Morphology of T. gambiense in the Circulating Blood.

T. gambiense varies from 13 μ to 36 μ in length, its average length being 24·8 μ, as was determined in 1913 by exact biometrical methods by Stephens and Fantham.[1] Three forms of parasite occur. According to Miss Robertson,[2] the relatively short forms from 13 μ to 21 μ long may be regarded as the mature or "adult" type of parasite in the blood. They carry on the cycle in the vertebrate. From them intermediate forms, which are longer than the "adult" but at first have the same breadth, arise by growth. They possess a free flagellum. The intermediate forms grow into long individuals, which are those about to divide. The products of division give rise, directly or indirectly, to the adult forms.

FIG. 28.—*Trypanosoma gambiense.* × 1,700. (After Dutton.)

The organism has an elongate body with an anterior or flagellar end and a blunter posterior or non-flagellar end. The protoplasm

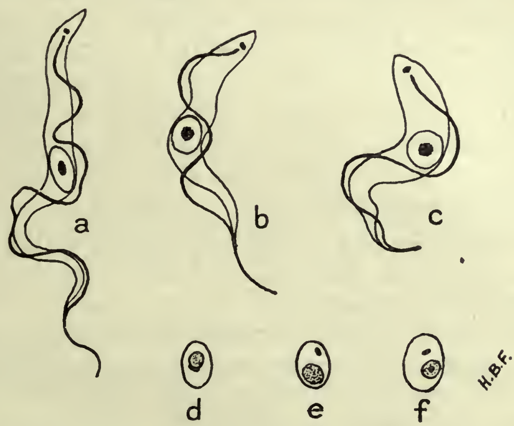


FIG. 29.—*Trypanosoma gambiense.* Development in vertebrate host. *a*, long, slender, *b*, intermediate and *c*, short, stumpy forms, found in the blood; *d*, *e*, *f*, non-flagellate, latent forms from internal organs. × 2,000. (Original. From preparations by Fantham.)

is finely granular, large inclusions being rare. The central nucleus is oval and large, often containing most of its chromatin concentrated as a karyosome, with small granules only scattered near or on the fine nuclear membrane. The blepharoplast is either rounded or rod-

[1] *Annals Trop. Med. and Parasitol.*, vii, p. 27. [2] *Phil. Trans.*, B (1913), cciii, pp. 161-184.

shaped. The undulating membrane is thrown into folds and is bordered by the flagellum. A small basal granule may be present near, or at the actual origin of the flagellum.

Multiplication in the vertebrate is brought about by longitudinal division. According to the recent account of division by Miss Robertson, the blepharoplast doubles, then the flagellum splits for the greater part of its length, and the daughter flagella separate, one being shorter than the parent flagellum. The nucleus often shows two well marked dark granules on the membrane at opposite poles, and these appear to act as centrosomes. Nuclear constriction occurs and the halves gradually separate. Finally the two daughter organisms become free, the aflagellar end splitting last. The products of division may be equal or unequal. Repeated division goes on in the general circulation until the blood swarms with parasites. Then the trypanosomes gradually disappear, and a period occurs when it is practically impossible to demonstrate the parasite in the blood. At such a period, trypanosomes can be obtained by puncture of the enlarged lymphatic glands or of the spinal canal, or can be found in the internal organs, more particularly in the spleen, lungs, liver and bone-marrow. In the latter organs, latent bodies are produced (fig. 29, *d—f*) which are capable of again becoming flagellates and entering the general circulation. Their formation was described by Fantham (1911).[1] The parasite contracts, the blepharoplast migrates towards the nucleus, a very thin coat differentiates around the two nuclei and a certain amount of cytoplasm, and the parts exterior to the coat disintegrate, leaving a small, oval body behind. Fuller details are given in connection with *T. rhodesiense*. Laveran (1911)[2] considers that latent bodies are "involution" forms, but acknowledges that they can flagellate and become infective in fresh blood.

No multiplication of the trypanosomes within the cells of the lung, liver or spleen of infected monkeys was found by Miss Robertson in her recent researches.

There appear to be negative periods in infected monkeys, since, although trypanosomes may occur in their blood at such times, they are not infective to *Glossina*.

Development in Glossina palpalis.—The principal accounts are those by Sir D. Bruce and his colleagues (1911),[3] and by Miss Robertson[4] (1912), whose results will be followed. According to the latter investigator *T. gambiense* never enters the body cells of the fly (*G. palpalis*), nor does it penetrate the gut wall into the body cavity. Practically no crithidial stage occurs in the fly's main gut, but a trypanosome facies is retained therein.

After the trypanosomes are ingested by the fly during a meal of

[1] *Proc. Roy. Soc.*, B, lxxxiii, p. 212.
[2] *C. R. Acad. Sci.*, 153, p. 649.
[3] *Proc. Roy. Soc.*, B, lxxxiii, p. 513.
[4] *Proc. Roy. Soc.*, B, lxxxvi, p. 66.

infected blood, sooner or later multiplication occurs. This development usually begins in the middle or posterior part of the mid gut, and trypanosomes of varying sizes are produced. After the tenth or twelfth day, many long, slender trypanosomes (fig. 30, *a*) are found, which gradually move forwards into the proventriculus. Such long, slender forms represent the limit of development in the lumen of the main gut. The proventricular type, developed about the eighth to the eighteenth or twentieth day, is not infective; it may occur in the crop, but is not to be found permanently there. Between the tenth and the fifteenth days multinucleate forms of trypanosomes are found, and may be styled multiple forms (fig. 30, *b*). Some of these latter may be degenerative.

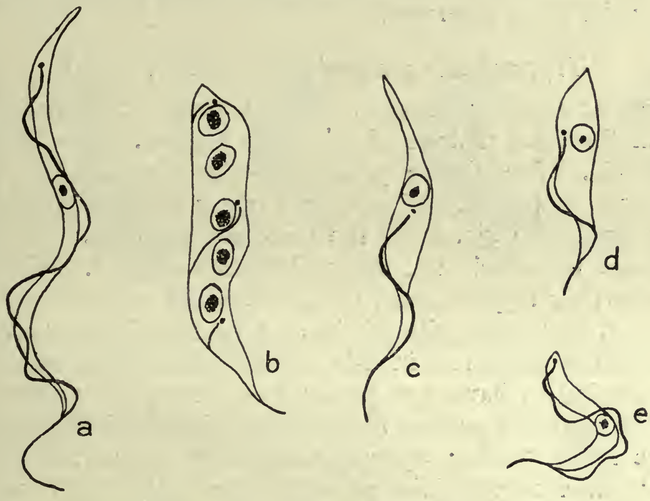


FIG. 30.—*Trypanosoma gambiense.* Development in the fly, *Glossina palpalis.* *a*, slender, proventricular form; *b*, multinucleate form; *c*, *d*, crithidial forms; *e*, infective type of trypanosome found in salivary gland. × 2,500. (After Robertson.)

Invasion of the Salivary Glands of the Fly.—Long, slender trypanosomes from the proventriculus pass forward into the hypopharynx. They then pass back along the salivary ducts, about sixteen to thirty days after the fly's feed. The trypanosomes reach the salivary glands as long, slender forms. In the glands they become shorter and broader, attach themselves to the surrounding structures, and assume the crithidial facies (fig. 30, *c*, *d*). As crithidial forms they remain attached to the wall and multiply in the glands. These crithidial stages differentiate into the short, broad trypanosome forms, capable of swimming freely (fig. 30, *e*).

Miss Robertson considers the development in the main gut to be indifferent multiplication, and that salivary fluid seems necessary to stimulate trypanosomes to the apparently essential reversion to the crithidial type. The second development in the salivary gland is the essential feature. The short, stumpy forms of trypanosomes (fig. 30, *e*) finally produced in the salivary glands are alone infective. No conjugation of trypanosomes occurs in the fly. Only about 5 per cent. of captive tsetse flies fed on trypanosome-infected blood become infective, but they probably remain infective for the rest of their lives.

J. G. Thomson and Sinton (1912)[1] have obtained in cultures the various trypanosome forms of *T. gambiense* seen in the fly's main gut.

Duke (1912)[2] found *T. gambiense* in a species of antelope, the situtunga (*Tragelaphus spekei*), on Damba Island in Victoria Nyanza. Wild *G. palpalis* could be infected therefrom. The antelope may then act as a sleeping sickness reservoir in that district, but men are apparently the chief reservoir.

Trypanosoma nigeriense, Macfie, 1913.[3]

Macfie has recently (August, 1913) described a human trypanosome from the Eket district of Southern Nigeria. It is common in young people. The disease produced does not seem to be of a virulent type in Nigeria, and does not occur in epidemic form. In the early stages the glands of the neck are enlarged. In the later stages—cases of which are rarer—lethargy appears. The parasite is a polymorphic trypanosome, morphologically almost indistinguishable from *T. gambiense*, though it may be slightly shorter. Macfie recorded the occurrence in his preparations of a few trypanosomes appearing to have a flagellum free during their whole length. Some of the parasites, as seen in a sub-inoculated guinea-pig, are very small (8 μ long). Other trypanosomes have their nuclei displaced somewhat anteriorly. This parasite may only be a variety of *T. gambiense*. The parasite is perhaps spread by *Glossina tachinoides*.

Trypanosoma rhodesiense, Stephens and Fantham, 1910.

The parasite was found in the blood of a young Englishman who had contracted sleeping sickness in the Luangwa Valley, North-eastern Rhodesia, in the autumn of 1909. The patient had never been in an area infested with *Glossina palpalis*.

(1) *Morphology*.—The morphology of the parasite in man and sub-inoculated rats was studied by Stephens and Fantham in 1910.[4] They pointed out a morphological peculiarity in the presence of certain trypanosomes with posterior nuclei in sub-inoculated animals, that is, parasites in which the nucleus (trophonucleus) was situated towards the posterior or aflagellar end, close up to or even beyond the

---

[1] *Annals Trop. Med. and Parasitol.*, vi, p. 331. [2] *Proc. Roy. Soc.*, B, lxxxv, pp. 156, 483.
[3] *Annals Trop. Med. and Parasitol.*, vii, p. 339; viii, p. 379.
[4] *Proc. Roy. Soc.*, B, lxxxiii, p. 28.

blepharoplast or kinetic nucleus (fig. 31, *4*, *5*). When the nucleus was beside the blepharoplast, the former was seen to be kidney-shaped (fig. 31, *4*). The posterior nuclear forms were of the stout and stumpy variety, and about 6 per cent. of the stumpy forms were found to have their nuclei displaced from the centre. The anterior or flagellar end of these trypanosomes often contained chromatoid granules. *T. rhodesiense* varies in length from 12 μ to 39 μ[1]; short stumpy forms vary from 13 μ to 21 μ, intermediate forms from 21 μ to 24 μ, and long, slender forms from 25 μ onwards. The average length is 24·1 μ.

Certain regular periods occur in the course of the trypanosomiasis when few or no flagellate trypanosomes are found in the peripheral blood of the patient or of the sub-inoculated animal. These periods can be explained in terms of morphology, for the trypanosomes are

FIG. 31.—*Trypanosoma rhodesiense.* 1, Long narrow form; 2-4, nucleus passing to posterior (aflagellar) end; 5, nucleus quite posterior. × 1,800. (After Stephens and Fantham.)

capable of assuming a non-flagellate form in the internal organs of the host, particularly in the lungs and in the spleen. Such forms are known as "latent" or "resting" forms. The term "latent body" was first used by Moore and Breinl in 1907[2] in connection with *T. gambiense.* Fantham[3] (1911) has described the process of formation of latent from motile forms and the reconversion of the latent bodies into active flagellates. Fresh preparations of splenic blood or lung blood containing trypanosomes were made. A trypanosome gradually withdrew or cast off its flagellum, concentrated its cytoplasm, and became more or less elongate oval. Nucleus and blepharoplast approached one another and came to lie more or less side by side. Then an opaque line often made its appearance around the nuclear area and differentiated as a slight envelope or covering, the cytoplasm external to this merely degenerating. The small, oval, refractile body (fig. 29, *d—f*) thus formed was a non-flagellate latent body, 2 μ to 4 μ in diameter, like *Leishmania* or the non-flagellate,

---

[1] Stephens and Fantham (1912-13), *Proc. Roy. Soc.*, B, lxxxv, p. 223, and *Annals Trop. Med. and Parasitol.*, vii, p. 27.

[2] *Annals Trop. Med. and Parasitol.*, i, p. 441. [3] *Proc. Roy. Soc.*, B, lxxxiii, p. 212.

multiplicative forms of *T. cruzi* (fig. 34), and remains temporarily inactive in the internal organs of the host. After this period of inactivity, the non-flagellate body, recuperated by its rest, begins to elongate again. The nuclei separate. From a small vacuole-like portion the flagellum differentiates and forces out the ectoplasm, which assumes the form of the undulating membrane with its flagellar border. Subsequent growth results in the production of the typical trypanosome form, which re-enters the circulating blood and multiplies by longitudinal binary fission. Division of the parasite prior to the formation of a latent body may occur and division of the latent forms themselves is known, though less common. Consequently latent bodies, like the flagellate forms themselves, show diversity in size. The blepharoplast of the latent bodies is sometimes less well marked than in *Leishmania* (see fig. 29, *d—f*). Laveran's views on these bodies have already been given on p. 74.

(2) *Animal Reactions.*—The posterior nuclear trypanosomes were found in all sub-inoculated animals, such as rats, guinea-pigs, dogs, mice, Macacus, rabbits and horses, but were not seen in the human patient, as few trypanosomes occurred in his peripheral blood. R. Ross and D. Thomson[1] found a periodic, cyclical variation in the number of the parasites in the patient's blood from day to day, the cyclical period being about a week (fig. 32). Fantham and J. G. Thomson[2] (1911) found a similar periodic, cyclical variation in the trypanosomes in the blood of sub-inoculated rats, guinea-pigs and rabbits. On counting the parasites in the blood of similar animals inoculated with *T. gambiense*, they established, by enumerative methods, that *T. rhodesiense* was more virulent than *T. gambiense*, while Yorke also showed this marked virulence of *T. rhodesiense* in practically all laboratory animals. In other words the duration of infection in the case of *T. rhodesiense* was shorter. It was also found that *T. rhodesiense* was resistant to atoxyl. The patient, from whom the original strain was obtained, died about nine months after the probable date of infection. Some patients infected with *T. rhodesiense* have died in an even shorter period, such as four or five months.

In sheep and goats *T. rhodesiense* causes an acute disease, marked by high fever, œdema of the face, and keratitis, as shown by Bevan and others, death resulting after a relatively short period. *T. gambiense* gives rise, in these animals, to no symptoms except fever, which may be overlooked. *T. rhodesiense* produces keratitis in dogs.

Stannus and Yorke (1911) observed *T. rhodesiense* in animals inoculated from a case of sleeping sickness in Nyasaland. Sir D. Bruce and his colleagues[3] have shown (1912) that *T. rhodesiense* is the

[1] *Proc. Roy. Soc.*, B, lxxxii, p. 411. [2] *Annals Trop. Med. and Parasitol.*, iv, p. 417.
[3] *Proc. Roy. Soc.*, B, lxxxv, p. 423.

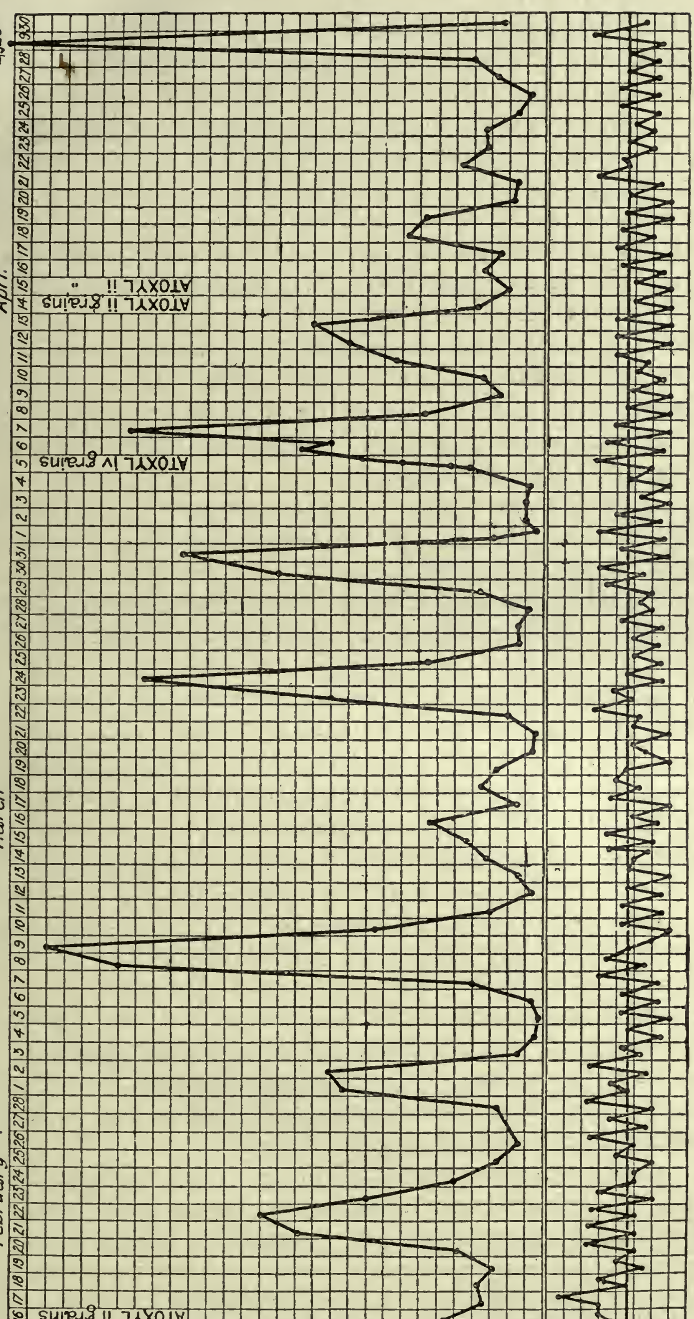


FIG. 32.—Chart showing daily counts of number of trypanosomes per cubic milimetre of peripheral blood from a case of Rhodesian sleeping sickness. (After R. Ross and D. Thomson.)

parasite usually found in man and in animals sub-inoculated from cases of sleeping sickness in Nyasaland. It has since been found in German East Africa and Portuguese East Africa, while Ellacombe has described a case from North-western Rhodesia.

(3) *Serum Reactions.*—Interesting experiments on this subject were performed during 1911 and 1912 by various French investigators.

(*a*) *Action of Immune Serum* (Mesnil and Ringenbach)[1]: (1) A goat was infected with *T. rhodesiense.* Twenty-two days later its serum mixed with *T. rhodesiense* was injected into a mouse. Result: Protection. (2) The serum mixed with *T. gambiense* was injected into a mouse. Result: Infection.

(*b*) *Action of Baboon Serum.*—Contrary to *T. gambiense, T. rhodesiense* is very susceptible to human and baboon sera. Mesnil and Ringenbach[2] showed that a dose of 1 c.c. of baboon (*Papio anubis*) serum cured mice infected with *T. rhodesiense.* In the same dose it acted very feebly on *T. gambiense.*

(*c*) *Action of Human Serum.*—1 c.c. of human serum cured *T. rhodesiense* mice in three out of four cases; on *T. gambiense* mice there was no appreciable effect.

Laveran and Nattan-Larrier[3] have shown the same, namely, that human sera act on *T. rhodesiense,* but are quite without action on *T. gambiense.*

(*d*) *Trypanolytic Reactions.*—Mesnil and Ringenbach[4] have also shown that the sera of animals (man, monkey and guinea-pig) infected with *T. gambiense* are trypanolytic for the homologous trypanosome, that is, *T. gambiense,* but have no action on the heterologous trypanosome, that is, *T. rhodesiense.*

(4) *Cross Immunity Experiments.*—(*a*) Mesnil and Ringenbach[5] immunized a monkey (*Macacus rhesus*) against *T. gambiense.* It was inoculated with *T. rhodesiense* on June 7, 1911; on June 27 trypanosomes appeared, the infection being slight; on July 4 it died. A control died in ten and a half days.

(*b*) Laveran[6] immunized a goat and mice against *T. gambiense.* When they had acquired a solid immunity, they were inoculated with *T. rhodesiense.* They became infected like the controls.

(*c*) Laveran and Nattan-Larrier[7] immunized a ram against *T. brucei,* it subsequently became infected with *T. rhodesiense.*

(*d*) Laveran[8] immunized a ram and a sheep against different strains of *T. brucei.* Inoculated with *T. rhodesiense* they both acquired acute infections and died. Conclusion: *T. rhodesiense* is not *T. brucei.*

---

[1] *C.R. Soc. Biol.*, lxxii, p. 58.
[2] *C.R. Acad. Sci.*, 153, p. 1,097.
[3] *C.R. Acad. Sci.*, 154, p. 18.
[4] *C.R. Soc. Biol.*, lxxi, p. 609.
[5] *C.R. Soc. Biol.*, lxxi, p. 271.
[6] *Bull. Soc. Path. Exot.*, v, pp. 26, 241.
[7] *C.R. Acad. Sci.*, 154, p. 18.
[8] *Bull. Soc. Path. Exot.*, v, p. 101.

When the converse set of experiments is tried, namely, immunizing an animal against *T. rhodesiense*, and then inoculating with *T. gambiense*, the difficulty immediately arises that it is impossible to immunize an animal against *T. rhodesiense*, owing to its virulence. But a partial and transitory immunity to *T. rhodesiense* can be obtained by treating the infected animal with drugs, such as arsenophenylglycin. The results, so far as they go, seem to show that an animal immunized against *T. rhodesiense* is immune not only to *T. rhodesiense*, but also to *T. gambiense*, a fact which, according to Mesnil and Léger, does not invalidate the specificity of *T. rhodesiense*, but tends to show that the two trypanosomes are closely related.

(5) *Mode of Transmission and Reservoir.*—Kinghorn has shown that *T. rhodesiense* is transmitted by *Glossina morsitans* in which it undergoes development. Kinghorn and Yorke[1] found that about 16 per cent. of the wild game examined in Northern Rhodesia was naturally infected with *T. rhodesiense*. The wild game examined included waterbuck, hartebeest, mpala, bushbuck and warthogs. One native dog near the Nyasaland border was found infected, but not domestic stock. Taute doubts whether *T. rhodesiense* really occurs in wild game. Approximately 3·5 per cent. of the tsetse flies fed on infected animals may become permanently infected with *T. rhodesiense*, and capable of infecting clean animals. Furthermore, a tsetse fly when once infective probably remains infective for the rest of its life.

Kinghorn and Yorke, however, have shown that climatic conditions, namely, those of temperature, also affect the infectivity of the tsetse fly, as the ratio of flies capable of transmitting *T. rhodesiense* to those incapable of transmitting the virus is 1 : 534 in hot valley districts (*e.g.*, Nawalia, Luangwa Valley, temperature 75° to 85° F.), while on elevated plateaux (*e.g.*, Ngoa, on the Congo-Zambesi watershed, temperature 60° to 70° F.) the ratio falls to 1 : 1312.

Mechanical transmission by the tsetse fly does not occur, if a period of twenty-four hours has elapsed since the infecting meal.

Developmental Cycle in the Fly.—The period which elapses between the infecting feed of the flies and the date on which they become infective varies from eleven to twenty-five days in the Luangwa Valley, according to Kinghorn and Yorke. Attempts carried out at laboratory temperature on the Congo-Zambesi plateau, during the cold season, to transmit *T. rhodesiense* by means of *G. morsitans* were always unsuccessful. The developmental cycle of the trypanosome in the fly is influenced by the temperature to which the flies are subjected (as stated above). The first portion of the developmental cycle proceeds at the lower temperatures (60° to 70° F.), but higher temperatures are necessary for the completion of the develop-

[1] *Annals Trop. Med. and Parasitol.*, vii, p. 183.

ment of the trypanosome. Kinghorn and Yorke found that the trypanosomes may persist in the fly, at an incomplete stage of their development, for at least sixty days when the climatic conditions were unfavourable.

The first portion of the developmental cycle of the trypanosome takes place in the gut of the fly. Invasion of the salivary glands of the tsetse is secondary to that of the intestine, but is necessary for the infectivity of the fly. A relatively high mean temperature, 75° to 85° F., is essential for the passage of the trypanosomes into the salivary glands and the completion of their development therein.

Kinghorn and Yorke[1] state that the predominant type of trypanosome in the intestine of infected *G. morsitans* was a large broad form, quite different from that which is most common in the salivary glands. The trypanosome in the glands resembles the short form seen in the blood of the vertebrate host. The authors quoted state that both the intestinal and salivary gland forms of infective *G. morsitans* are virulent when inoculated into healthy animals.

Bruce and colleagues[2] have quite recently (June, 1914) published an account of their investigations of *T. rhodesiense* in *G. morsitans* in Nyasaland. (Incidentally it may be remarked that Bruce considers *T. rhodesiense* to be identical with a polymorphic strain of *T. brucei*—see pp. 83, 94). The development of *T. rhodesiense* takes place in the alimentary canal and salivary glands, not in the proboscis, of the tsetse fly. In feeding experiments with laboratory bred flies, as well as with a few wild flies, fed on infected dogs or monkeys, only 8 per cent. of the flies were found to be infected on dissection. Of such infected flies, however, only some allow of the complete development of the trypanosomes within them, in other words only about 1 per cent of the flies become *infective*. The length of time which elapses before a fly becomes infective varies from fourteen to thirty-one days, averaging twenty-three days, when kept at 84° F. (29° C.). The dominant intestinal type of flagellate in the fly is that seen in the proventriculus, which contains many long, slender trypanosomes. These proventricular forms find their way to the salivary glands, wherein crithidial and encysted forms are seen. They change into "blood forms," which are short, stumpy trypanosomes and are infective. "The infective type of trypanosome in the salivary glands —corresponding to the final stage of the cycle of development—is similar to the short and stumpy form found in the blood of the vertebrate host." The cycle is thus very similar to that of *T. gambiense* in *G. palpalis* (fig. 30).

CULTURE.—J. G. Thomson (1912),[3] and subsequently Thomson

---

[1] *Annals Trop. Med. and Parasitol.*, vii, p. 281. [2] *Proc. Roy. Soc.*, B, lxxxvii, p. 516.
[3] *Annals Trop. Med. and Parasitol.*, vi, pp. 103, 331.

and Sinton, succeeded in cultivating *T. rhodesiense* in a modified Novy-MacNeal medium. The development obtained resembled that of the trypanosome in the intestine of *Glossina*.

General Note on Trypanosomes with Posterior Nuclei.

Posteriorly placed nuclei have been found to occur not only in *T. rhodesiense* by Stephens and Fantham (1910), but also in *T. pecaudi* by Wenyon (1912), in *T. brucei* by Blacklock (1912), and in *T. equiperdum* by Yorke and Blacklock (1912).

Recently Stephens and Blacklock (1913)[1] have shown that two trypanosomes, different morphologically, have been confused under the name *T. brucei*. One of these is polymorphic (*i.e.*, it exhibits long and slender as well as short and stumpy forms) and came from Uganda, while the other is monomorphic and is the original Zululand strain described by Bruce from cattle suffering from "nagana." Bruce (1914) considers that morphological change has occurred in *T. brucei* in its passage through laboratory animals, and thus explains the diversity of views. The posterior nuclear forms described by Blacklock occurred in the Uganda strain of *T. brucei*. (See p. 95.) Similarly, a posterior nuclear form, *T. equi*, has been separated from *T. equiperdum*. (See p. 98.)

Again, Bruce and his colleagues on the Royal Society Commission investigating sleeping sickness in Nyasaland, have stated (April, 1913) that "evidence is accumulating that *T. rhodesiense* and *T. brucei* (Plimmer and Bradford) are identical." The exact identity of trypanosomes showing posterior nuclei is, then, far from settled, although Laveran by cross immunity tests has declared that *T. brucei* is distinct from *T. rhodesiense*. No one has yet seen posterior nuclei in *T. gambiense*.

Trypanosoma cruzi, Chagas, 1909.

Syn.: *Schizotrypanum cruzi*, Chagas, 1909.

The trypanosome was discovered by Chagas[2] in the intestine of the bug, *Triatoma* (*Conorhinus*) *megista*, in Brazil, and then in the blood of a small monkey bitten by the bug. A little later it was found in the blood of a child, aged two years, suffering from irregular fever, extreme anæmia and enlarged glands in the State of Minas Geraes, Brazil. Chagas found that he was able to infect many of the usual laboratory animals with the trypanosome, by allowing the bug to bite them. He was also able to culture the parasite on blood agar.

Chagas found the Reduviid bug, *Triatoma megista*, in the houses of the poorer inhabitants of the Brazilian mining State, and that it attacked the people, more especially the children, at night, biting the face. On this account the insect is called "barbeiro" by the

---

[1] *Proc. Roy. Soc.*, B, lxxxvi, p. 187.

[2] *Mem. Inst. Oswaldo Cruz.*, i, p. 159.

inhabitants. The bite is somewhat painful. The disease has since been found in other parts of Brazil, *e.g.*, Matta de São João in Bahia province, Goyaz, Matto Grosso and São Paulo provinces, as well as in Minas Geraes.

Morphology.—The trypanosome has a large blepharoplast or kinetic nucleus. It is stated to occur both free and in the red blood corpuscles in the peripheral blood. It is about 20 μ long, on an average.

Two forms of the parasite (fig. 33, *6*, *7*) are described in the human blood. In one free form there is a large egg-shaped blepharoplast and the posterior (aflagellar) end of the parasite is drawn out. The blepharoplast (kinetic nucleus) may have a chromatin appendage. The nucleus is oval or band-like, containing a karyosome. The flagellum, starting close to the blepharoplast or its appendage, has a free portion of variable length. The other free form in the blood has a more or less round, terminal blepharoplast, smaller than in the first form, without a chromatin appendage as a rule. The body of this second form is decidedly broader than that of the first mentioned.

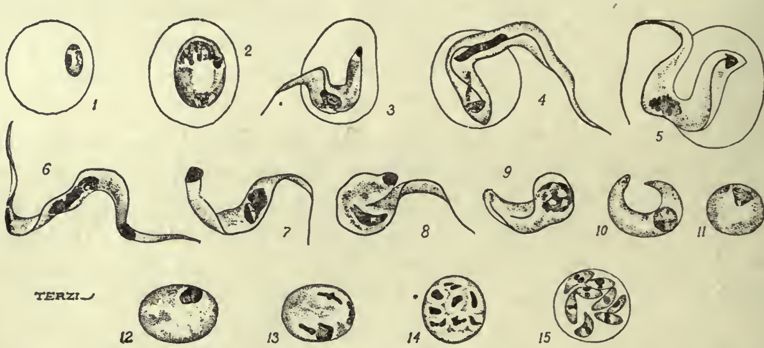


FIG. 33.—*Trypanosoma cruzi.* Schizogony. *1*, merozoite in red blood corpuscle; *2*, parasite totally enclosed in red cell, no flagellum or undulating membrane; *3-5*, parasites partially enclosed in red cell; *6*, *7*, parasites in human blood; *8-11*, parasites in lungs of the monkey, *Callithrix*; *12*, *13*, initial forms of schizogony; *14*, *15*, schizogony in the lungs of *Callithrix.* (After Chagas.)

The dimorphism has been interpreted sexually, the first mentioned forms being termed males, the second ones females. The correctness of this interpretation is very doubtful.

No sign of longitudinal division was ever seen in the peripheral blood or in the internal organs. The "endocorpuscular" forms may be completely or partially enclosed in the red cell or only attached thereto (fig. 33, *1-5*). At the beginning of infection the endocorpuscular forms are the more numerous. Some authorities, however, doubt these stages.

Life-history in the Vertebrate Host.—Chagas found fluctuations in the number of the parasites in the peripheral blood. He believes the increase of the parasites to be periodic.

The investigations of Chagas and of Hartmann have revealed two types of multiplication which take place in the internal organs of the vertebrate host.

(*a*) The first type—which possibly belongs to another organism, *Pneumocystis carinii*, see p. 90—occurs in the capillaries of the lungs. The flagellate parasite entering the lung capillaries loses its flagellum and undulating membrane. Its body becomes curved, and the two ends fuse, and so an oval mass is formed (fig. 33, *8-11*). In some cases the blepharoplast disappears, in other cases it blends or fuses with the nucleus. The nucleus of the rounded parasite then divides into eight by successive divisions (fig. 33, *12-15*). Next the body, which is surrounded by its own periplast, also divides, giving rise to eight tiny daughter individuals or merozoites (fig. 33, *15*). The merozoites lie inside the periplast, which acts as a sort of "cyst wall." The merozoites are said to exhibit dimorphism, and Chagas has interpreted the dimorphism in terms of sex. The daughter forms, produced by the parent trypanosomes which kept their blepharoplasts, themselves have blepharoplasts as well as nuclei, and have been termed "males" or "microgametes." The merozoites, arising from parent trypanosomes which lost their blepharoplasts, have themselves only nuclei, and have been called "females" or "macrogametes." In the case of the so-called "female" forms the single nucleus divides into two unequal parts, of which the smaller becomes the blepharoplast, and a flagellum is formed later. The so-called "males" possess early a rudiment of a flagellum. Both kinds of merozoites escape from the parent periplast wall, and enter red blood corpuscles. They grow into flagellates within the corpuscles, and then become free as adult trypanosomes in the blood-stream.

(*b*) The second mode of multiplication is one of asexual reproduction (schizogony or agamogony). It was first described by Hartmann from hypertrophied endothelial cells of the lungs. It has since been found in the cardiac muscle, in the neuroglia of the central nervous system, and in striped muscle (fig. 34). In laboratory animals it has also been found in the testicle and suprarenal capsules. In these tissues the parasite is intracellular, appearing as a small rounded body with nucleus and blepharoplast, without flagellum or undulating membrane. In other words the parasite is *Leishmania*-like in the body tissues, and recalls the organism of kala-azar.

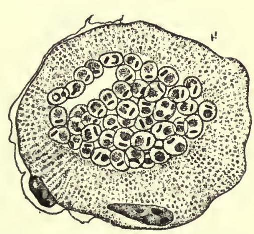


FIG. 34. — *Trypanosoma cruzi*. Transverse section of a striated muscle containing rounded forms of the parasite in the central portion. × 1,000 approx. (After Vianna.)

Chagas considers this second mode of multiplication to be strictly asexual. By this means the number of parasites in the vertebrate host is increased, and symptoms are produced. On the other hand the first mode of multiplication, seen in the lung capillaries, is considered by Chagas to be a process of gametogony, in which sexual forms are differentiated. He finds that (1) the adult trypanosomes exhibit a dimorphism in human blood rarely seen in artificially infected guinea-pigs. In these guinea-pigs (infected from guinea-pigs) the so-called gametogony in the lungs is seldom seen. (2) The intermediate host, *Triatoma* (*Conorhinus*), becomes infective if fed directly on infected human blood, but very rarely so if fed on guinea-pigs. Chagas is led to believe that the occurrence of sexual forms constantly in the blood of man implies a greater resistance to infection on the part of man than on the part of guinea-pigs or other animals, assuming the general hypothesis that the formation of gametes represents a reaction of the Protozoön to unfavourable conditions. In human infection the number of parasites is always less than in laboratory animals, and their presence in the blood is transitory, lasting from fifteen to thirty days in acute cases. In many cases examination of the tissues at death has shown the presence of parasites in patients who did not exhibit them in the general circulation.

FIG. 35.—*Trypanosoma cruzi.* Development in *Triatoma megista.* *1-6*, forms found in the mid gut of *Triatoma*; *7* flagellate forms found in the posterior part of the gut of *Triatoma.* (After Chagas.)

Life History in the Invertebrate Host.—About six hours after the ingestion of infected blood by the bug (*Triatoma megista*), the kinetic nucleus of the trypanosome moves towards the nucleus, and the flagellum is usually lost (fig. 35, *1-5*). The parasite becomes rounded and *Leishmania*-like (fig. 35, *3-5*), and multiplies rapidly by division. After a time, multiplication having ceased, the rounded forms become pear-shaped and develop a flagellum at the more pointed end. Crithidial forms (fig. 35, *7*) are thus produced and pass into the intestine, where they multiply and may be seen in about twenty-five hours after the ingestion of blood. The crithidial forms may also be found in the rectum and fæces. The last stage in the invertebrate is a small, trypanosome-like type, long and thin with a band-like nucleus and conspicuous kinetic nucleus. These parasites are found in the hind gut and in the body cavity. They find their way into the salivary glands, and are the forms (fig. 36) which are transmissible to a new vertebrate host. The development in the bug takes about eight days altogether, after which time the bugs are infective.

There are thus three principal phases in the development of *T. cruzi* in *Triatoma megista*: (1) A multiplicative phase (*Leishmania*-like) in the stomach of the bug, (2) a crithidial phase, which is also multiplicative, in the hind-gut, and (3) a trypanosome phase, which is "propagative," and apparently passes through the wall of the alimentary canal into the body cavity and so into the salivary glands.

FIG. 36.—*Trypanosoma cruzi.* Forms found in the salivary glands of *Triatoma megista.* (After Chagas.)

Brumpt found that *T. cruzi* could live in *Cimex lectularius*, *C. boueti*, and *Ornithodorus moubata*. The *Cimex* fæces may be infective. Blacklock found multiplication of the parasite in *C. lectularius*.

Culture.—The trypanosome can be cultivated on Novy-MacNeal's blood agar, and the cultural forms resemble those described in the bug.

Possible Reservoir.—Chagas thinks that probably the armadillo or "tatu" (*Dasypus novemcinctus*) may be the reservoir of *T. cruzi*. He also thinks that *Triatoma geniculata* is a transmitter; it lives in the burrows of the armadillo. Other carriers may be *Triatoma infestans* and *T. sordida*.

Clinical Features.—The trypanosomiasis of Brazil, produced by *T. cruzi* and spread by *Triatoma* spp. has received various names, such as oppilação, canguary, parasitic thyroiditis, and coreotrypanosis. It is also known as the human trypanosomiasis of Brazil, South American trypanosomiasis, and Chagas' disease.

Chagas[1] reports two principal forms—acute and chronic. The *acute infection* is rare, and is characterized by increase in the volume of the thyroid gland, pyrexia, a sensation of crackling in the skin, enlarged lymphatic glands in the neck, axilla, etc., while the liver and spleen are increased in volume. Sclerosis of the thyroid gland is found at autopsy and fatty degeneration of the liver. During an attack of fever, trypanosomes are found in the blood. The acute form was only observed in children.

In the chronic form Chagas reports several varieties: (*a*) A pseudo-myxœdematous form, occurring in most cases, especially up to the age of 15. There is hypertrophy of the thyroid gland or at least signs of hypothyroidism, general hypertrophy of glands,

[1] *Brazil Medico*, Nov. 15, 1910. Longer account in *Mem. Inst. Oswaldo Cruz*, iii, pp. 219-275. See *Sleep. Sick. Bull.*, Nos. 35 and 40.

disturbance of heart rhythm, and nervous symptoms. (*b*) The myxœdematous form is characterized by similar symptoms, especially by considerable swelling of the thyroid body, and myxœdema of the subcutaneous cellular tissue; sometimes there is a true pachydermic cachexia. (*c*) In the nervous form there are motor disturbances, aphasia, disturbances of intelligence or signs of infantilism, athetosis of the extremities and idiocy. There are also paralytic symptoms of bulbar origin, disturbances of mastication, phonation and deglutition, and in some cases convulsive attacks. (*d*) The cardiac form, characterized by disturbance of the heart rhythm. In all these forms the parasite is found at autopsy in the nervous substance, brain, bulb and heart.

Vianna (1911)[1] has studied the histopathology of the disease. Some of the chief points are: in the heart muscle destruction of the sarcoplasm, followed by interstitial myocarditis; in the central nervous system invasion of the neuroglia cells and inflammatory reaction; in the suprarenal capsule invasion of medulla or cortex; inflammatory reaction can also be seen in the kidneys, the hypophysis and thyroid gland.

Recently Chagas states[2] that "schizotrypanosomiasis" has been found in a child 15 to 20 days old, and that *Trypanosoma cruzi* has also been found in a fœtus—the mother being infected with the trypanosome. The trypanosomiasis can, then, be transmitted hereditarily.

Trypanosoma lewisi, Kent, 1881.

The trypanosome has a nucleus somewhat displaced anteriorly, about one-third of the way from the anterior (flagellar) end of the body, a relatively straight edge to the undulating membrane, and a rod-shaped blepharoplast (fig. 37, A). It averages about 25 μ long and 1·5 μ broad.

Much attention has been devoted in recent years to the elucidation of the life history of the rat parasite, *Trypanosoma lewisi*. It is usually non-pathogenic to its host. It has been shown that the trypanosome can be transmitted from rat to rat by the rat-flea, *Ceratophyllus fasciatus*, and by *Ctenocephalus canis* (the so-called dog-flea). (See also p. 92). The flagellate may also persist, but doubtfully develop, in the rat-louse, *Hæmatopinus spinulosus*. These researches may now be summarized.

Life Cycle in the Vertebrate Host.—After infection of a rat, the trypanosomes usually appear in the animal's blood in five to seven days. This incubation period applies either to a natural or an artificial infection. The trypanosomes first observed in the rat's blood are diverse in form (fig. 37), being small, medium and large in size. This diversity is explained by the rapid multiplication taking place. A

[1] *Mem. Inst. Oswaldo Cruz*, iii, p. 276. [2] *Rev. Med. S. Paulo* (1912), xv, p. 337.

trypanosome may divide by equal longitudinal fission (fig. 37, C, D), but more commonly multiple fission occurs (fig. 37, G, H), and is unequal. Rosette forms are produced, in which the parent form can be recognized by its long flagellum (fig. 37, H) and attached to it are

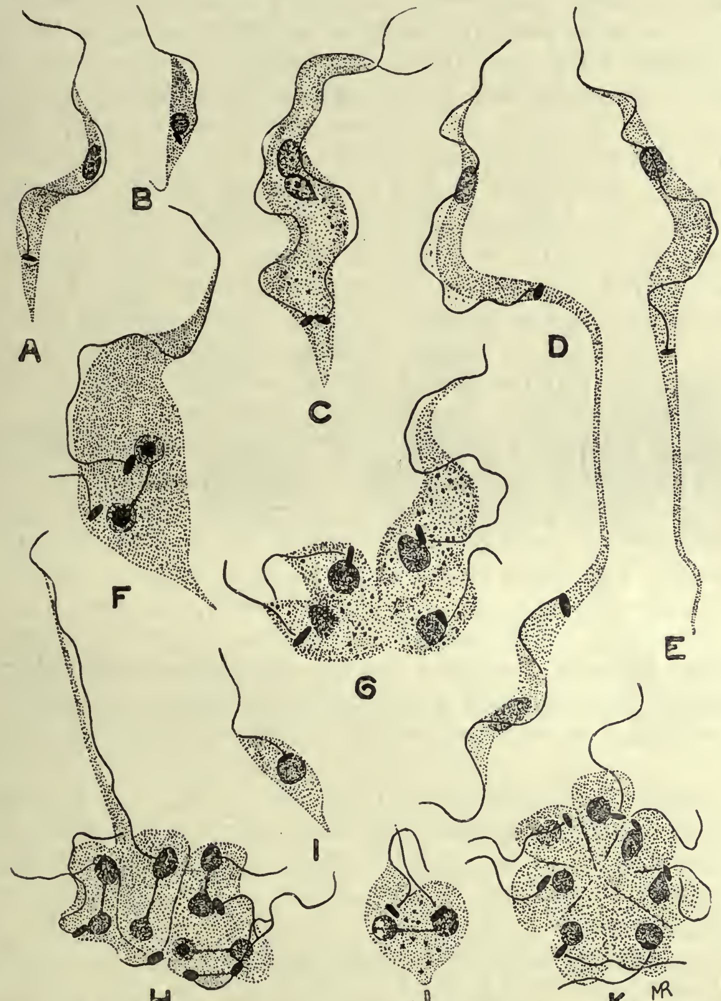


FIG. 37.—*Trypanosoma lewisi*, from rat's blood. A, ordinary form; B, small form; C, D, stages in equal binary fission; E, elongate form (*longocaudense* type), resulting from division as seen in D; F, unequal binary fission; G, H, multiple fission into four and eight; I, small form; J, binary fission of small form; K, division rosette. × 2,000. (After Minchin and Thomson.)

daughter individuals, smaller in size, from which flagella are growing. Minchin and J. D. Thomson (1912) find that the daughter forms may be set free sometimes with a crithidia-like facies (fig. 37, I), the blepharoplast being anterior but near to the nucleus. The daughter forms, when set free, may themselves divide by binary or multiple fission, in the latter case forming rosettes (fig. 37, K). Rosette forms were described by Moore, Breinl and Hindle in 1908.

Lingard, some years ago, described as a distinct species, *T. longocaudense*, certain forms with markedly elongate posterior ends (fig. 37, E). According to Minchin, "these forms appear to arise by binary fission" (fig. 37, D). These long drawn-out forms "are of constant occurrence and very numerous at a certain stage of the multiplication period." It is about the eighth or tenth day after infection that the multiplication of *T. lewisi* is at its maximum in the rat's blood. About the twelfth or thirteenth day the trypanosomes seen in the blood appear uniform. According to Minchin (1912)[1] the rat "gets rid of its infection entirely sooner or later, without having suffered, apparently, any marked inconvenience from it, and is then immune against a fresh infection with this species of trypanosome." There is, then, a cycle of development in the vertebrate host. Minchin notes that the records of the pathogenicity of *T. lewisi* in rats, causing their death, need further investigation.

T. lewisi inoculated into dormice (*Myoxus nitela*) and jerboas may become pathogenic thereto.

Carini found cysts in the lungs of rats infected with *T. lewisi*. He thought the cysts were schizogonic stages of the trypanosome, comparable with those found in the lungs of animals sub-inoculated with *T. cruzi*. Delanoë (1912)[2] has found, however, that such cysts, containing eight vermicules, occurred in rats uninfected with *T. lewisi*. Delanoë concludes that the pneumocysts are independent of *T. lewisi*, and represent a new parasite, *Pneumocystis carinii*. The pneumocysts may be allied to the Coccidia, and must be considered when investigating the life-cycle of a trypanosome in a vertebrate host. Some of the stages of *T. cruzi* may possibly be of this nature.

Life-cycle in the Invertebrate Host.—This occurs in fleas, and has been investigated in considerable detail by Minchin and Thomson in *Ceratophyllus fasciatus*, and by Nöller in *Ctenocephalus canis* and *Ctenopsylla musculi*.

When infected rat's blood is taken up by the flea, the parasites pass with the ingested blood direct to the mid-gut of the Siphonapteran. In the flea's stomach they multiply in a somewhat remarkable manner, namely, by penetration of the cells of the lining epithelium, and division inside the epithelial cells. Inside these lining cells the trypanosomes first grow to a large size and then form large spherical bodies, within which nuclear multiplication occurs (fig. 38, A—F). Any one of these large spherical bodies contains at first a number of nuclei, blepharoplasts and developing flagella, the original flagellum

[1] "Protozoa," p. 294. [2] *C. R. Acad. Sci.*, clv, p. 658.

still remaining attached for a time. The cytoplasm then divides into daughter trypanosomes which are contained within an envelope, formed by the periplast of the parent parasite. Inside the periplast envelope are a number of daughter trypanosomes "wriggling very actively; the envelope becomes more and more tense, and finally bursts with explosive suddenness, setting free the flagellates, usually about eight in number, within the host-cell" (fig. 38, F). The daughter forms escaping from the host cell into the stomach lumen of the flea are fully formed, long trypanosomes.

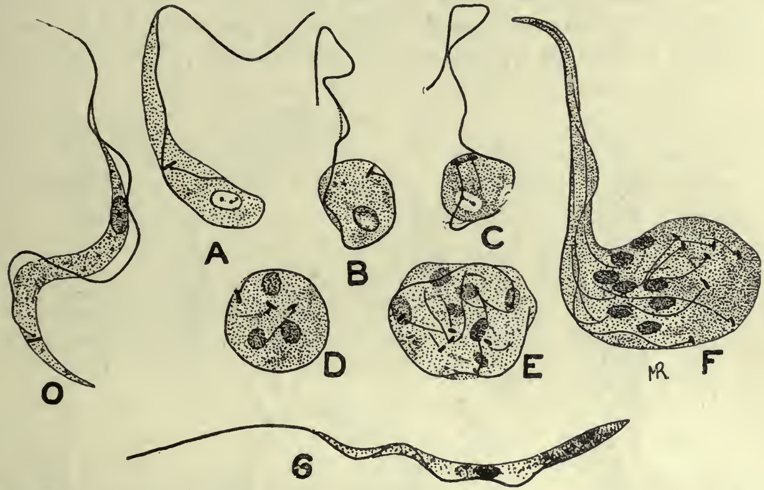


FIG. 38.—*Trypanosoma lewisi.* Developmental stages from stomach of rat flea. O, ordinary blood type; A—F, stages occurring in gut-epithelium of flea, when the trypanosome becomes rounded and undergoes multiplication, forming in F eight daughter trypanosomes; G, type of trypanosome resulting from such division which passes back to the rectum. × 2,000. (After Minchin.)

The trypanosomes (fig. 38, G) pass into the flea's rectum. The next phase is a crithidial one. The parasites become pear-shaped, in which the blepharoplast (kinetic nucleus) has travelled anteriorly past the nucleus towards the flagellum (fig. 39). The crithidial forms attach themselves to the wall of the rectum, and multiply by binary fission (fig. 39, D). A stock of parasites is thus formed which, according to Minchin and Thomson, "persist for a long time in the flea—probably under favourable conditions, for the whole life of the insect" (fig. 39, A—I).

From the crithidial forms of the rectum, according to Minchin, small infective trypanosomes arise by modification morphologically (fig. 39, J—M). The flagellum grows longer and draws out more the anterior part of the body, the blepharoplast migrates posteriorly, behind the nucleus, and carries with it the flagellar origin. These trypanosomes are small, but broad and stumpy (fig. 39, N), and can infect a rat. Minchin and Thomson formerly considered that the small, stumpy, infective trypanosomes pass forwards from the rectum into the stomach, and "appear to be regurgitated into the rat's blood when the flea feeds." However, the small infective trypanosomes were previously described by Swellengrebel and Strickland.[1] They may be found in the flea's fæces. Nöller (1912)[2] has found that the development of *T. lewisi* proceeds quite well in the dog flea (*Ctenocephalus canis*) in Germany. Wenyon confirms this, and states that the human flea, *Pulex irritans*, and the Indian rat-flea, *Xenopsylla cheopis*, are also able to serve as true hosts for *T. lewisi*.

Nöller stated that rats were not infected with *T. lewisi* by infective fleas biting them, but by the rats licking up the fæces passed by the

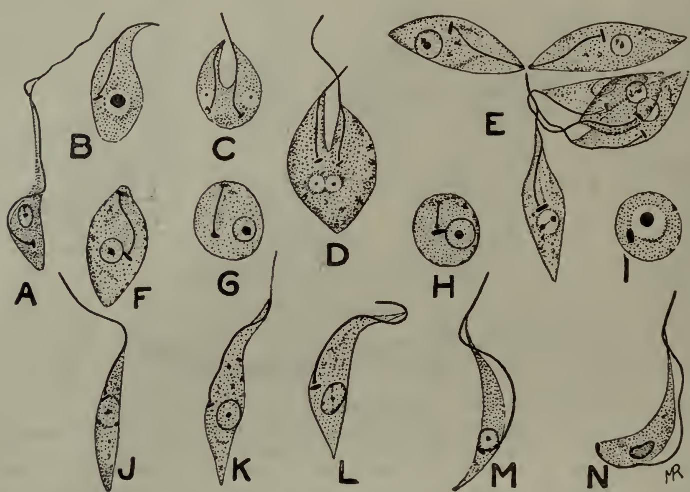


FIG. 39.—*Trypanosoma lewisi*. Developmental stages from rectum of rat-flea. A, early rectal form; C, D, division of crithidial form; E, group of crithidial forms; F—I, crithidial forms without free flagella, some becoming rounded; J—M, transitional forms to trypanosome type seen in N, which represents the final form in the flea. × 2,000. (After Minchin.)

fleas while feeding. This is not in agreement with Minchin and Thomson's earlier views of regurgitation, which, apparently, they have now abandoned.[3] Wenyon (1912) confirms Nöller's experiments. He took a dog flea, containing infective trypanosomes in its fæces, and allowed it to feed on a clean rat. The fæces of the flea, passed while feeding, were carefully "collected on a cover glass and taken up in culture fluid with a fine glass pipette." The contents of the pipette were discharged into the mouth of a second clean rat. Injury to the rat's mouth was carefully avoided. The first rat, on which the infective flea was fed, did not become infected, while the

[1] *Parasitology*, iii, p. 360. [2] *Arch. f. Protistenkunde*, xxv, p. 386.
[3] Report to Advis. Comm. Trop. Dis. Research Fund for 1913, p. 74.

second rat, in whose mouth infective flea fæces were placed, became infected in six days.

When infective forms of *T. lewisi* have been developed within the gut of a rat flea, they may enter and infect the vertebrate host by[1] (*a*) being crushed and eaten by the rodent; (*b*) the rat may lick its fur on which an infected flea has just passed infective excrement; or (*c*) the rat may lick, and infect with flea excrement, the wound produced by the bite of the flea.

The time taken for the full development of *T. lewisi* in the flea is about six days. The intracellular phase is at its height about the end of the first day; the crithidial phase, in the flea's rectum, begins during the second day; the stumpy, infective trypanosomes are developed in the rectum about the end of the fifth day.

Wenyon[2] writes that, "the fleas, when once infected with *T. lewisi*, remain infected for long periods, for though many small infective trypanosomes are washed out of the gut at each feed, those that remain behind multiply to re-establish the infection of the hind gut. Further, the infection is still maintained even if the flea is nourished on a human being, so that fresh human blood does not appear to be destructive to the infective forms in the flea."

The best method of controlling fleas during experiments is that due to Nöller. He adopted the method of showmen who exhibit performing fleas, and secure them on very fine silver wire.

Of fleas fed on an infected rat only about 20 per cent. become infective. About 80 per cent. are immune. If fleas are examined twenty-four hours after feeding, trypanosomes will be found in all, so that many of the parasites are destined to degenerate.

It may be of interest to note that Gonder[3] (1911) has shown that a strain of *T. lewisi* resistant to arsenophenylglycin loses its resistance after passage through the rat-louse, *Hæmatopinus spinulosus*. These experiments suggest that physiological "acquired characters" may be lost by passage through an invertebrate host.

Trypanosoma brucei, Plimmer and Bradford, 1899.

Trypanosoma brucei was discovered by Sir D. Bruce in 1894 in cattle in Zululand and was named *T. brucei* by Plimmer and Bradford in 1899 in honour of its discoverer. This trypanosome is of considerable economic importance, as it is responsible for the fatal tsetse fly disease, or "nagana," in cattle, horses and dogs. The disease is widely distributed in Africa and is transmitted from host to host by the tsetse, *Glossina morsitans*, and other species of *Glossina*.

---

[1] Nuttall, *Parasitology*, v, p. 275.

[2] Report to Advis. Comm. Trop. Dis. Research Fund, October, 1912, p. 91. See also *Journ. Lond. Sch. Trop. Med.*, ii, p. 119.

[3] *Centralbl. f. Bakt.*, Orig., lxi, p. 102.

The virus is maintained in nature in certain big game, such as wildebeest, bushbuck and koodoo, which thus act as living reservoirs of disease from which the tsetse may become infected. These reservoir hosts are not injured, apparently, by the presence of the parasites.

T. brucei is rapidly fatal to the small laboratory animals, such as rats and mice. Horses, asses and dogs practically always succumb to its attacks, while a very small number of cattle recover from "nagana." The disease is characterized by fever, destruction of red blood corpuscles, severe emaciation and by an infiltration of coagulated lymph in the subcutaneous tissue of the neck, abdomen and extremities giving a swollen appearance thereto. The natural reservoirs in which *T. brucei* has been long acclimatized are unaffected by the trypanosomes, while the newer hosts, such as imported cattle in Africa, are rapidly destroyed by their action.

FIG. 40.—*Trypanosoma brucei.* × 2,000. (After Laveran and Mesnil.)

The general morphology and life history in the vertebrate host is that of a typical trypanosome (fig. 40). Its length is from 12 μ to 35 μ, its breadth from 1·5 μ to 4 μ. Multiplication by longitudinal division proceeds in the peripheral blood (fig. 26), while latent, leishmaniform bodies are produced in the internal organs.

Bruce and colleagues[1] have quite recently (June, 1914) described the development of a Zululand strain of *T. brucei* in *G. morsitans.* The tsetse flies were bred out in Nyasaland. In vertebrate blood the *brucei* strain was polymorphic. The development was like that found for *T. gambiense* in *G. palpalis* (fig. 30), and by Bruce and colleagues for *T. rhodesiense* in *G. morsitans* in Nyasaland. Long trypanosomes were found in the proventriculus of the tsetse. Crithidial, rounded or encysted, and immature "blood forms" occurred in the salivary glands; and finally infective, stumpy, "blood forms" were differentiated in the salivary glands. The period of development of *T. brucei* in *G. morsitans* takes about three weeks, and then the fly becomes infective. Bruce believes that *T. rhodesiense* of Nyasaland and *T. brucei* of Zululand are the same, their cycles of development in *G. morsitans* being "marvellously alike." (But see Laveran, p. 80.)

T. brucei has been cultivated with difficulty by Novy and MacNeal, using blood agar. The best treatment for nagana is arsenic in some form.

It is probable that more than one trypanosome has been confused under the name *T. brucei*, more especially as the occurrence of many species of trypanosomes in various animals in Africa was not

[1] *Proc. Roy. Soc.*, B, lxxxvii, p. 526.

suspected until comparatively recent times. It has been shown by Stephens and Blacklock (1913) that the original Zululand strain of *T. brucei* was monomorphic, while the organism sent from Uganda, and at the time believed by Bruce to be the same as the Zululand trypanosome, has been found to be polymorphic, with morphological resemblances to *T. rhodesiense*. Stephens and Blacklock[1] have suggested the name *T. ugandæ* for the polymorphic trypanosome, which, however, has marked resemblances with **Trypanosoma pecaudi**, and they are, perhaps, identical. *T. pecaudi* was the name given by Laveran[2] in 1907 to the causal agent of "baleri" in equines and sheep in the French Sudan. *T. pecaudi*, which is dimorphic, is widely distributed in Africa. An extremely small number of both *T. pecaudi* and *T. ugandæ* have been shown to possess posterior nuclei. *T. pecaudi* is transmitted by various species of *Glossina*, and is said to develop in the gut and proboscis of the fly.

On the other hand, Bruce and colleagues (1914), examining a strain sent from Zululand in 1913, state that *T. brucei* is polymorphic. Bruce (1914) suggests that passage through laboratory hosts has influenced and altered the morphology of the parasite.

Trypanosoma evansi, Steel, 1885.

Syn.: *Spirochæta evansi*, Steel, 1885; *Hæmatomonas evansi*, Crookshank, 1886; *Trichomonas evansi*, Crookshank, 1886.

Trypanosoma evansi, first found by Evans in 1880, in India, is the causal agent of the disease known as "surra." The malady affects more particularly horses, mules, camels and cattle in India and neighbouring countries, such as Burma and Indo-China. It occurs also in Java, the Philippines, Mauritius and North Africa. Elephants may be affected. A serious outbreak among cattle in Mauritius occurred in 1902, the disease being imported into the island. The symptoms are fever, emaciation, œdema, great muscular weakness and paralysis culminating in death.

T. evansi varies from 18 μ to 34 μ in length and 1·5 μ to 2 μ in breadth. It has a pointed posterior extremity, and, anteriorly, there is a free portion to the flagellum (fig. 41). It is possibly monomorphic, but a few broad forms occur. The trypanosome multiplies by longitudinal fission in the blood. Rounded leishmaniform stages occur in the spleen of the vertebrate host, which stages Walker[3] (1912) considers to be phases of schizogony.

The parasite is transmitted in nature by various species of *Tabanus* and *Stomoxys*, though at present little is known of the life-history within these invertebrate hosts.

---

[1] *Proc. Roy. Soc.*, B, lxxxvi, p. 187. [2] *C.R. Acad. Sci.*, cxliv, p. 243.
[3] *Philippine Journ. Sc.* (Sect. B), vii, p. 53.

Dogs are said to contract the disease by feeding on animals dead of surra.

A variety of *T. evansi* is the cause of "mbori" in dromedaries in Africa (Sahara and Sudan). Another possible variety, or closely allied form, is *T. soudanense*, the causal agent of "el debab" in camels and horses in North Africa, especially Algeria and Egypt.

FIG. 41. — *Trypanosoma evansi.* × 2,000. (Original. From preparation by Fantham.)

An extraordinary example of the possible infection of a human being with an animal trypanosome is recorded in the case of Professor Lanfranchi, of the Veterinary School, Parma. The Professor became infected with trypanosomes, although only nagana and surra were maintained in his laboratory, and he himself had never visited the tropics. He suffered from irregular attacks of fever and was œdematous, but his mind remained clear. The identification of the trypanosome from Lanfranchi's blood has been a matter of great difficulty. Apparently Mesnil and Blanchard (1914)[1] consider the strain found in the patient is almost indistinguishable in its reactions from *T. gambiense*, though the parasite is monomorphic. Lanfranchi considers that he was infected with *T. evansi*.

Trypanosoma equinum, Voges, 1901.

Syn.: *Trypanosoma elmassiani*, Lignières.

Trypanosoma equinum was found by Elmassian to be the cause of the fatal disease, "mal de caderas," of horses and dogs, in South America (Paraguay, Argentine, Bolivia). The name refers to the fact that in the disease, as in other trypanosomiases, the hind quarters become paralysed. Cattle are refractory to inoculation.

T. equinum is about 22 μ to 24 μ long and about 1·5 μ broad (fig. 42). Although this trypanosome is very active, yet it is characterized by the blepharoplast (kinetic nucleus) being very minute or even absent, as the granule sometimes seen may be the basal granule of the flagellum.

FIG. 42. — *Trypanosoma equinum.* × 2,000. (After Laveran and Mesnil.)

The mode of transmission of *T. equinum* is not known with absolute certainty. Migone has shown that the parasite causes a fatal disease in the large South

[1] *Bull. Soc. Path. Exot.*, vii, p. 196.

American rodent, the capybara (*Hydrochœrus capybara*). This animal appears to be a reservoir of the parasite. Dogs may become infected by eating diseased capybaras, and it is suggested that the infection is spread from the dogs to horses by the agency of fleas. Some authorities consider that *T. equinum* may be spread by various *Tabanidæ* and by *Stomoxys*. Neiva (1913)[1] doubts all these modes of transmission in Brazil, and suggests *Chrysops* or *Triatoma* as vectors.

Trypanosoma equiperdum, Doflein, 1901.

Syn.: *Trypanosoma rougeti*, Laveran and Mesnil.

The malady of horses known as "dourine" or "mal du coït" is due to a trypanosome, *T. equiperdum*, discovered by Rouget in 1894. "Dourine"—also known as "stallion disease" or "covering disease"—is found among horses and asses in Europe, India, North Africa and North America. The trypanosome is transmitted by coitus, and so far as is known not by insect agency.

FIG. 43. — *Trypanosoma equiperdum*. × 2000 approximately. (Original. From preparation by Fantham.)

The progress of the disease may be considered under three periods. The *period of œdema*, when signs of œdema of the genitalia are seen. The œdema is generally painless and non-inflammatory. This period lasts about a month. It is succeeded by the *period of eruption*, which sets in about two months after infection. Circular œdematous areas ("plaques"), often about the size of a two-shilling piece, appear under the skin of the sides and hind quarters, and also, at times, under the skin of the neck, thighs and shoulders. The eruption is variable, but usually lasts about a week and leaves the animal in an enfeebled condition. Gland enlargement and swelling of the joints and synovia also may occur. The third period of the disease is described as that *of anæmia and paralysis*. The animal becomes very anæmic, emaciation is marked, superficial non-healing abscesses often form, and conjunctivitis and ulcerative keratitis can occur. Paralysis ensues, and in from two to eighteen months the animal dies. In the acute form of the disease the animal may die after the first period from acute paralysis.

It is difficult to find the trypanosomes in naturally infected animals, and they are best obtained from the plaques of the eruption. Apparently the parasite occurs more in the lymph than in the blood.

[1] *Brazil Medico*, xxvii, p. 366.

Ruminants are said to be refractory to this trypanosome.

T. equiperdum is about 25 μ to 28 μ in length on an average, but varies from 16 μ to 35 μ. Its cytoplasm is relatively clear, and does not show chromatic granules (fig. 43). It is stated to be monomorphic.

It has been shown recently by Blacklock and Yorke (1913)[1] that there is another trypanosome giving rise to dourine in horses. This trypanosome is dimorphic (resembling *T. pecaudi* and *T. ugandæ*), and is named *T. equi*. Previously *T. equiperdum* and *T. equi* had been confused.

Uhlenhuth, Hübner and Worthe have demonstrated the presence of endotoxins in *T. equiperdum*. These endotoxins may be set free by trypanolysis.

Trypanosoma theileri, Bruce, 1902.

This parasite, 60 μ to 70 μ long, and 4 μ to 5 μ broad, is distinguished for its large size, though it is not so large as *T. ingens* from Uganda oxen, whose length may be 72 μ to 122 μ, and breadth 7 μ to 10 μ. The posterior end of *T. theileri* is drawn out. Small forms of the flagellate are known, 25 μ to 53 μ in length. Probably other forms of the parasite have the nucleus posterior, and these flagellates were formerly separated as *T. transvaaliense* (Laveran, 1902). Myoneme fibrils may be seen on its body. The pathogenicity of this organism is doubtful, it was formerly thought to be the causal agent of "gall-sickness" in cattle in South Africa. *T. theileri* also occurs in Togoland, German East Africa, and Transcaucasia. Allied or identical parasites occur in cattle in India.

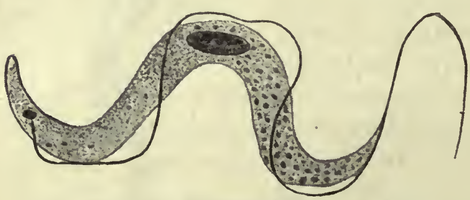


FIG. 44.—*Trypanosoma theileri*. × 2,000. (After Laveran and Mesnil.)

Trypanosoma theileri, specific to cattle, is perhaps transmitted by the fly *Hippobosca rufipes* in South Africa.

Trypanosoma hippicum, Darling, 1910.

Trypanosoma hippicum causes the disease of mules known as "murrina."[2] It was found in mules imported to Panama from the United States. It can live in other equines. The parasite varies from 18 μ to 28 μ in length, and is from 1·5 μ to 3 μ broad. Its undulating membrane is little folded. The trypanosome has a noticeable blepharoplast. It can penetrate mucous membranes, and it is thought that the trypanosome may be transmitted during coitus. It may also

[1] *Proc. Roy. Soc.*, B, lxxxvii, p. 89. [2] *Bull. Soc. Path. Exot.*, iii, p. 381.

be spread mechanically by species of *Musca*, *Sarcophaga* and *Compsomyia*, sucking the wounds of infected animals and carrying over the trypanosomes to wounds on healthy ones.

Endotrypanum schaudinni, Mesnil and Brimont, 1908.

This organism was discovered in the blood of a sloth (*Cholœpus didactylus*), in South America (French Guiana).[1] It possesses special interest, in that the best known form of the organism is endoglobular, inhabiting the erythrocytes of the sloth. A free trypanosome in the same animal was considered to be different from the endoglobular form, which was somewhat like a peg-top, and possessed a short flagellum. Darling[2] (November, 1914) has seen the organism in Panama. He describes free crithidial forms in shed blood, but not in the blood-stream of the sloth.

Trypanosoma boylei, Lafont, 1912.

This is a parasite of the Reduviid bug, *Conorhinus rubrofasciatus*. The insect attacks man in Mauritius, Réunion and other places. Lafont infected rats and mice by intraperitoneal injection with the gut-contents of infected bugs. Trypanosomes appeared in the mice. Other flagellate types were assumed by the parasites in the bug.

MONOMORPHIC TRYPANOSOMES.

A number of trypanosomes, characterized by relative uniformity in size and structure, may be considered under this heading. They occur in cattle, sheep, goats and horses in Africa, especially West Africa. Morphologically, they are characterized by the posterior (aflagellar) part of the body being swollen, while the anterior part narrows. The nucleus is central and situated at the commencement of the narrowing of the body. The blepharoplast is almost terminal, the undulating membrane is narrow and not markedly folded, so that the flagellar border lies close to or along the body. The flagellum may or may not possess a free portion.

Some recent workers have considered that *T. brucei* (Zululand strain) and *T. evansi* are also monomorphic, but they do not exhibit the general characteristics outlined above. *T. brucei* and *T. evansi* have already been considered separately.

The monomorphic trypanosomes, as defined above, include :—

Trypanosoma vivax, Ziemann, 1905.

This trypanosome[3] occurs in cattle, sheep and goats, and was first found in the Cameroons. It is fatal to cattle. Equines are also affected. Antelopes are the possible reservoirs of the trypanosome.

---

[1] *C. R. Soc. Biol.*, lxv, p. 581. [2] *Journ. Med. Research*, xxxi, p. 195.

[3] See Bruce and colleagues (1910), *Proc. Roy. Soc.*, B, lxxxiii, p. 15.

It is probably transmitted by *Glossina palpalis* and other tsetse flies. Its movement is very active. It possesses a free flagellum (fig. 45) and it averages 23 μ to 24 μ in length. *T. cazalboui* (Laveran, 1906)—the causal agent of "souma" in bovines and equines in the French Sudan—is probably synonymous with *T. vivax*.

Fig. 45.—*Trypanosoma vivax*. × 2,000. (Original. From preparation by Fantham.)

Trypanosoma capræ (Kleine, 1910) is allied, but is somewhat broader and more massive. It was found in goats in Tanganyika.

Trypanosoma congolense, Broden, 1904.

Probable synonyms.—*Trypanosoma dimorphon*, Laveran and Mesnil, 1904; *Trypanosoma nanum*, Laveran, 1905; *Trypanosoma pecorum*, Bruce, 1910; *Trypanosoma confusum*, Montgomery, 1909.

This trypanosome causes disease among horses (*e.g.*, Gambia horse sickness), cattle, sheep, goats, pigs, and dogs. It is widely distributed in Central Africa (*e.g.*, Gambia, Congo, Uganda, Nyasaland), the strain probably being maintained naturally in big game. It is transmitted by various *Glossinæ*, and perhaps by *Tabanus* and *Stomoxys*. It is said to develop in the gut and proboscis of *Glossina palpalis* and *G. morsitans*. The trypanosome averages 13 μ to 14 μ in length and has no free flagellum (fig. 46). It is about 2 μ broad. Formerly *T. nanum* and *T. pecorum* were said to differ in their pathogenicity, the former being said not to infect the smaller laboratory animals. Yorke and Blacklock (1913), however, consider that the virulence varies and that these trypanosomes are probably the same.

Fig. 46. — *Trypanosoma congolense*. × 2,000. (Original. From preparation by Fantham.)

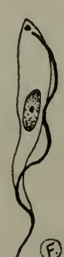


Fig. 47. — *Trypanosoma uniforme*. × 2,000. (Original. From preparation by Fantham.)

The *T. dimorphon* originally obtained by Dutton and Todd (1903) in Gambian horse sickness has been shown to be a mixture of *T. vivax* and *T. congolense*.

Trypanosoma simiae (*T. ignotum*) is like *T. congolense*. It averages 17·5 μ long. It is virulent to monkeys and pigs.

Trypanosoma uniforme, Bruce, 1910.

This trypanosome was found in oxen in Uganda.[1] It can be inoculated to oxen, goats and sheep, but is refractory to dogs, rats and guinea-pigs. It has been found in antelopes. It resembles *T. vivax*, but is smaller (fig. 47), averaging 16 μ in length. A free flagellum is present. It is transmitted by *Glossinæ*.

Many other trypanosomes occur in mammals, while birds, reptiles, amphibia (fig. 48) and fish also harbour them. The discussion of these forms does not come within the scope of the present work. They are dealt with in Laveran and Mesnil's "Trypanosomes et Trypanosomiases," 2nd edit., 1912.

Fig. 48. — *Trypanosoma rotatorium*, from blood of a frog. × 1,400. (After Laveran and Mesnil.)

General Note on Development of Trypanosomes in Glossina.

Before concluding the account of trypanosomes, it may be of interest to remark that several African trypanosomes develop in various species of *Glossina*, and are found in different parts of the alimentary tract and in the proboscis. Thus (*a*) *T. vivax*, *T. uniforme* and *T. capræ* develop in the fly's proboscis (labial cavity and hypopharynx) only; (*b*) *T. congolense*, *T. simiæ* and *T. pecaudi* develop first in the gut of the fly and then pass forward to its proboscis; and (*c*) *T. gambiense* and *T. rhodesiense* develop first in the gut and later invade the salivary glands of the tsetse. The proboscis or the salivary glands in such cases are termed by Duke[2] the *anterior station* of the trypanosome, wherein it completes its development.

Adaptation of Trypanosomes.

These flagellates may exhibit power of adaptation to changes of environment, such as those due to the administration of drugs, change of host, etc. A few examples of such mutations may be briefly considered :—

(1) *Blepharoplastless Trypanosomes.*—*T. brucei* may become resistant to pyronin and oxazine. Accompanying this drug resistance is a change in morphology, namely, the loss of the blepharoplast (Werbitzki).[3] A race or strain of blepharoplastless trypanosomes may be thus produced which retains its characteristic feature after as many as 130 passages (Laveran).[4] Oxazine is the more powerful drug, and it acts directly on the blepharoplast. (Compare the natural blepharoplastless character of *T. equinum*.)

[1] *Proc. Roy. Soc.*, B, lxxxiii, p. 176.

[2] *Repts. Sleeping Sickness Commission Roy. Soc.* (1913), xiii, p. 82.

[3] *Centralbl. f. Bakt.* (1910), Orig., liii, p. 303.

[4] *Bull. Soc. Path. Exot.*, iv, p. 233.

(2) Reference has been made on p. 93 to the experiments of Gonder, who showed that a strain of *T. lewisi* rendered resistant to arsenophenylglycin lost its resistance after passage through the rat louse. This is in marked contrast with the retention of drug resistance during passage by inoculation from rat to rat.

(3) *T. lewisi* from the blood of a rat when transferred to a snake seems largely to disappear, as very few flagellates are seen. When blood from the snake is inoculated into a clean rat, then trypanosomes reappear in the rat, but they are not all like those originally inoculated. It seems certain that, in such a case, changes in form and virulence of the trypanosome have occurred. Similar experiments were made with *T. brucei* from rats to adders and other animals and back to rats. Changes in the form and virulence of *T. brucei* occurred.

These interesting experiments were performed by Wendelstadt and Fellmer.[1]

Genus. **Herpetomonas**, Saville Kent, 1881.

Herpetomonas is a generic name for certain flagellates possessing a vermiform or snake-like body, a nucleus placed approximately centrally, and a blepharoplast (kinetic nucleus) near the flagellar end. There is no undulating membrane (fig. 49, *a*). The organisms included in this genus certainly possess one flagellum, while according to Prowazek (1904) *Herpetomonas muscæ-domesticæ*, the type species, possesses two flagella united by a membrane. Patton,[2] Porter[3] and others affirm, however, that the biflagellate character of *H. muscæ-domesticæ* (from the gut of the house-fly) is merely due to precocious division. The matter is further complicated by the generic name *Leptomonas*, given by Kent in 1881, to an uniflagellate organism found by Bütschli in the intestine of the Nematode worm, *Trilobus gracilis*. This parasite, *Leptomonas bütschlii*, has not yet been completely studied. Until these controversial points relating to the identity or separation of *Herpetomonas* and *Leptomonas* have been satisfactorily settled, we may retain the better known name *Herpetomonas* for such uniflagellate, vermiform organisms. However, the name *Leptomonas*, having been used by Kent two pages earlier in his book ("Manual of the Infusoria") than *Herpetomonas*, would have priority if the two generic names were ultimately shown to be synonymous.

A full discussion of these interesting and important flagellates hardly comes within the purview of the present work; brief mention can only be given here to certain species.

The Herpetomonads occur principally in the digestive tracts of insects, such as Diptera and Hemiptera. They are also known in the

---

[1] *Zeitschr. f. Immunitatsforschung*, iv, p. 422 (1909), and v, p. 337 (1910).

[2] *Arch. f. Protist.*, xiii, p. 1. [3] *Parasitology*, ii, p. 367.

guts of fleas and lice, but are not confined to blood-sucking insects. One example, *H. ctenocephali* (Fantham, 1912)[1] occurs in the digestive tracts of dog fleas, *Ctenocephalus canis,* in England, France, Germany, Italy, India, Tunis, etc. It is a natural flagellate of the flea, and might easily be confused with stages of blood parasites in the gut of the dog flea. Dog fleas are stated by Basile to transmit canine kala-azar, which is believed to be the same as human infantile kala-azar. Confusion is further likely to arise since herpetomonads pass through pre-flagellate, flagellate and post-flagellate or encysted stages; pre- and post-flagellate stages being oval or rounded and *Leishmania*-like. The post-flagellate stages are shed in the fæces, and are the cross-infective stages by means of which new hosts are infected by the mouth. The possible presence of such natural flagellates must always be considered when experimenting with fleas, lice, mosquitoes, etc., as possible vectors of pathogenic flagellates like *Leishmania* and *Trypanosoma*. *H. pediculi* (Fantham, 1912) occurs in human body lice.[2] See further remarks on pp. 107, 112.

Laveran and Franchini (1913-14)[3] have recently succeeded in inoculating *Herpetomonas ctenocephali*, from the gut of the dog flea, intraperitoneally into white mice, and producing an experimental leishmaniasis in the mice. A dog was also infected. They have also succeeded in infecting mice with *H. pattoni*—a natural flagellate of the rat flea—by mixing infected rat fleas with the food of the mice, and by causing them to ingest infected fæces of rat fleas. Further, they have shown that infection with the herpetomonas occurs naturally by this method, that is, by the rodents eating the fleas and not by the insects inoculating the flagellates into the vertebrates when sucking blood. These experiments shed an interesting light on the probable origin of *Leishmania* and its cultural herpetomonad stage, which were very probably once parasitic flagellates in the gut of an insect.

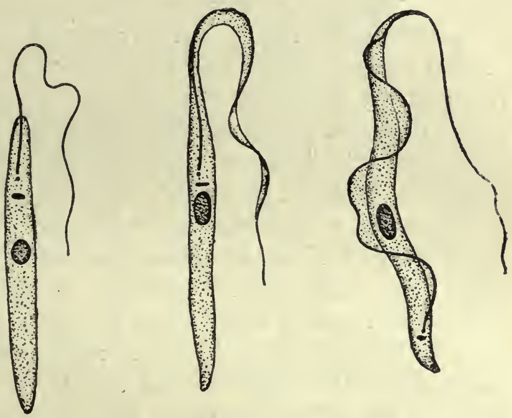


FIG. 49.—*a*, *Herpetomonas*; *b*, *Crithidia*; *c*, *Trypanosoma*. (After Porter.)

[1] *Bull. Path. Exot.*, vi, p. 254. [2] *Proc. Roy. Soc.*, B, lxxxiv, p. 505.

[3] *C. R. Acad. Sci.*, clvii, pp. 423, 744. *Ibid.*, clviii, pp. 450, 770. *Bull. Soc. Path. Exot.*, vii, 605.

Fantham and Porter[1] (1914-15) have shown that young mice may be inoculated or fed with *Herpetomonas jaculum*, from the gut of the Hemipteran, *Nepa cinerea* (the so-called "water-scorpion"), with fatal results. The pathogenic effects are like those of kala-azar. They also showed that the post-flagellate stages of the herpetomonads seemed most capable of developing in the vertebrate.

A herpetomonad, *H. davidi*, has been found in the latex of species of the plant-genus *Euphorbia* in Mauritius, India, Portugal, etc. It is apparently transmitted to the plants by Hemiptera. The plants sometimes suffer from "flagellosis."

Franchini (1913)[2] has described a new parasite, *Hæmocystozoon brasiliense*, from the blood of a man who had lived in Brazil for many years. It possesses flagellate and rounded stages, and is closely allied to the herpetomonads.

Genus. **Crithidia**, Léger, 1902, emend. Patton, 1908.

Crithidia is the generic name of vermiform flagellates with a central nucleus, a blepharoplast or kinetic nucleus in the neighbourhood of the principal nucleus, and a rudimentary undulating membrane bordered by a flagellum arising from a basal granule, which is the centrosome of the kinetic nucleus (fig. 49*b*). The anterior or flagellar end of the body is attenuated and fades off as the undulating membrane.

Crithidia fasciculata, the type species, was found by Léger in the alimentary canal of *Anopheles maculipennis*. Crithidia occur in bugs, flies, fleas,[3] and ticks. Some of them are found in the body-fluid of the invertebrate host as well as in the gut. Others may be restricted to the body cavity or intestine respectively. *C. melophagia* from the sheep-ked, *Melophagus ovinus*, and *C. hyalommæ* from the hæmocœlic fluid of the tick, *Hyalomma ægyptium*, pass into the ovaries and eggs of their hosts, and the young keds or ticks are born infected.

C. fasciculata has been shown by Laveran and Franchini to be inoculable into white mice, producing a sort of experimental leishmaniasis therein. In one case cutaneous lesions were produced like those of Oriental sore.

Crithidia are natural flagellates of Arthropoda, with their own pre-flagellate, flagellate and post-flagellate stages, and must not be confused with transitory crithidial stages of trypanosomes.

Genus. **Leishmania**, Ross, 1903.

With an oval body containing nucleus and blepharoplast (kinetic nucleus) but no flagellum. An intracellular parasite in the vertebrate host.

Included in the genus *Leishmania* are three species, namely :—

---

[1] *Proc. Camb. Philosoph. Soc.*, xviii, p. 39. [2] *Bull. Soc. Path. Exot.*, vi, pp. 156, 333, 377.
[3] See Porter, *Parasitology*, iv, p. 237.

(1) *Leishmania donovani*, Laveran and Mesnil, 1903, the parasite of Indian kala-azar, a generalized systemic disease, usually fatal, occurring in subjects of all ages.
(2) *Leishmania tropica*, Wright, 1903, the parasite of Delhi boil, Oriental sore, Aleppo button—a localized, cutaneous disease, usually benign.
(3) *Leishmania infantum*, Nicolle, 1908, the parasite of infantile kala-azar, occurring in children (and a few adults) around the shores of the Mediterranean. The disease is perhaps a form of Indian kala-azar, and the parasite is probably identical with *L. donovani*.

These diseases may be termed collectively leishmaniases. The morphology of the various species is practically identical.

Leishmania donovani, Laveran and Mesnil, 1903.

Syn.: *Piroplasma donovani*, Laveran and Mesnil.

The parasite of Indian kala-azar was demonstrated in 1900 by Leishman from a *post-mortem* examination of a case of "Dum-Dum fever," but details were not published till May, 1903. In July, 1903, Donovan found similar bodies from cases in Madras. Rogers succeeded in cultivating the parasite in July, 1904.[1] The original centre of the disease was probably Assam; it occurs also in Madras, Ceylon, Burma, Indo-China, China and Syria. A variety of this leishmaniasis is found in the Sudan. The patient becomes emaciated, with a greatly enlarged spleen. There is anæmia and leucopenia.

The parasite, commonly known as the Leishman-Donovan body, is intracellular (fig. 50, *2*, *3*). It is found in the endothelial cells of the capillaries of the liver, spleen, bone-marrow, lymphatic glands and intestinal mucosa, and in the macrophages of the spleen and bone-marrow. Some host cells may contain many parasites. It is rather rare in the circulating blood, but may be found in the blood from the femoral, portal and hepatic veins. It does not occur in the red blood corpuscles as was formerly thought. The parasites liberated from the endothelial cells are taken up by the mononuclear and polymorphonuclear leucocytes. The Leishman-Donovan body is the resting stage of a flagellate. As found in man it is a small, oval organism, about 2·5 μ to 3·5 μ in length by 2 μ in breadth, and containing two chromatinic bodies, corresponding to the nucleus and kinetic nucleus (blepharoplast) of a flagellate. The latter element is the smaller and more deeply staining, and is usually placed at the periphery, transversely to the longer axis of the oval organism.

---

[1] The literature up to 1912, on kala-azar and other leishmaniases is reviewed in the *Kala-azar Bulletin*. Afterwards in the *Tropical Diseases Bulletin*.

There is sometimes a very short, slightly curved filament to be seen, which may be a rhizoplast. Multiplication takes place by binary or multiple fission. The presence of the parasite used to be demonstrated by splenic or hepatic puncture; nowadays it can be demonstrated in peripheral blood, *e.g.*, of the finger, or by culture of infected blood.

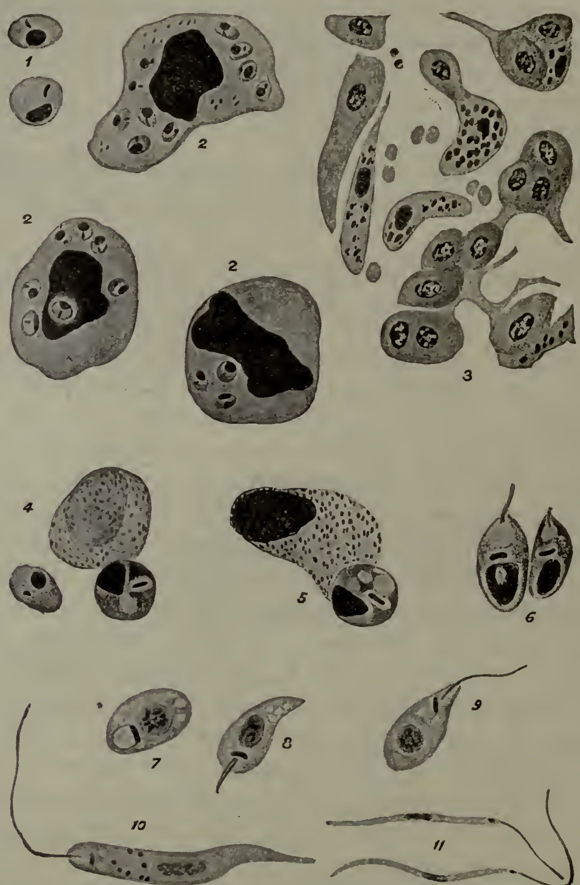


FIG. 50.—*Leishmania donovani*. *1*, Free forms, each with nucleus and rod-shaped blepharoplast (after Christophers); *2*, endothelial cell and leucocytes containing parasites (after Christophers); *3*, capillary in the liver showing endothelial cells containing parasites (after Christophers); *4*, two parasites escaping from a leucocyte in the alimentary canal of the bug (after Patton); *5*, further development in bug (after Patton); *6*, young flagellate forms in bug (after Patton); *7-11*, culture forms (after Leishman); *7*, *8*, *9*, show development of flagellum.

L. donovani can be cultivated in citrated splenic blood, under aerobic conditions, at 22° to 25° C. This was first accomplished by Rogers (1904). It is not so easily culturable as *L. infantum* on the Novy-MacNeal-Nicolle medium.[1] *L. donovani* is inoculable with

[1] For the composition of this medium, see Appendix.

some difficulty into experimental animals—in India, white rats, white mice, dogs and monkeys (*Macacus spp.*), have been inoculated. The Sudan variety, somewhat less virulent, is inoculable to monkeys. Row also produced a local lesion in *Macacus sinicus* by subcutaneous inoculation of *L. donovani*. Parasites taken from such a local lesion were found to be capable of producing a generalised infection in *Macacus sinicus* and white mice.

In cultures the various species of *Leishmania* all grow into herpetomonad, uniflagellate organisms (fig. 50, *10*), about 12 μ to 20 μ in body length. On this account Rogers[1] and Patton place the Leishman-Donovan body within the genus *Herpetomonas*. The method of culture may be used in diagnosing leishmaniases.

Kala-azar is very probably an insect-borne disease. Patton[2] suspects the bed-bug to be the transmitter and finds (fig. 50, *4-6*) that the Leishman-Donovan body can develop into the flagellate stage in the digestive tract of the bed-bug. Feeding experiments are unsatisfactory, since there are very few cases in which the parasites occur in sufficient numbers in the peripheral blood to make the infection of the insect possible, or at any rate easy. In examining the alimentary tracts of insects for possible flagellate stages of *Leishmania*, it must be remembered that in many insects natural flagellate parasites, belonging to the genus *Herpetomonas*, may occur therein ; such natural insect flagellates may be harmless, and have no connection with the life-cycle of *L. donovani*. Natural herpetomonads are known to occur in the alimentary tracts of flies, mosquitoes, sand-flies, fleas and lice, but not in bed-bugs. Further, if such flagellates are able to be inoculated into and live within vertebrate hosts, producing symptoms like those of leishmaniasis, the origin of kala-azar is indicated (see pp. 104, 112).

Leishmania tropica, Wright, 1903.

Syn. : *Helcosoma tropicum*, Wright, 1903 ; *L. wrighti*, Nicolle, 1908 ; *Ovoplasma orientale*, Marzinowsky and Bogrow.

It is believed by some that the parasite was first described by Cunningham in 1885, and studied by Firth in 1891, being called by him *Sporozoon furunculosum*. If these earlier studies were of the parasite, then its correct name is *L. furunculosa*, Firth, 1891.

The benign disease produced by this parasite has received many names, among the best known being Oriental sore, Tropical sore, Delhi boil and Aleppo button. These names, however, are not happy ones, as cutaneous leishmaniasis (*e.g.*, on the ear) is now known to occur in the New World, for example in Mexico, Venezuela, Brazil and neighbouring States. However, it may be necessary to subdivide cutaneous leishmaniases later.

---

[1] *Proc. Roy. Soc.*, B, lxxvii, p. 284.

[2] *Sci. Mem. Govt. India*, Nos. 27, 31 (1907-08).

In the Old World the disease occurs in India, Persia, Arabia and Transcaucasia. It is also known in Algeria, Northern Nigeria, Egypt, Sudan, Crete, Calabria, Sicily and Greece.

The boils often occur on the face, and before ulceration the parasites may be found in the cells at the margin and floor of the "button." In searching for parasites the scab should be removed and scrapings made from the floor and edges. Where lesions occur atrophy of the epidermis takes place, and infiltration of mononuclear cells (*e.g.*, plasma cells, lymphoid and endothelial cells) follows. The parasites are intracellular, being found inside mononuclear cells. In non-ulcerating sores, Cardamitis found some free parasites. Non-ulcerating forms are said to occur in the Sudan. In the Old World the sores are often limited to exposed surfaces of the body. Infection of mucous membranes (such as the lip, palate, buccal and nasal membranes) may occur, especially in South America, and are often known there as "Espundia." Christopherson (1914) has recorded a case in Khartoum.

Leishmania tropica is equally well cultivated on Novy-MacNeal-Nicolle medium or on citrated blood. The usual temperature for cultivation is 22° to 28° C., though Marzinowski claims to have cultivated the parasite at 37° C. *L. tropica* can be inoculated into monkeys and dogs, with the production of local lesions. Material from a human sore or flagellates from a culture may be thus successfully inoculated. Also infected material may be rubbed directly into a scarified surface. The incubation period is long, extending over several months. The duration of the disease may be from twelve to eighteen months. Recovery from one attack of tropical sore confers immunity, and the Jews in Bagdad inoculate their children with the disease on a part of the body which will be covered, and so secure immunity in adult life.

The mode of transmission of *L. tropica* is unknown. Wenyon (1911)[1] has found that the parasite develops into the flagellate stage in the digestive tract of *Stegomyia fasciata* in Bagdad. Patton (1912)[2] has found similar development in the bed-bug in Cambay. The house-fly, *Phlebotomus* and *Simulium* have been suspected as transmitters in different parts of the world.

An interesting announcement has been made recently (May, 1913), that Neligan has found that *L. tropica* occurs in dogs in Teheran, Persia, producing ulcers on the dogs' faces (*cf.* natural occurrence of *L. infantum* in dogs—see p. 110). Yakimoff and Schokhor (1914),[3] have found the disease in dogs in Tashkent.

Gonder[4] (1913) has performed some interesting experiments

---

[1] *Parasitology*, iv, p. 387.
[2] *Sci. Mem. Govt. India*, No. 50.
[3] *Bull. Soc. Path. Exot.*, vii, p. 186.
[4] *Arch. f. Schiffs- u. Trop.. Hyg.*, xvii, p. 397.

showing the relation of infantile kala-azar to Oriental sore. Gonder infected mice with *L. infantum* and with *L. tropica*. He used culture material and injected intraperitoneally or intravenously. In each a general infection resulted, with enlargement of the liver and spleen. Later, however, mice injected with Oriental sore (North African variety) developed peripheral lesions on the feet, tail and head, and the lesions contained *Leishmania*. No such peripheral lesions developed in the case of the mice infected with the kala-azar virus. Gonder suggested that Oriental sore, like kala-azar, is really a general infection overlooked in its earlier stages, and that it is in the later stages that peripheral lesions on the skin are developed. Row (1914)[1] also obtained a general infection in a mouse by the injection of cultures of *L. tropica* from Oriental sore of Cambay.

Leishmania infantum, Nicolle, 1908.[2]

Infantile splenic anæmia has been long known in Italy. It also occurs in Algeria, Tunis, Tripoli, Syria, Greece, Turkey, Crete, Sicily, Malta,[3] Spain and Portugal. This leishmaniasis is, then, distributed along the Mediterranean littoral; also in Russia. Cathoire (1904) in Tunis and Pianese (1905) in Italy were among the first to see the parasite. Nicolle then found the parasite in patients in Tunis, and further found spontaneous infection in dogs. The patients are usually children between the ages of 2 and 5 years. There are a few cases known in which the infantile type of leishmaniasis occurred in youths and adults of the ages of 17 to 19, while one patient in Calabria was 38 years old. The symptoms are like those of Indian kala-azar. Several Italian investigators and others consider that *L. infantum* is the same as *L. donovani*, and that the latter name should be used for the parasite of Mediterranean leishmaniasis. This view, as to the identity of *L. donovani* and *L. infantum*, seems coming into general favour.

There are, however, differences between the Indian and infantile kala-azars, in addition to the ages of the patients affected, thus: (*a*) As regards cultures, it is found that *L. infantum* is readily grown on the Novy-MacNeal-Nicolle ("N.N.N.") medium (saline blood-agar), and that sub-cultures are easily obtained; in citrated blood *L. infantum* grows with difficulty. The reverse is the case with regard to culture media for *L. donovani*, which grows with difficulty on the N.N.N. medium, but relatively easily in citrated splenic blood. (*b*) Considering inoculability into experimental animals, it is found that *L. donovani* is inoculated generally with some difficulty into white rats,

[1] *Bull. Soc. Path. Exot.*, vii, p. 272. [2] *Arch. Inst. Pasteur Tunis*, i, p. 26.

[3] *See* Wenyon (1914), *Trans. Soc. Trop. Med. and Hyg.*, vii, p. 97; also Critien (1911), *Annals Trop. Med. and Parasitol.*, v, p. 37.

white mice and monkeys, and with greater difficulty into dogs, while *L. infantum* can be inoculated into several experimental animals, especially into dogs and monkeys, with ease. (*c*) At present *L. donovani* is not known to occur spontaneously in animals, but *L. infantum* is found naturally in dogs in the Mediterranean region, and the disease in dogs is often referred to as canine kala-azar. Kittens have occasionally been found infected. However, these differences must not be emphasized too much.

The material for cultivation is obtained from punctures of spleen, liver or bone-marrow of cases infected with *L. infantum*. It is not always easy, however, to infect from cultures, as the cultural flagellates inoculated into the body are often phagocytosed.

Similarly, the material for animal inoculation is obtained from emulsions of infected spleen, liver or bone-marrow. Dogs and monkeys are easily inoculated with such material; Nicolle inoculates into the liver or the peritoneal cavity. Mice, white rats, guinea-pigs and rabbits only show slight infections after such inoculations.

Dogs infected experimentally with infantile leishmaniasis may show either acute or chronic symptoms. The acute course occurs more often in young dogs, and is usually fatal in three to five months. The chronic course is found more commonly in older dogs, and may last seventeen to eighteen months. In acute forms there is irregular fever, progressive wasting, diarrhœa occasionally, motor disturbances involving the hind quarters, and the animal dies in a comatose condition. In the chronic form the animal may appear well, except for loss of weight. The parasites may be found in the internal organs of these experimental dogs, but are not numerous in the peripheral blood except at times of high fever. Experimental monkeys live about three months.

It may be interesting to record the number of dogs found to be infected naturally with leishmaniasis in various countries. In Tunis, Nicolle and Yakimoff found about 2 per cent. infected out of about 500 dogs examined. Sergent in Algiers found 9 infected out of 125 dogs examined. In Italy and Sicily, Basile found about 40 per cent. of the dogs to be infected out of 93 examined at Rome and Bordonaro. Cardamitis found 15 infected out of 184 examined in Athens. In Malta, Critien found 3 infected out of 30 dogs examined. Alvares found 1 infected dog out of 19 examined in Lisbon. Pringault has recently (December, 1913) found an infected dog in Marseilles.[1] Yakimoff and Schokhor found 24 per cent. infected out of 647 dogs examined in Turkestan.

The distribution of the parasites in the body of the human patient is much the same as in the case of Indian kala-azar. Critien records

[1] *Bull. Soc. Path. Exot.*, vii, p. 41.

the finding of parasites in the mucous flakes of the stools of a three-year-old Maltese child.[1] Intestinal lesions rarely occur in infantile leishmaniasis.

Ætiology.—Infantile leishmaniasis is stated to be transmitted by fleas, especially dog fleas, *Ctenocephalus canis* (= *Pulex serraticeps*), and by *Pulex irritans*. Children living in contact with infected dogs may be bitten by infected dog fleas, and so contract the disease. Basile (1910-11) and Sangiorgi (1910) state that they found *L. infantum* parasites in the digestive tract of the dog flea. After searching they found infected dog fleas on the beds, mattresses, and pillows used by children suffering from the disease. Franchini (1912) thinks that *Anopheles maculipennis* may be concerned in the transmission.

Basile[2] tried a number of experiments to show that infantile leishmaniasis is transmitted by fleas, thus :—

(1) Fleas were taken from a healthy dog. They were placed in vessels containing infected spleen-pulp and allowed to feed thereon. The fleas were then killed and dissected, and portions of the gut-contents examined for parasites. The remainder of the gut was emulsified and injected into a young puppy, whose bone-marrow had been shown previously to be uninfected. Basile states that the puppy became infected. The parasites are said to increase in number in the flea's gut.

(2) Two healthy pups, each a month old, and born in the laboratory, were placed in a disinfected, flea-proof cage. A few days after, an infected dog was placed in the cage, so that fleas from the infected dog could pass on to the puppies. A month later the two pups became infected, parasites being found in them after liver puncture. A number of control puppies from the same litter remained uninfected and in good health.

(3) Basile next used other laboratory-born puppies, a month old. Four of the litter were placed in a disinfected, flea-proof gauze cage in Rome. The cage was isolated from other dogs. Fleas obtained from an infected area in Sicily were placed in the cage. The puppies were examined by hepatic puncture, but were found to be negative for two months. Then two of the puppies showed infection, and six days later the remaining two puppies were found to be infected, and all four died. They showed irregular temperatures, and were getting thin. Control puppies remained healthy.

From these experiments Basile concludes that fleas transmit leishmaniasis. However, Basile did not exclude the possible occurrence of natural herpetomonads in the gut of the fleas.[3] *Herpetomonas*

---

[1] Quoted by Leishman (1911) in his interesting review of Leishmaniasis, *Journ. Roy. Army Med. Corps*, xvii, p. 567, xviii, pp. 1, 125. Also *Quart. Journ. Med.* v, pp. 109-152.

[2] Numerous papers in *Rendiconti R. Accad. dei Lincei* (Rome), xix, xx (1910-11).

[3] See Fantham, *Brit. Med. Journ.*, 1912, ii, p. 1196.

ctenocephali is known to occur in the gut of *Ctenocephalus canis* A natural *Herpetomonas* is also known in the gut of *Pulex irritans,* as well as a *Crithidia* (*C. pulicis*, Porter). These natural flagellates of the fleas pass through non-flagellate stages, like the Leishman-Donovan body. In consequence Wenyon and Patton, among others, have criticized Basile's results. Further, other investigators, such as Wenyon and Da Silva (1913), have repeated Basile's flea experiments and been unable to confirm them.

In feeding and inoculation experiments the incubation period of the parasite may be long, and so it is necessary to wait a long time to see whether the parasite will develop.

Immunity.—Nicolle has tried some experiments with *L. infantum* and *L. tropica*. He finds that in animals recovery from an attack of the former confers immunity against infection by the latter and vice-versâ.

Laveran[1] records that a monkey having an immunity against *L. infantum* was also immune to *L. donovani*.

As mentioned on p. 103, Laveran and Franchini (1913), working in Paris, have succeeded in inoculating *Herpetomonas ctenocephali*, a natural flagellate in the gut of the flea, *Ctenocephalus canis,* into white mice. Leishmaniform stages of the flea flagellate were recovered from the peritoneal exudate, blood and organs of the mice some weeks after inoculation. The parasites may also be conveyed by way of the digestive tract of the vertebrate. Similar experiments have succeeded with *H. pattoni*. These experiments go to show, together with those of Fantham and Porter with *H. jaculum* (see p. 104), that, in the words of the latter authors, "it may be expected that the various leishmaniases, occurring in different parts of the world, will prove to be insect-borne herpetomoniases."

Genus. **Histoplasma,** Darling, 1906.

Under the name *Histoplasma capsulatum*,[2] Darling described small round or oval parasites, enclosed in a refractile capsule, and each containing a single nucleus. The bodies were found in cases of splenomegaly in Panama. They occurred in the endothelial cells of the small blood-vessels of the liver, spleen, lungs, intestine and lymphatic glands, and also within the leucocytes. A few flagellates were stated to occur in the lungs. The parasite has usually been placed near *Leishmania,* but recently Rocha-Lima has stated that *Histoplasma* is a yeast.

Genus. **Toxoplasma,** Nicolle and Manceaux, 1908.

The genus was created for crescentic, oval or reniform parasites, 2·5 μ to 6 μ by 2 μ to 3 μ, possessing a single nucleus and multiplying by binary fission. They occur

---

[1] *Annales Inst. Pasteur* (1914-15), xxviii, pp. 823, 885; xxix, pp. 1, 71.

[2] *Journ. Amer. Med. Assoc.*, xlvi, p. 1283: *Journ. Exptl. Med.* (1909), xi, p. 515.

in mononuclear and polymorphonuclear cells in the blood, spleen, liver, peritoneum etc. (fig. 51). The parasites have been found in the gondi, dog, rabbit, mole, mouse, pigeon and other birds. Although various species names have been given to the parasites in these hosts, it seems probable, from cross infection experiments, that there is but one species with several physiological races. Splendore[1] (1913) has described a flagellate stage.

Castellani (1913-14)[2] has described similar parasites from a case of splenomegaly, with fever of long standing, in a Sinhalese boy. The

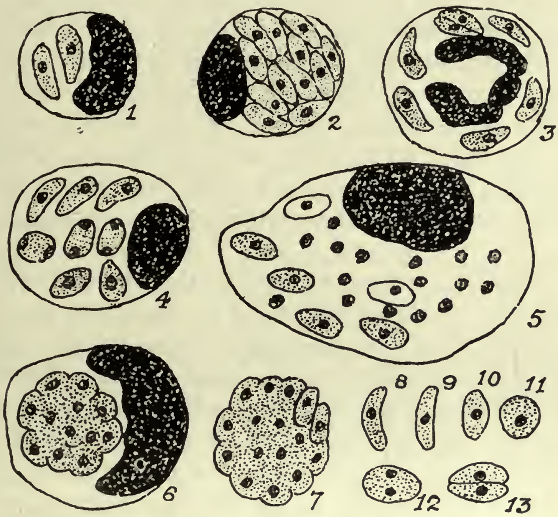


FIG. 51.—*Toxoplasma gondii*, endocellular or free in the peritoneal exudate of infected mice. 1, 2, mononuclear leucocytes containing toxoplasms. 3, polynuclear, containing parasites. 4, 5, 6, endothelial cells containing toxoplasms, agglomerated in 6. 7, agglomeration forms. 8-11, free forms. 12-13, division stages. × 1,600. (After Laveran and Marullaz.)

FIG. 52.—*Toxoplasma pyrogenes*. 1, body found in blood. 2-7, bodies found in spleen. [1 is about the size of a red blood corpuscle, as drawn in the figures]. Magnification not stated. (After Castellani.)

bodies were found in the spleen and more rarely in the blood (fig. 52). Castellani has named them *Toxoplasma pyrogenes*. Further researches are needed.

[1] *Bull. Soc. Path. Exot.*, vi, p. 318. [2] *Journ. Trop. Med. and Hyg.*, xvii, p. 113.

THE SPIROCHÆTES.

The Spirochætes are long, narrow, wavy, thread-like organisms, with a firm yet flexible outer covering or periplast. There is a diffuse nucleus internally in the form of bars or rodlets of chromatin distributed along the body. In some forms there is a membrane or crista present (fig. 53), which in the past was compared with the undulating membrane of a trypanosome, but the membrane of a spirochæte does not undulate. Progression is very rapid, corkscrew-like and undulatory movements occurring simultaneously.

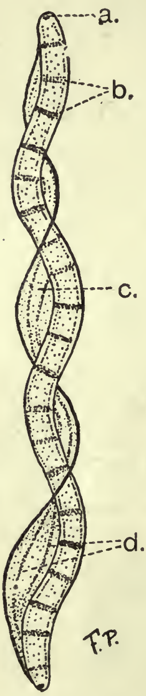


FIG. 53.—*Spirochæta balbianii*. *a*, basal granule or polar cap. *b*, chromatin rodlets. *c*, membrane ("crista"). *d*, myonemes in membrane. (After Fantham and Porter.)

The genus *Spirochæta* was founded by Ehrenberg in 1833 for an organism which he discovered in stagnant water in Berlin. Ehrenberg named the organism *Spirochæta plicatilis*. According to Zuelzer (1912) *S. plicatilis* does not possess a membrane or crista, but an axial filament. *S. gigantea* has been described by Warming from sea-water.

Spirochætes occur in the crystalline style and digestive tract of many bivalve molluscs. The first molluscan spirochæte to be studied was that of the oyster, named by Certes (1882) "*Trypanosoma*" *balbianii* (fig. 53). Similar spirochætes, probably belonging to the same species, occur in various species of *Tapes* and in *Pecten* (the scallop). *S. balbianii* has rounded ends (fig. 53). Other spirochætes occur in fresh-water mussels (*Anodonta* spp). *S. anodontæ*, studied by Keysselitz (1906) and by Fantham (1907), has pointed ends. Gross (1911) suggested the generic name *Cristispira* for molluscan spirochætes, because they possess a well-marked membrane or "crista," which appears to be absent from *S. plicatilis*, according to Zuelzer's researches.

Schaudinn in 1905 founded the genus *Treponema* for the parasite of syphilis (*T. pallidum*), discovered by him and by Hoffmann. According to Schaudinn the Treponemata have no membrane or crista. The pathogenic agent of yaws or frambœsia, discovered by Castellani, is also placed in the genus *Treponema*, as *T. pertenue*.

There remain the blood spirochætes. It is somewhat disputed as to whether these organisms possess a membrane. The present writer considers that they have a slight membrane or crista. The name of the genus in which to place the blood-inhabiting forms is somewhat uncertain and disputed. Various generic names given to them are *Spirochæta*, *Treponema*, *Spiroschaudinnia* (Sambon) and *Borrelia* (Swellengrebel). Included in this division are the causal agents of relapsing or recurrent fever. These Protists will be named, for description, Spirochætes without prejudice as to the ultimate correct generic name.

It is sometimes made a matter of argument as to whether the spirochætes are Protozoa or Bacteria. Such arguments are somewhat unprofitable. Morphologically the spirochætes are like the Bacteria in possessing a diffuse nucleus. They differ from *Spirillum*, an undoubted bacterial genus, in being flexible and not possessing flagella. Molluscan spirochætes, however, may appear to have flagella if their membrane becomes frayed or ruptured, when the myonemes therein (fig. 53), becoming separated, form apparent threads or flagella (Fantham, 1907-08).[1]

Again, the mode of division of spirochætes has been used as a criterion of their bacterial or protozoal affinity. They have been stated to divide transversely, longitudinally, and by "incurvation," or bending on themselves in the form of a U, "a form of transverse fission." The present writer believes that they divide both transversely and longitudinally, and that there is a periodicity in their mode of division at first longitudinal (when there are few spirochætes in, say, the blood) and then transversely (when spirochætes are numerous in the blood).[2] Some authors consider that longitudinal division is explained by "incurvation."

The spirochætes of relapsing fever show a remarkable periodic increase and decrease in numbers in the blood. They are transmitted by ticks or by lice. They react to drugs (*e.g.*, salvarsan or "606") rather like trypanosomes, and—like Protozoa, but unlike Bacteria—they are cultivated with difficulty. These and other criteria have been used to endeavour to determine whether they are Protozoa or Bacteria. The present writer believes that they are intermediate in character, showing morphological affinities with the Bacteria and physiological and therapeutical affinities with the Protozoa. The group Spirochætacea, as an appendix to the Protozoa, has been created for them by the present writer (Jan., 1908). Others have placed them in the Spirochætoidea of the Bacteria or with the Spirillacea. Doflein (1909) called them Proflagellata. Further discussion is unnecessary, as they are undoubtedly Protista (see p. 29).

There is no true conjugation, sex or encystment in spirochætes, but morphological variation may occur.[3] They may agglomerate.

---

[1] *Quart. Journ. Microsc. Sci.*, lii, p. 1. [2] *Proc. Roy. Soc.*, B, lxxxi, p. 500.
[3] Fantham, *Parasitology*, ii, p. 392.

The Spirochætes form an interesting chapter in the evolution of parasites. There are free living forms, parasitic forms in the guts of both vertebrates and invertebrates, and blood-inhabiting forms. These probably represent the order of evolution of parasitism. The blood-inhabiting forms are pathogenic to warm-blooded hosts.

We must now consider the blood Spirochætes and the Treponemata (organisms of syphilis and of yaws).

THE SPIROCHÆTES OF THE BLOOD.

There are at least two important human parasites included hereunder :—

(*a*) *Spirochæta recurrentis* (= *S. obermeieri*), (*b*) *Spirochæta duttoni.*

More is known of the life-cycle of *Spirochæta duttoni*, and it will be convenient to consider that first.

Spirochæta duttoni, Novy and Knapp, 1906.

The specific name *duttoni* was also given, independently, to this parasite in 1906 by Breinl and Kinghorn.

S. duttoni is the pathogenic agent of African tick fever in man, prevalent in the Congo State and other parts of Africa. The full-grown organism is about 16 μ to 24 μ long, and has pointed ends. It is 0·25 μ to 0·5 μ broad. P. H. Ross and Nabarro were among the earliest to see a spirochæte in the blood of patients in Uganda. It is transmitted by the tick, *Ornithodorus moubata.*

In the blood of the patient some of the spirochætes may show, after staining, lighter and darker portions (chromatin dots) and evidence of the possession of a very narrow membrane (fig. 54). The mode of division has already been discussed. Periodicity in the direction of division was first described by Fantham and Porter,[1] (1909). Just before the crisis in African tick fever, Breinl has stated that *S. duttoni* becomes thinner in the spleen and bone-marrow and rolls up into skein-like forms, which are surrounded by a thin "cyst" wall (probably the periplast). Such occur in apyrexial periods. Inside the cyst the spirochæte breaks up into granules. Balfour and Sambon have described somewhat similar rolled up forms, breaking into granules, inside the red blood cells of Sudanese fowls in the case of *S. granulosa* (possibly only a variety of *S. gallinarum*). The intracorpuscular stage is not definitely established.

The granule phase, however, is an essential one in the invertebrate transmitter (fig. 54*c*). In 1905,[2] Dutton and Todd proved experimentally that *O. moubata* transmitted *S. duttoni*. They fed ticks, obtained

[1] *Proc. Roy. Soc.*, B, lxxxi, p. 500.

[2] *Liverpool Sch. Trop. Med., Memoir* xvii ; *Lancet*, Nov. 30, 1907, p. 1523.

from Congo native huts in which infected persons lived, on monkeys and the latter became infected. Dutton and Todd also found the offspring of infected ticks to be capable of transmitting the infection to experimental animals. They concluded that *O. moubata* was a true intermediate host.

A little later in 1905, Koch stated that spirochætes from the gut of the tick penetrated the gut wall and tissues and found their way into the eggs in the ovary. Koch figured tangled masses of spirochætes as occurring in the tick eggs. He found ticks infective to the third generation. He thought that the infection was spread by the salivary fluid of the tick, in the act of biting. (This is now known to be incorrect.) Markham Carter (1907) corroborated Koch's work on the spirochætes in the tick eggs, and they have been seen since by Kleine and Eckard (1913).

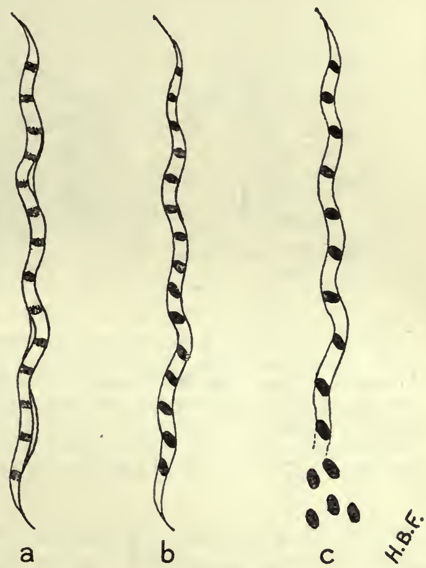


FIG. 54. — *Spirochæta duttoni*. *a*, blood form showing slight membrane; *b*, granules or coccoid bodies clearly formed within the organism; *c*, beginning of extrusion of coccoid bodies in the tick. (After Fantham.)

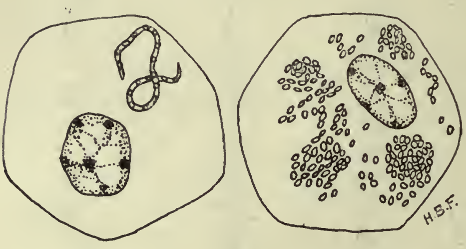
Sir William Leishman,[1] in 1909-10, found that at ordinary temperatures the salivary glands of infected ticks (*O. moubata*) were not themselves infective, and that the infection occurred by way of the ticks' excretion. The spirochætes (contained in the ticks' excrement) found their way into the vertebrate host through the wound made by biting. While feeding, ticks pass large quantities of clear fluid from the coxal glands; in this fluid an anticoagulin occurs. Some of the ticks also pass thick, white Malpighian secretion, that is, excrement, towards the end of the feed. Leishman, using experimental monkeys, showed that if infected ticks were interrupted while feeding, then no infection resulted in the monkeys. If, however, the ticks were allowed to finish their feed, and the Malpighian secretions were passed, then the experimental monkeys became infected. Fantham[2] and Hindle[3] (1911), independently, have repeated the experiments with mice.

[1] *Journ. Roy. Army Med. Corps*, xii, p. 123; *Lancet* (1910), clxxviii, p. 11.
[2] *Annals Trop. Med. and Parasitol.*, v, p. 479. [3] *Parasitology*, iv, p. 133.

Leishman's methods and results may be summarized thus: Saline emulsions of the organs of infected ticks were made, after the organs had been most carefully dissected out. The ticks were first kept for several days at certain constant temperatures, such as 24° to 25° C. or blood heat, 37° C. The saline emulsions of the organs were inoculated, separately, into experimental animals, and the results recorded :—

	At 24° C.	At 37° C.
Salivary glands	Negative ...	Positive
Malpighian tubules	Positive ...	Positive
Gut and contents	Positive ...	Positive
Excrement	Positive ...	Positive
Genital organs	Positive ...	Positive

Coxal fluid is usually negative; thick, white excrement from Malpighian tubes is positive.



a *b*

FIG. 55.—*Spirochæta duttoni* and its coccoid bodies in the tick (*O. moubata*).—Mononuclear cells of the tick (*O. moubata*) containing (*a*) Spirochæte breaking up into coccoid bodies; (*b*) Similar tick-cell containing coccoid bodies or granules. Such mononuclear cells occur in various organs of ticks and in developing Malpighian tubules. (Original. From preparations by Fantham.)

When the ticks were incubated at 21° to 24° C. no spirochætes, as such, were seen in the organs, except perhaps in the gut, where they often disappeared in a few days. When the ticks were previously incubated at 35° to 37° C. for two to three days, spirochætes, as such, reappear in the gut, organs and hæmocœlic fluid. The infection proceeds, not from the salivary gland, but from the infective excrement, that is, from the thick, white material voided by the tick while feeding, usually towards the end of the meal. This Malpighian excrement passes into the wound caused by the bite, being greatly aided by the clear and more limpid coxa fluid, which bathes the under surface of the tick's body, and mixes with and carries the infective excrement into the wound. Ticks remain infective for a long time.

The spirochætes in the gut of infected ticks divide by a process of multiple transverse fission into granules, which are composed of chromatin (fig. 54). These granules—sometimes known as coccoid bodies—are capable of multiplication. Leishman first found them in clumps inside the cells of the Malpighian tubules (*cf.* fig. 55).

To summarize, when spirochætes are ingested by a tick, some of them pass through the gut-wall into the hæmocœlic (body) fluid. They then bore their way into the cells of various organs (fig. 55 *a*) and break up into coccoid bodies. In this manner the granules find their way into the ovaries and ova, thus explaining how the young ticks are born infected. Inoculation of these chromatinic granules usually produces infection. Infective granules are also seen in the rudiments of the Malpighian tubules of embryo ticks. Bosanquet and Fantham (1911), independently, have shown that molluscan spirochætes also break up into similar granules or coccoid bodies. Gross has also demonstrated multiple transverse fission in molluscan forms. Marchoux and Couvy (1913) and Wolbach (1914) consider the granules or coccoid bodies to be degeneration products. This is unlikely (see below).

Schuberg and Manteufel have found that certain *O. moubata*, perhaps 30 per cent. of the specimens of a given neighbourhood, may acquire a natural active immunity against infection with *S. duttoni*.

S. duttoni, or a closely allied form (by some termed *S. novyi*), occurs in Colombia, and is spread by the tick *Ornithodorus turicata*. In Panama a similar spirochæte is probably spread by *O. talaje*.

Spirochæta gallinarum, Stephens and Christophers, 1905 (= **Spirochæta marchouxi**, Nuttall, 1905).

This Spirochæte, which occurs in fowls and is pathogenic, is transmitted by the tick *Argas persicus*. It is about 10 μ to 20 μ long. There is a pathogenic spirochæte known to occur in geese, named by Sakharoff (1891) *S. anserina*, and found in Caucasia. This may be the same as *S. gallinarum*, in which case the name *S. anserina* will have priority. These organisms cause fever, diarrhœa, anæmia and death. The life history of the avian pathogenic spirochætes has been studied by Balfour, by Hindle[1] and by Fantham.[2] It is essentially similar to that of *S. duttoni*.

Marchoux and Couvy[3] (1913) consider that the "fragmentation of the chromatin" in spirochætes is a process of degeneration. Working with *A. persicus* and *S. gallinarum*, they state that a large number of the spirochætes ingested by the Argas almost immediately pass through the wall of the alimentary canal and appear in the hæmocœlic fluid. Marchoux and Couvy consider that Leishman's granules may be found in the Malpighian tubules of various Arachnids. They found spirochætes in the cephalic glands of infected Argas. They consider that spirochætes remain as wavy spirochætes within the tick, if they are to be infective, though the spirochætes may become so thin as to be invisible! The latter argument is obviously weak, and it was never asserted that all granules in the Malpighian tubules of infected ticks were derived from spirochætes. With dark-ground

[1] *Parasitology*, iv, p. 463. [2] *Annals Trop. Med. and Parasitol.* (1911), v, p. 479.
[3] *Annales Inst. Pasteur*, xxvii, pp. 450, 620.

illumination small, refractile spirochætal granules may be seen to grow into spirochætes. The granule phase of spirochætes has recently been discussed by Fantham[1] (1914).

Spirochæta recurrentis, Lebert, 1874.

Syn.: *Spirochæta obermeieri*, Cohn, 1875.

This organism was discovered by Obermeier (1873) in cases of relapsing fever in Berlin. Short forms 7 μ to 9 μ long, and longer (probably adult) forms, 16 μ to 19 μ, are found in the blood. The width is 0·25 μ. Parasites 12 μ or 13 μ long are often observed.

The spirochæte is found in the blood during febrile attacks and relapses, but not during intervening periods. It can be inoculated into monkeys, rats and mice. It can live in the bed-bug, *Cimex lectularius*, and Nuttall has succeeded in transmitting *S. recurrentis* from mouse to mouse by the bites of the same bug. The French investigators Sergent and Foley (1908-9) in Algeria, and Nicolle, Blaizot and Conseil (1912) in Tunis, have shown experimentally that *S. recurrentis* (var. *berbera*) is transmitted by lice. The latter workers also demonstrated the method of infection that commonly occurs, namely, by the scratching of the skin and crushing of lice containing spirochætes on the excoriated surface of the body.

Lice as transmitting agents for relapsing fever were indicated by Mackie[2] in 1907. An epidemic among Indian school children furnished the materials.[3] It was noted that out of 170 boys, 137 were infected, and the boys were very verminous. Among the girls, 35 out of 114 suffered, and few lice were found on them. Twenty-four per cent. of the lice taken from the boys contained spirochætes as compared with 3 per cent. of those from the girls. As the epidemic died out among the boys, the lice also became fewer, and an increase in the number of cases among the girls coincided with an increase in the number of lice. Spirochætes were found in the gut, Malpighian tubules and genital organs of the lice. Mackie thought that infection of the patients was brought about by the regurgitation of the spirochætes when the lice fed, but proof of this was lacking.

In 1912, Nicolle, Blaizot and Conseil,[4] working in Tunis and using chiefly an Algerian strain of relapsing fever spirochætes (sometimes called *S. berbera*), showed by direct experiments that infection by means of the bites of *Pediculus vestimenti* and *P. capitis* was untenable. As many as 4,707 infected lice were fed on one man, and 6,515 on another occasion were allowed to bite a man after they had fed on a monkey heavily infected with spirochætes, yet no infection of the man followed. Examination of the lice showed that the spirochætes left the gut soon after they were ingested, and

---

[1] *Annals Trop. Med. and Parasitol.*, viii, p. 471.

[2] *Brit. Med. Journ.*, Dec. 14, 1907, p. 1706.

[3] See also Nuttall, Herter Lecture on Spirochætosis, *Parasitology*, v, p. 269.

[4] *C.R. Acad. Sci.*, cliv, p. 1636; clv, p. 481.

passed into the body cavity, which swarmed with spirochætes. The contents of the alimentary tract and the fæces of the lice alike were uninfective. The spirochætes did not reappear in the gut till eight days after an infective feed, but some persisted as late as the nineteenth day when kept at 28° C.

It was noted that the irritation due to the lice caused scratching, and that thereby lice became crushed on to the skin. An emulsion was made of two infected lice and rubbed on to the slightly excoriated skin of one of the above workers. Infection followed five days later. A drop of emulsion placed on the conjunctiva of the human eye produced spirochætosis after an incubation of seven days. The body contents of such lice, then, produce infection when they reach the blood by any excoriated or penetrable surface. The stages leading up to infection in nature briefly are : The irritation due to the louse bites causes scratching, and the lice are crushed on to the skin. The slight abrasion is quite sufficient to permit the entry of the parasite. The louse bite alone is harmless. Infection by way of the eye is quite probable in Africa, remembering the constant trouble due to sand, dust, insects, etc., resulting in frequent touching of the eyes.

The spirochætes occur in the body fluid of the lice and can pass in it to the adjacent organs. Thus they probably find their way into the genital organs, and into the eggs of the lice. Eggs laid twenty to thirty days after the parent became infected have retained the infection, and the larvæ issuing from such eggs must have contained some form of spirochætes, for an emulsion of either the eggs or the larvæ produced spirochætosis when inoculated into monkeys. Further details regarding the spirochætosis in the eggs of the lice and in the larvæ are needed. Hereditary infection, however, has been demonstrated, but is not very common. Sergent and Foley (1914) state that the spirochæte possesses a very small and virulent form which it assumes during apyrexial periods in man and during a period following an infecting meal in the louse. Nicolle and Blanc (1914) find that the organisms are infective in the louse just before they reappear as spirochætes. Nicolle and Blaizot found that female lice were more susceptible to spirochætes than males, four times as many females as males being infected.

Tictin (1897) found *S. recurrentis* in bugs recently fed on patients, and infected a monkey with the fluids of crushed bugs. Karlinski (1902) found the spirochætes in bed-bugs in infected houses. There is some other evidence to show that bugs may transmit the spirochæte in Nature. Further researches are needed regarding the relationship of bed-bugs and human spirochætosis.

Multiplication of *S. recurrentis* is by longitudinal and transverse division (including so-called "incurvation"), and the organism forms small, ovoid bodies ("coccoid" bodies) in the same way as *S. duttoni*.

S. recurrentis is the cause of European relapsing fever, and a number of possible varieties of it are associated with relapsing fevers in other parts of the world. Such spirochætes only differ by biological reactions, such as acquired immunity tests. They include :—

S. rossii, the agent of East African relapsing fever; *S. novyi*, the agent of North American relapsing fever; *S. carteri*, the agent of Indian relapsing fever; *S. berbera*, the agent of North African and Egyptian relapsing fever.

OTHER HUMAN SPIROCHÆTES are:—

S. schaudinni. This organism, according to Prowazek, is the agent of ulcus tropicum. It varies in length from 10 μ to 20 μ.

S. aboriginalis has been found in cases of granuloma inguinale in British New Guinea and Western Australia. It also occurs in dogs, and may not be truly parasitic.

S. vincenti. This spirochæte is 12 μ to 25 μ in length, tapers at both ends and has few coils. It has been associated with angina vincenti. It often occurs in company with fusiform bacilli.

S. bronchialis, found by Castellani in 1907 in cases of bronchitis in Ceylon. The parasites are delicate, but show morphological variation. This organism is important and has since been found in the West Indies, India, Philippine Islands and various parts of Africa, such as the Anglo-Egyptian Sudan, Uganda and West Africa. It has recently been the subject of research by Chalmers and O'Farrell, Taylor, and Fantham.

S. phagedenis was found by Noguchi in a ten days old ulcerated swelling of the labium. The organism shows much variation in size, being 4 μ to 30 μ in length.

S. refringens (Schaudinn, 1905) occurs in association with *Treponema pallidum* in syphilitic lesions, but is non-pathogenic. It is 20 μ to 35 μ long and 0·5 μ to 0·75 μ broad, being larger than *T. pallidum* and more easily stained.

Various spirochætes have also been notified in vomits, chiefly in Australia; others from the human intestinal tract, *e.g.*, *S. eurygyrata*; *S. stenogyrata* (Werner); *S. hachaizæ* (Kowalski), in cholera motions; *S. buccalis* (Cohn, 1875) and *S. dentium* occurring in the human mouth and in carious teeth (*S. dentium*, Koch, 1877, being the smaller); *S. acuminata* and *S. obtusa* found by Castellani in open sores in cases of yaws.

Animal spirochætes of economic importance include:—

S. anserina, highly pathogenic to geese.

S. gallinarum (= *S. marchouxi*) in fowls. (See p. 119.)

S. theileri in cattle and *S. ovina* in sheep also occur in Africa; their pathogenicity is not clear.

S. laverani (= *S. muris*), occurring in the blood of and pathogenic to mice, is probably the smallest spirochæte from the blood, being only 3 μ to 6 μ long.

Numerous spirochætes have been recorded from the guts of various mammals, birds, fishes, amphibia and insects.

CULTIVATION OF SPIROCHÆTES.—Cultures of spirochætes have been made with little success or with great difficulty until comparatively recently, when Noguchi (1912) devised a means whereby he has cultivated most of the pathogenic spirochætes as well as some Treponemata.

Noguchi has now cultivated *S. duttoni*, *S. recurrentis*, *S. rossii*, *S. novyi* and *S. gallinarum* from the blood; *S. phagedenis*[1] from human phagedænic lesions; *S. refringens*[2] and spirochætes from the teeth.

His method is as follows:—

A piece of fresh, sterile tissue, usually rabbit kidney, is placed in a sterile test-tube. A few drops of citrated blood from the heart of an infected animal, *e.g.*, rat or mouse, is added, and about 15 c.c. of sterile ascitic or hydrocœle fluid is poured quickly into the tube. Some of the tubes are covered with a layer of sterile paraffin oil, others are left uncovered. The tubes are incubated at 37° C. The best results are obtained if the blood is taken from an animal forty-eight to seventy-two hours after it has been inoculated, that is, before the spirochætes reach their maximum multiplicative period in the blood. The presence of some oxygen seems indispensable for these blood spirochætes, and they fail to develop *in vacuo* or in an atmosphere of hydrogen.

For subcultures, 0·5 c.c. of a culture is added to the medium instead of citrated blood, and it is useful to add a little fresh, normal blood, either human or from an animal, such as a rat.

Noguchi found that the events in cultures were:—

S. duttoni,[3] maximum multiplication on the eighth to ninth day; disintegration beginning on the tenth day, spirochætes disappeared after about the fifteenth day. No diminution of virulence was found at the ninth day.

S. rossii (= *S. kochi*).[4] Maximum development on the ninth day, after which the virulence diminishes. The incubation period is also prolonged.

S. recurrentis[5] (=*S. obermeieri*). Maximum growth on the seventh day.

S. novyi.[6]—Maximum development on the seventh day. It is more difficult to grow than the preceding forms.

All the above spirochætes showed undoubted longitudinal division and transverse division was observed in part.

S. gallinarum[7] can be cultivated as above, but transverse division

---

[1] *Journ. Exptl. Med.*, xvi, p. 261.
[2] *Journ. Exptl. Med.*, xv, p. 466.
[3] *Journ. Exptl. Med.*, xvi, p. 202.
[4] *Ibid.*, p. 205.
[5] *Ibid.*, p. 205.
[6] *Ibid.*, p. 208.
[7] *Ibid.*, p. 620.

was usual here. Maximum growth occurred in the culture about the fifth day.

Treponemata.

The genus *Treponema* (Schaudinn, 1905), includes minute, thread-like organisms, with spirally coiled bodies, the spirals being preformed or fixed. No membrane or crista is present, according to Schaudinn, though a slight one is said by Blanchard to be present in the organism of yaws. The ends of the organisms are tapering and pointed. Multiplication is by longitudinal and transverse division. The most important members of the genus are *T. pallidum*, the agent of syphilis, and *T. pertenue*, which is responsible for frambœsia or yaws.

Treponema pallidum, Schaudinn, 1905.

Syn.: *Spirochæta pallida.*

Treponema pallidum was first described by Schaudinn and Hoffmann in 1905 under the name of *Spirochæta pallida.* It has also been described under the names of *Spironema pallida*, *Microspironema pallida* and *Trypanosoma luis.* Siegel in 1905 described an organism which he called *Cytorhyctes luis* and considered to be the agent of syphilis. Schaudinn reinvestigated Siegel's work and found *T. pallidum*, which he considered to be the causal agent of the disease, and pronounced against *Cytorhyctes luis.* It is probable now that both workers were correct, for Balfour (1911) has seen the emission of minute granules or "coccoid" bodies from *T. pallidum* and these granules probably correspond to the *C. luis* of Siegel. Recently E. H. Ross, having observed a spirochæte stage in the development of Kurloff bodies, thinks that *T. pallidum* is a stage in the life-history of a Lymphocytozoon. MacDonagh has also described a complicated and somewhat similar cycle, but these observations require further study and confirmation.

Fig. 56.—*Treponema pallidum.* (After Bell, from Castellani and Chalmers.)

T. pallidum varies from 4μ to 10μ in length, its average length being 7μ, while its width is usually about $0{\cdot}25\mu$. Longer individuals of 16 μ to 20 μ have been recorded. The body has from eight to ten spiral turns and forms a tapering process at each end (fig. 56). The organism is most difficult to stain, and its internal structure is little known. It is possibly like that of *Spirochæta duttoni* or *S. balbianii*, as the "granule shedding" observed by Balfour is strongly suggestive of the formation of resistant bodies by those spirochætes. Hoffmann (1912) has seen the formation of spores in *T. pallidum*.

The Treponemata occur in the primary and secondary sores, but are difficult to find in the tertiary eruptions of syphilis. Noguchi and Moore (1913) and Mott[1] (1913) have demonstrated *T. pallidum* in the brain in cases of general paralysis of the insane. Marie and Levaditi (1914), however, consider that the treponeme found in the brain in such cases is different from *T. pallidum*.

CULTIVATION *of T. pallidum*.—This has been accomplished successfully by Noguchi,[2] using a modification of his method for spirochæte cultivation, for *T. pallidum* is much more difficult to grow than spirochætes, being a strict anaerobe.

The apparatus consists of two glass tubes, the upper being connected to the lower by a narrower tube passing through a rubber cork (fig. 57). Both tubes are carefully sterilized.

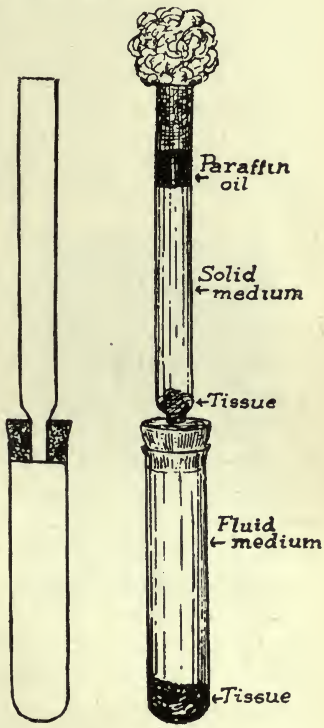


FIG. 57.—Diagram of apparatus for cultivation of *Treponema pallidum* by Noguchi's method. (After Noguchi.)

A piece of fresh, sterile rabbit's kidney is placed in the lower tube, which is filled with ascitic fluid, or ascitic fluid and bouillon mixture. The tube is inoculated with syphilitic material and corked by inserting the upper tube. In the bottom of the upper tube a piece of sterile rabbit's kidney is placed and syphilitic material poured over it. A mixture of one part ascitic fluid and two parts of slightly alkaline agar is then poured over the tissue and allowed to solidify. When solid, a layer of sterile paraffin oil is poured on top of it, and the top plugged with cotton wool (fig. 57). The whole is then incubated at 37° C. for two or three weeks. The tissue removes traces of oxygen from the lower levels of the medium and also probably

[1] *Brit. Med. Journ.*, Nov. 15, 1913. p. 1,271.
[2] *Journ. Exptl. Med.*, xv, p. 90; xvi, p. 211.

provides a special form of nourishment. At first *T. pallidum* grows in the solid medium, and then when the cultural conditions in the lower fluid portion become favourable, the organisms migrate thither and multiply abundantly. At first the culture is impure, but after several transferences a pure culture is obtained readily.

The syphilitic material for culture is prepared by cutting off pieces of tissue from the lesions, washing in sterile salt solution containing 1 per cent. sodium citrate, and then emulsifying the tissue in a mortar with sodium citrate.

Good cultures show rapid multiplication, which is invariably by longitudinal division.

In his various cultivation experiments Noguchi[1] found morphological and pathogenic variations in *T. pallidum.* Three forms of the organism were found, namely, thicker, average and thinner types. The lesions caused in the testicle of the rabbit differ according to the variety inoculated, but more work is necessary on the subject.

Noguchi[2] has cultivated a separate organism, *T. calligyrum*, from the surface of human genital or anal lesions, either syphilitic or non-syphilitic. It is apparently non-pathogenic, and is 6 μ to 14 μ long.

Hata (1913)[3] has modified the Noguchi technique for the cultivation of spirochætes and treponemes, with a view to simplification and convenience. Hata substitutes normal horse serum for ascitic fluid and the "buffy coat" of the clot of horse blood in place of the small pieces of rabbit's kidney. It is unnecessary to place sterile paraffin on the surface of the medium.

The horse serum is mixed with twice its volume of physiological saline solution. The mixture is placed in tubes which are heated on a water-bath at 58° C., the temperature being raised gradually until it reaches 70° or 71° C. in three hours. The tubes are then heated at 71° C. for half an hour. After cooling, the contents will consist of an opaque semi-coagulated mass. This semi-coagulated serum and saline mixture may be substituted for Noguchi's ascitic fluid.

The buff coagulum is cut into small pieces, about 1 c.c. in volume. They must be forced with a sterile glass rod to the bottom of the semi-coagulated serum and saline mixture. The medium is inoculated with a small quantity of infected blood and kept at 37° C. In the case of *S. recurrentis*, growth of spirochætes is observed on the second day, reaching a maximum in five to seven days. The growth of the organisms proceeds rather more slowly, they live for a longer period and maintain their virulence better than in Noguchi's medium.

---

[1] *Journ. Exptl. Med.*, xv, p. 201. [2] *Journ. Exptl. Med.*, xvii, p. 89.
[3] *Centralbl. f. Bakt.*, Orig., lxxii, p. 107.

Treponema pertenue, Castellani, 1905.

Syn.: *Spirochæta pertenuis; S. pallidula*, Castellani, 1905.

Castellani discovered the organism in 1905, in scrapings of yaws pustules. He first described it under the name of *Spirochæta pertenuis.*

Treponema pertenue (fig. 58), though delicate and slender, shows great morphological variation both in length and thickness. It may be short, *e.g.*, 7 μ, but can attain 18 μ to 20 μ in length and may be even larger. In cultures made by Noguchi, thick, medium and thin forms were found, each giving rise to a different type of frambœsial lesion when inoculated into the testicles of rabbits, thus suggesting the possibility of the occurrence of varieties of *T. pertenue.*

The organism is difficult to stain, but occasionally deeper staining granules are found along its body. They may represent a diffuse nucleus. Granule formation similar to that of *T. pallidum* has been observed by Ranken, using dark-ground illumination.

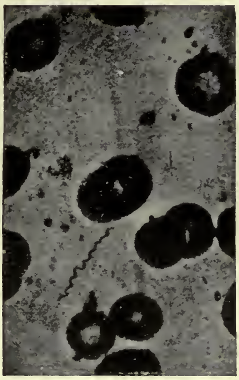


FIG. 58.—*Treponema pertenue.* (After Castellani and Chalmers.)

Many experiments have been made with a view to establishing the identity of the organism of yaws and also of differentiating between the causative agents of yaws and syphilis. Both monkeys and the human subject have been experimentally inoculated with yaws material and have developed the disease.

In an early experiment, negroes were inoculated with the secretion from lesions of yaws. All of them developed the disease, nodules appearing, chiefly at the seat of inoculation, in from twelve to twenty days, followed by the usual eruption. Similar results were obtained with thirty-two Chinese prisoners, who were inoculated with yaws, twenty-eight becoming infected.

A naturally infected yaws patient when inoculated with syphilis, contracted that infection, thus showing that yaws does not confer immunity to syphilis. This has also been observed naturally, when yaws patients have contracted syphilis.

Experiments with monkeys have been successfully performed. The incubation period varies from sixteen to ninety-two days. Lesions appear first at the seat of inoculation, and in some monkeys the eruption is localized to this spot, though the infection is general, *T. pertenue* occurring in the spleen, lymphatics, etc. Monkeys inoculated with splenic blood of a yaws patient, and also sometimes with blood from the general circulation, have become infected.

Castellani and others have shown that monkeys successfully inoculated with syphilis do not become immune to yaws, and vice-versâ.

Craig and Ashburn, using the monkey *Cynomolgus philippinensis*, found these animals susceptible to yaws but not to syphilis.

The ulcerated lesions of frambœsia are rapidly invaded by numerous bacteria as well as by different spirochætes, of which Castellani has described three distinct species. One is identical with *Spirochæta refringens*, Schaudinn, the other two are thin and delicate. One, *S. obtusa*, has blunt ends; the other *S. acuminata*, has pointed ends. *T. pertenue* is also present.

The reasons for considering *T. pertenue* to be the specific cause of frambœsia are:—

(1) *T. pertenue* is the only organism present in non-ulcerated papules, in the spleen and in the lymphatics of yaws patients, or of monkeys artificially infected with the disease. By no method has any other organism been obtained.

(2) Extract of frambœsia material, free from all organisms other than *T. pertenue*, reproduces the disease if inoculated.

(3) Extract of frambœsia material deprived by filtration of *T. pertenue* is no longer infective on inoculation.

The method of infection is contaminative, by direct contact. Women in Ceylon are frequently infected by their children. Any slight skin abrasion is sufficient to admit the parasite. In some cases, insects may carry the disease from person to person, and even in hospitals, when dressings are removed, it has been noticed that flies greedily suck the secretion from the ulcers. *T. pertenue* has been recovered from flies that have fed on yaws, and monkeys have contracted the disease when flies were placed and retained on them for a short time, after the insects had fed on yaws material.

CULTIVATION.—*T. pertenue* has been cultivated by Noguchi, who finds three types of parasites in his cultures, as before mentioned. Its multiplication is by longitudinal division.

Noguchi[1] (1912), has cultivated species of Treponema from the human mouth, e.g., *T. macrodentium*, *T. microdentium* and *T. mucosum*, the latter from pyorrhea alveolaris. These parasites in the past may have been confused under the name *Spirochæta dentium*.

Class III. **SPOROZOA**, Leuckart, 1879.

The third group of the Protozoa consists entirely of parasitic organisms forming the class known as the Sporozoa or spore-producing animals. The members of this class are characterized

[1] *Journ. Exptl. Med.*, xv, p. 81; xvi, p. 194.

by possessing very great powers of multiplication, coupled with a capacity for producing forms that serve for the transference of the organisms to other hosts. These reproductive bodies, whether for increase of numbers within one host or for transmission to another host, are called spores. But, strictly, the term spore should be used only in the latter connection, when a protective or resistant coat known as a sporocyst envelops the body of the spore.

The Sporozoa are widely distributed, occurring in various tissues and organs of Annelids, Molluscs, Arthropods, and Vertebrates. Their food, which is fluid, is absorbed osmotically. The life-cycle of a Sporozoön may be completed within one host or may be distributed between two different hosts.

The Sporozoa were divided by Schaudinn into two groups or sub-classes, called (1) the **Telosporidia**, and (2) the **Neosporidia**.

The Telosporidia are Sporozoa in which the reproductive phase of the parasites is distinct from the growing or trophic phase, and follows after it. The Neosporidia include Sporozoa in which growth and spore-formation go on simultaneously. This classification is not final, for certain exceptions and difficulties are already known with regard to it. It is possible that the class Sporozoa is not a natural entity, but should be replaced by two classes of equal rank, corresponding in most respects with the Telosporidia and Neosporidia.

The **Telosporidia** comprise the **Gregarinida**, the **Coccidiidea**, and the **Hæmosporidia**. Doflein combines the two latter orders into one known as the **Coccidiomorpha**.

The **Neosporidia** comprise the **Myxosporidia**, the **Microsporidia**, the **Actinomyxidia**, the **Sarcosporidia**, and the **Haplosporidia**. Doflein combines the first three orders into one, the **Cnidosporidia**.

Sub-Class. TELOSPORIDIA, Schaudinn.

Sporozoa in which the reproductive phases follow completion of growth.

Order. **Gregarinida**, Aimé Schneider emend. Doflein.

Knowledge of the Gregarinida probably goes back as far as the year 1684, when Redi observed gregarines in the crab, *Cancer pagurus*. Von Cavolini (1787) found them in *Cancer depressus*. The name *Gregarina* was created by L. Dufour (1828), who observed masses of these organisms in the gut of insects of different orders. Hammerschmidt (1838) and von Siebold found rich infestations in insects, while Dujardin (1835) and Henle described various genera from segmented worms. Henle (1835) also observed cysts containing "navicellæ" in the sperm-sacs of segmented worms, and attention was drawn to his researches by the discovery by von Siebold (1839) of "pseudonavicellæ" in the gut of *Sciara nitidicollis*. Up to this time many workers considered the gregarines to be worms, but Kölliker (1845) investigated many of them and maintained their unicellular nature, while Stein's work (1848) showed the interrelation of the pseudonavicellæ and the gregarines.

The discovery of amœboid germs in the pseudonavicellæ by Lieberkühn (1855) and the demonstration of myonemes further aided in the elucidation of their true systematic position. The entire process of conjugation, of which Dufour had seen one phase, was followed by Giard under the microscope.

From 1873 onwards Aimé Schneider made important additions to the knowledge of the morphology, life-history, and systematic position of numerous gregarines. Bütschli (1881) and L. Léger (1892) also contributed much work on the subject. The discoveries of Schaudinn with regard to the life-cycle of Coccidia gave a fresh stimulus to the study of the Gregarines, whereby the life-cycles of numerous forms and the phases thereof have been elucidated.

Asexual multiplication is not common among the Gregarines, but is known to occur in the sub-order Schizogregarinea, formerly known as the Amœbosporidia.

Although the Gregarinida are not known to be parasitic in man or other vertebrates, they are of great interest, inasmuch as they are among the earliest known Sporozoa, and therefore will be briefly described here.

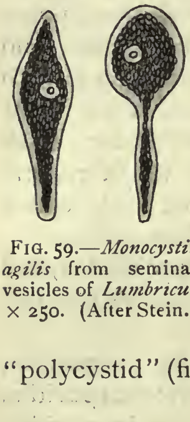
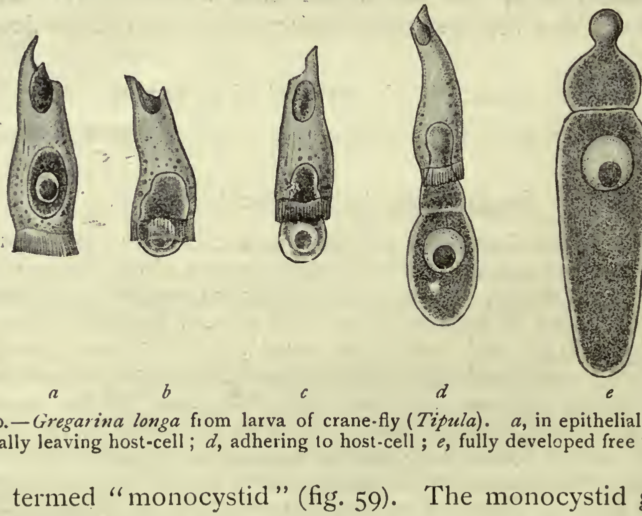


FIG. 59.—*Monocystis agilis* from seminal vesicles of *Lumbricus* × 250. (After Stein.)

The Gregarines are usually elongate, somewhat flattened organisms (figs. 59, 60), whose bodies are enclosed in an elastic and often thick cuticle. The enclosed living substance shows a separation into ectoplasm and endoplasm, as is common among Protozoa. The cuticle is sometimes regarded as the outer portion or epicyte of the ectoplasm. A single, vesicular, spherical, or elliptical, large nucleus, with its chromatin concentrated to form a spherical karyosome, is present. The body of some gregarines may be divided by ingrowing ectoplasmic partitions or septa, and are then said to be "septate" or "polycystid" (fig. 61). Other gregarines remain simple and non-septate,



a *b* *c* *d* *e*

FIG. 60.—*Gregarina longa* from larva of crane-fly (*Tipula*). *a*, in epithelial cell of host; *b*, *c*, gradually leaving host-cell; *d*, adhering to host-cell; *e*, fully developed free trophozoite.

and are termed "monocystid" (fig. 59). The monocystid gregarines occur especially in the body cavity of Chætopoda and Insecta, more rarely in Echinodermata, in the parenchyma of Platyhelminthes, also in the gut of Tunicata and Insecta (fig. 60) and in the seminal vesicles of Annelida. In the polycystid gregarines a single septum only is present as a rule, and thus the body presents two portions: (1) an anterior portion termed the protomerite; (2) a posterior, larger portion, known as the deutomerite, which generally contains the nucleus. The protomerite is often modified anteriorly to form an organ of attachment, termed the epimerite (fig. 61), which is developed from the pointed rostrum of the sporozoite or primary infecting young gregarine. The structure of the epimerite may be complicated, being provided with hooks, spines, knobs, and other appendages. An extension of the polycystid condition is seen in *Tæniocystis mira* Léger (from the dipteran larva, *Ceratopogon solstitialis*), whose body shows a number of partitions, giving the organism a superficial resemblance to a tapeworm.

FIG. 61.—*Xyphorhynchus firmus* with epimerite in intestinal epithelial cell of host. (After Léger.)

The ectoplasm of a gregarine exhibits three layers: (1) An epicyte (cuticle) externally of which the epimerite is composed; (2) a sarcocyte which forms the septa if present; (3) the deeper myocyte layer containing contractile elements in the form of fibrils or threads termed myonemes (fig. 62).

The endoplasm is fluid and granular, containing many enclosures, which are of the nature of reserve food materials. They consist of fat droplets or of paraglycogen, and give the organisms an opaque appearance. *Lithocystis* contains crystals of calcium oxalate in its endoplasm.

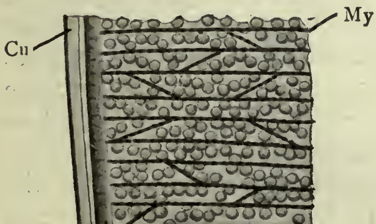


FIG. 62.—*Gregarina munieri* (from the beetle, *Chrysomela hæmoptera*). Section through surface layers. *Cu*, cuticle; *E*, ectoplasm proper; *G*, gelatinous layer; *My*, myonemes in myocyte layer. × 1500. (After Schewiakoff.)

Many gregarines are capable of active movements, though they do not possess obvious locomotor organs. The movement is of a smooth, gliding character and two suggestions have been put forward to explain it. According to Schewiakoff, a gelatinous substance is secreted between the layers of the ectoplasm. This is extruded posteriorly and thus the animal is pushed forward. On the other hand, Crawley considers that the movements are produced by contractions of the myonemes.

These two explanations are probably correct as far as each goes, and are to be regarded as supplementary to one another.

Occasionally, temporary associations of gregarines are formed by a number of individuals adhering to one another end to end. Such temporary associations are examples of syzygy. Such syzygies must not be confused with true associations which form an essential part of the life-cycle.

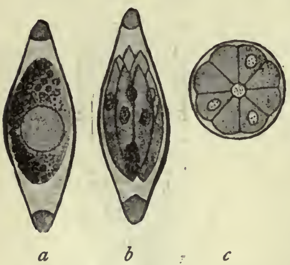


FIG. 63.—*Monocystis agilis*. Spores from vesicula seminalis of the Earthworm. *a*, Sporoblast with single nucleus, enclosed in sporocyst; *b*, mature spore containing sporozoites; *c*, diagrammatic cross-section of spore, showing eight sporozoites round residual protoplasm. (After Bütschli.)

The life-cycle of a relatively simple gregarine, such as *Monocystis agilis* (fig. 59), parasitic in earthworms, may now be considered. The gregarines, being members of the Sporozoa, produce spores at one phase of the life-cycle. Each gregarine spore (fig. 63) develops within itself a number of minute, sickle-shaped or vermicular bodies, known as sporozoites or primary infecting germs. Eight sporozoites are often formed within each spore. When absorbed by a new host, the spore softens and the sporozoites issue from it. They are capable of active movement and may or may not enter a cell, such as one of those of the digestive tract, or, as in *Monocystis*, a cell lining the vesicula seminalis which becomes a sperm-cell aggregate (sperm morula). When the sporozoite has reached the place of its choice in the host it ceases active movements and proceeds to feed passively on the fluid substances around it, whether they be those of tissues or body fluids. This passive, growing and feeding form is known as the trophozoite. After a trophic existence of longer or shorter duration, the trophozoite ceases to feed and prepares for reproduction. Two trophozoites associate together, each of them first becoming somewhat rounded. The two trophozoites, now known as sporonts or gametocytes, become invested in a single common envelope or cyst (fig. 64, *a*). The nucleus of each gametocyte then divides by a series of binary fissions (fig. 64, *b*), and the daughter nuclei thus produced arrange themselves at the periphery of the parent cells (fig. 64, *c*). Cytoplasm collects around each of these nuclei, and thus a number of gametes are formed within each gametocyte. The gametes for a time exhibit active movements, and ultimately ripe gametes of different parentage fuse in pairs, that is, conjugation occurs (fig. 64, *d*). In this way zygotes are produced, the nucleus of each zygote being formed by the fusion of two gamete nuclei.

The zygote grows slightly and becomes oval or elongate, and at this period is often called the sporoblast. It then secretes an external

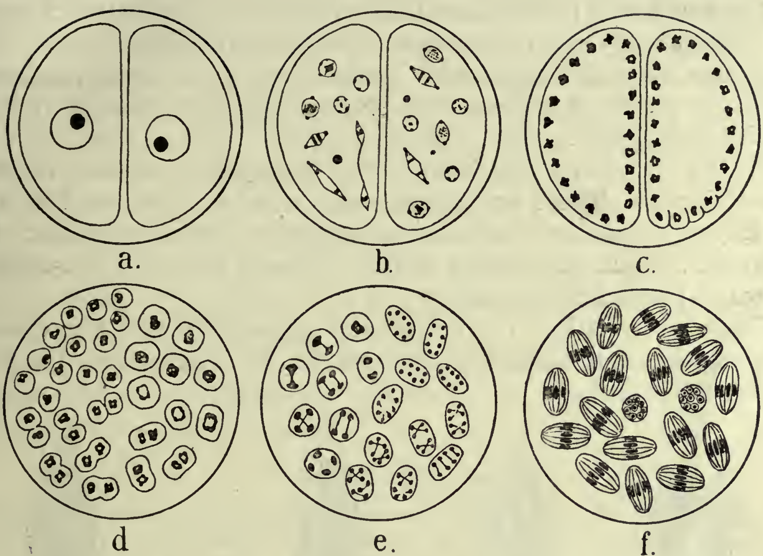


FIG. 64.—Schematic figures of conjugation and spore formation in Gregarines. For details see text. (After Calkins and Siedlecki, modified.)

FIG. 65.—*Stylorhynchus oblongatus*. *a*, cyst containing two sporonts or gametocytes, each full of gametes, those in the upper one being male. *b*, ripe male and female gametes. × 1,600. (After L. Léger.)

membrane, the sporocyst. Nuclear division occurs inside the sporocyst by a series of three binary fissions (fig. 64, *e*), so that each sporocyst, now usually referred to as a spore, contains eight nuclei. The cytoplasm collects around each nucleus and eight vermicular sporozoites are produced within each spore (fig. 64, *f*), thus completing the life-cycle.

It will be noticed that in the above life-cycle no asexual multiplication occurs. These organisms, such as *Monocystis*, are known as the Eugregarines, and include the majority of the gregarines. The remainder, which have introduced schizogony into their life-cyle, are known as the Schizogregarines.

There are variations in the morphology and life-cycle of gregarines besides those that have been mentioned. It is not within the scope

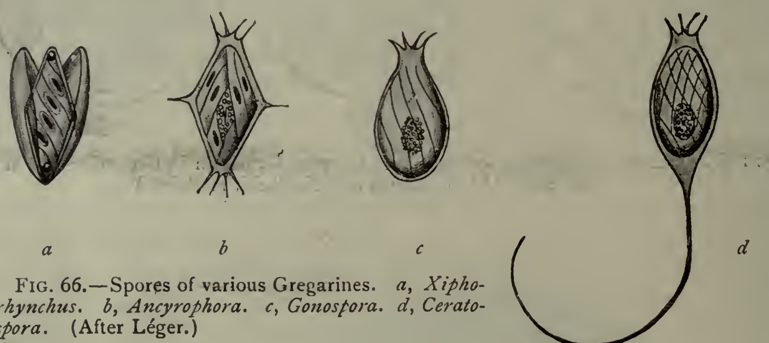


FIG. 66.—Spores of various Gregarines. *a*, *Xiphorhynchus*. *b*, *Ancyrophora*. *c*, *Gonospora*. *d*, *Ceratospora*. (After Léger.)

of this book to discuss them in detail, but the following may be noted:—

Morphological differentiation of gametes may occur as in *Stylorhynchus oblongatus* (fig. 65), which differentiation is probably of a sexual nature.

The sporocyst really consists of two layers, an epispore and an endospore. Externally the spores of different gregarines show great variety in shape and markings, and spines, or long processes may be present (fig. 66).

The resistant spores serve for the transmission of the gregarines from host to host. The mode of infection is contaminative, the spores expelled with the dejecta of one host being absorbed with the food of a new host.

The Gregarinida may be classified as follows:—

Sub-order I.—**Eugregarinea**, without schizogony.

Tribe 1.—*Acephalina.*—Without an epimerite and non-septate; often "cœlomic" (body-cavity) parasites. *E.g.*: *Monocystis*, with several species parasitic in the seminal vesicles of earthworms. Many other genera parasitic in Echinodermata, Tunicata, Arthropoda, etc.

Tribe 2.—*Cephalina.*—With an epimerite, either temporarily or permanently, in the trophic phase. Usually septate (except *Doliocystidæ*). Many families, genera and species. Common in the digestive tracts of insects. *E.g.* : *Gregarina*, with several species, *Gregarina ovata* in the earwig, *Gregarina blattarum* in the cockroach, *Stylorhynchus* in beetles, *Pterocephalus* in centipedes, etc.

Sub-order II.—**Schizogregarinea**, with schizogony.

Tribe 1.—*Endoschiza.*[1]—With schizogony occurring in the intracellular phase, *e.g.*, *Selenidium* (from Annelida and Gephyrea), *Merogregarina* (from an Ascidian).

Tribe 2.—*Ectoschiza.*—In which the schizont is free, and schizogony is extracellular, *e.g.*, *Ophryocystis* (from *Blaps*, a beetle), and *Schizocystis* (from *Ceratopogon* larva).

Order. **Coccidiidea.**

Hake (1839) first saw the organisms now termed Coccidia during his investigations on the so-called coccidial nodules of rabbits. The opinions as to the nature of these peculiar formations were very diverse. The discoverer considered them to be a sort of pus corpuscle ; Nasse (1843) took them for epithelial cells of the biliary passages, others for helminthes, especially the ova of trematodes (Dujardin, Küchenmeister, Gubler, etc). Remak (1845) was the first to draw attention to their relation to the Psorospermia (Myxosporidia), and this investigator found them also in the small intestine and vermiform appendix of rabbits. Lieberkühn (1854), who examined not only the coccidia of rabbits, but found similar forms in the kidneys of frogs, likewise called them definitely psorosperms. To differentiate Müller's psorosperms, which are found in fishes, from those of rabbits, etc., the latter were called egg-shaped psorosperms (Eimer), until R. Leuckart (1879) named them *Coccidia* and placed them in a group of the Sporozoa analogous to that of the Gregarinida, Myxosporidia, etc. Numerous works confirmed the occurrence of coccidia, not only in all classes of vertebrate animals, but also in invertebrates (Mollusca, Myriapoda, Annelida, etc.). A large number of genera and species have in the course of time been described which inhabit the epithelium of the intestine and its appendages for choice, but are also found in other organs (kidneys, spleen, ovaries, vas deferens, testicles). Some also live in the connective tissue of various organs, more particularly of the intestine.

The knowledge of the development of the coccidia was of particular importance in determining their classification. By means of encysted coccidia from the liver of rabbits, Kauffmann (1847) first confirmed the fact that the cyst, which was partly or entirely filled with granular contents, divided into three or four pale bodies (fig. 71) after a long sojourn in water. Lieberkühn observed the same process in the host in the case of the coccidia of the kidney of the frog. Stieda (1865) studied more minutely the changes that occur within the encysted coccidia of the liver of rabbits after the death of the host. He discovered that the bodies now known as "spores" were oval formations pointed at one pole, and surrounded by a delicate membrane, which exhibited a certain thickness at the pointed extremity and enclosed a slightly bent rodlet, expanding at either end into a strongly light-refracting globule ; a finely granular globule was present in the middle of the spore. Waldenburg (1862) saw the

[1] See Fantham (1908), *Parasitology*, i, p. 369.

same phenomenon in coccidia from the epithelium of the villi and Lieberkühn's glands of the intestine of the rabbit; but the process in this case took place in a much shorter time.

According to the discovery of Kloss (1855), the spores of the coccidia of the urinary organ of the garden snail were formed in far greater numbers : the round spores also harboured several (five to six) rodlets, which after the bursting of the spore-envelope became free. Eimer's researches (1870) afforded information regarding a Coccidium from the intestine of the mouse, which was transformed *in toto* into a "spore," containing small sickle-shaped bodies. The fact was, moreover, established that the little bodies left the delicate envelope when in the intestine, made movements of flexion and extension, and were finally transformed into amœboid organisms, which apparently penetrated the epithelial cells ; at all events, similar bodies of various sizes were seen in these cells. Taking the immense number of these parasites into account and the lack of any other cause, Eimer attributed the sudden death of his mice to the *Gregarina falciformis*, as the parasite was then called, just in the same way as a few years previously Reincke ascribed the acute and fatal intestinal catarrh of rabbits to the invasion of intestinal coccidia.

All that had become known about coccidia up to 1879 was then compiled by Leuckart, and completed by his own observations on the coccidia of the liver of the rabbit. Experimental infections had already been conducted by Waldenburg (1862) with intestinal coccidia of rabbits, and by Rivolta (1869-73) with the coccidia of fowls, which experiments confirmed the importance of the spores, or bodies enclosed in them, in the transmission of the parasites to other animals. Accordingly, it was assumed that after the entry of the spores into the intestine the sporozoites were set free, actively penetrated into the intestinal cells, where they grew into coccidia, and finally became encysted. The further development, *i.e.*, the formation of spores, took place outside the host's body in these cases ; in other cases (Kloss, Eimer) it took place within the host. Although much regarding the cycle of development was still hypothetical, the ideas coincided with the observations, and were therefore universally regarded as established. Further research confirmed this view in numerous new forms.

L. Pfeiffer's statements (1891) on the part that certain coccidia or their sporozoites played, or seemed to play, as causes of disease gave a renewed impetus to the investigation of the coccidia. The ingestion of even very numerous spores did not appear to account for the mass infection so frequently observed, even after Balbiani had confirmed the fact that there were two, and not one, sporozoites contained in every spore of the coccidia of rabbits (fig. 72). The hypothesis was therefore advanced that the sporozoites or young coccidia were able to divide once again by sporulating. The question was finally solved quite differently. R. Pfeiffer (1892) first confirmed the fact that in addition to the well-known method of sporulation in the coccidia of the rabbit that causes the infection of fresh hosts ("exogenous sporulation"), an enormous increase may follow in the already infected host in a manner that Eimer first observed in the coccidia of the intestine of the mouse ("endogenous sporulation"). It had hitherto been believed that some of the species of coccidia increased like the rabbit parasite, then known as *Coccidium oviforme*, and others like *Eimeria falciformis*, and this difference had been made the foundation of a classification. R. Pfeiffer was successful in observing the occurrence of both kinds of development in the same species, and expressed the opinion that endogenous sporulation (fig. 73), which takes place within the host, was the cause of the mass-infection that is mostly accompanied by serious consequences (fig. 74). L. Pfeiffer sought, especially, to demonstrate the correctness of this view as regards other species of coccidia and for this purpose he utilized the experiences already published. Coccidia were known to exist in a number of different hosts, and to propagate in some according to the *Coccidium* type, in others according to the *Eimeria* type. It therefore was reasoned that in this case it was not a question of two species belonging to different genera living side by side, with a different mode of development, but of one species, in the life of which both forms of development occurred alternately.

This interpretation of facts was combated especially by A. Schneider (1892) and by Labbé, but has, nevertheless, proved true, apart from the circumstance that Schuberg succeeded in discovering the hitherto unknown *Coccidium* form in the intestine of the mouse; and that, moreover, Léger confirmed the fact that there are no Arthropoda in which Eimeria are not found together with coccidia. The question was finally settled by experiments made by Léger with the coccidia of *Scolopendra cingulata*, by Schaudinn and Siedlecki with those of *Lithobius forficatus*, and by Simond with the coccidia of the rabbit. On Simond's suggestion the sickle-shaped germs corresponding to the sporozoites, which are formed by endogenous sporulation, are generally termed merozoites; and in accordance with Schaudinn's suggestion, those individuals which form merozoites are termed schizonts, and those which produce spores are called sporonts. In contradistinction to sporogony (exogenous sporulation), the term schizogony (endogenous sporulation) is used.

The more minute examination of these processes at last led to the discovery of sexual dimorphism, of copulation and of alternation of generations in the coccidia. Schuberg was the first to consider the possibility of copulation in coccidia; in addition to the formations which now are termed merozoites, he observed very diminutive bodies ("microsporozoites") in the coccidia of the intestine of the mouse, which were able eventually to copulate. Labbé confirmed this observation in some of the species, and Simond expressed the opinion that bodies termed "chromatozoites" occurred in all coccidia. Copulation itself was then observed by Schaudinn and Siedlecki (1897). The copulating bodies were termed gametes. As, however, they differed considerably one from the other, the males were called microgametes (*i.e.*, the microsporozoites of Labbé and the chromatozoites of Simond) and the females macrogametes. After copulation was completed sporogony took place, and in the cycle of development of one species this regularly alternated with schizogony (asexual multiplication). Schaudinn in 1900 described in detail the life-cycle of *Eimeria* (*Coccidium*) *schubergi*.

The recognition of this unsuspected complicated process was bound to effect reforms in the classification of the coccidia; and all the forms that had been regarded as developmental stages (*Eimeria*, etc.) had to be reconsidered.

Occurrence.—The Coccidiidea in their mature condition usually live within the epithelial cells of various organs, and by choice inhabit those of the intestine and of its associated organs. They also occur frequently in the excretory organs of mammals, birds, amphibia, molluscs, arthropods, and may also be found in the testes and vas deferens, but the statement that they live in hen's eggs, as well as in the oviducts of fowls, has not been confirmed.[1] Some species inhabit the nuclei of cells, others live in the connective tissue, but

[1] Notwithstanding the progress made during the last decades, the ova of helminthes and more particularly of trematodes, have been mistaken for Coccidia. Thus Poschinger (*Zool. Anz.*, 1819, ix, p. 471) and Gebhard (*Virchow's Arch.*, 1897, No. 147, p. 536) mistook the ova of *Distoma turgidum*, Brds., for Coccidia. Podwyssotzki (*Centralbl. f. allg. Path.*, 1890, i, p. 135) made a similar error with the ova (and vitelline sacs) of a species of *Prosthogonimus* (*Distoma ovatum* of the authors); von Willach (*Arch. f. wiss. u. prakt. Thierheilk.*, 1892, xviii, p. 242) mistook the ova of a nematode for Coccidia.

their presence in the latter situation is probably only secondary, that is, they have only reached it from the epithelium of the affected organs.

The size of the Coccidiidea, corresponding as a rule to the capacity of their habitat, is usually small, but there are said to be species that attain a diameter of 1 mm. Their form[1] is globular, oval, or elliptical. External appendages are lacking, at least during the trophic or vegetative period of their life, which is spent in epithelial cells, within which they increase in size. Frequently one only is present in each cell, but more can occur. The body substance is composed of a more or less finely granular or distinctly alveolar protoplasm which exhibits no differentiation into ecto- and endoplasm. All species possess a nucleus that enlarges with their growth; sometimes it only shows through the cytoplasm as a lighter spot, or may even be quite concealed. It is vesicular, and besides containing very delicate threads of chromatin in the clear nucleoplasm, it contains generally only one large karyosome.

The infected epithelial cells degenerate sooner or later as the parasite feeds on them (fig. 67, II-IV). After their form has been changed by the action of the growing parasite, they finally perish. The cell membrane then alone surrounds the coccidia, which, at least in the species sufficiently known, begin to propagate by an asexual process (schizogony), the parasites themselves becoming schizonts, as the initial stage is usually called. They differ from later stages (sporonts or gametocytes), which resemble them in form, by the absence of granulations in the cytoplasm, as well as by the vesicular nucleus. The form is not always the same, for in some cases, at least, many schizonts assume a globular form.

Schizogony (fig. 67, V-VII) commences with a division of the nucleus, which takes place in different ways in the various species. This finally leads to the formation of numerous daughter nuclei which become smaller and smaller, and which collect beneath the surface of the schizonts. In some species the daughter nuclei collect only in one half of the schizont. A part of the protoplasm of the periphery now divides around each daughter nucleus, the remaining part (residual body) being left in the centre or on one side. The segments of the divided cytoplasm, each containing a nucleus, assume a fusiform shape and become merozoites, which very soon become free (fig. 67, VIII) and leave the residual body. They are distinguishable from the very similar sporozoites (fig. 67, I), as the merozoites possess a karyosome.

---

[1] The life-cycle given here is based on that of *Eimeria* (*Coccidium*) *schubergi*, after Schaudinn (1900). See "Untersuchungen über den Generationswechsel bei Coccidien," *Zool. Jahrb.*, Abt. f. Anat., xiii, pp. 197-292, 4 plates.

FIG. 67.—Life-cycle of *Eimeria* (*Coccidium*) *schubergi*, Schaud., from the intestine of *Lithobius*. (After Schaudinn.) The infection is caused by a cyst (XX), containing spores, which reaches the intestine of a *Lithobius*, where it discharges the sporozoites (I). II, A sporozoite invading an intestinal epithelial cell; III, intestinal epithelial cell with young trophozoite; IV, intestinal epithelial cell with a globular schizont; V, nuclear segmentation within the schizont; VI, the daughter nuclei arranging themselves superficially; VII, formation of the merozoites; VIII, merozoites that have become free, and which, penetrating into other epithelial cells of the same intestine, repeat the schizogony (II-VIII); IX and X, merozoites which, likewise invading the epithelial cells of the same intestine, become sexually differentiated; XIa, young macrogametocyte; XIb, older macrogametocyte; XIc, mature macrogametocyte (discharging particles of chromatin); XIIa, young microgametocyte; XIIb, older microgametocyte; XIIc, increase of nuclei in the microgametocyte; XIId, the globular residual body around which numerous microgametes have formed; XIIe, an isolated microgamete; XIII, the mature macrogamete surrounded by numerous microgametes and forming a cone of reception or fertilization prominence; XIV, shows the nucleus of a microgamete that has penetrated and fused with the nucleus of the macrogamete (fertilization)—the latter forms a membrane and becomes an oöcyst; XV, XVI, XVII, nuclear segmentation in the oöcyst; XVIII, oöcyst with four sporoblasts; XIX, the sporoblasts transformed into spores, each containing two sporozoites; XX, the cyst introduced into the intestine and liberating the sporozoites by bursting.

The merozoites move in a manner similar to that of the sporozoites. The movements consist either of slow incurvations with subsequent straightenings, or annular contractions along the entire extent of the body. In addition, there are gliding movements similar to those of many gregarines, and brought about in a like manner by the secretion at the posterior extremity of a gelatinous substance that hardens rapidly.

The merozoites do not gain the open in the usual way, but are destined to infect still further the same host by actively penetrating into other epithelial cells of the affected organ. Here they continue their growth and may again and again undergo schizogony. In the Infusoria the repeated segmentations finally cease and are renewed only after a conjugation. This is likewise the case with the Coccidia, with the difference that in the latter the two conjugating individuals (gametes) are differently constituted one from the other, whereas in the Infusoria they are almost always similar.

When the schizogony ceases, the merozoites, that had penetrated the epithelial cells and become trophozoites there, consist of two kinds of differently constituted individuals. One kind possesses a clear cytoplasm (fig. 67, XII), the other an opaque, richly granular cytoplasm (fig. 67, XI), while both possess a vesicular nucleus with a karyosome. In order to continue their development, the more granular individuals must be fertilized, and are therefore termed either female gametes or, on account of their size, macrogametes. The male individuals (microgametes) necessary to conjugation, are formed in greater numbers from the less dense microgametocytes or male mother-cells (fig. 67, XIId). They are slender bodies consisting chiefly of nuclear substance, and in most species bear two flagella of unequal length directed backwards, the place of insertion of which varies according to the species (fig. 67, XIIe).

While the development of the microgametes is rapidly advancing a change occurs in the nucleus of the female parent forms or macrogametocytes. Parts of the karyosome are extruded (fig. 67, XIc), and the nucleus loses at the same time its vesicular form. One macrogamete results, after nuclear maturation, from one macrogametocyte. By this time the macrogametes are capable of conjugation, and the process takes place within the host, generally, however, outside the affected and degenerated host cells. The microgametes that have now become free from the very large residual body, crowd around the mature macrogametes, which often send out a small prominence ("cone of reception" or fertilization protuberance) for their reception (fig. 67, XIII). As soon as a microgamete comes in contact with this and penetrates into the cytoplasm of the macrogamete, the latter surrounds itself with a membrane which prevents the intrusion of other microgametes. The nucleus of the microgamete that has gained entry unites with the nucleus of the macrogamete, which latter is afterwards capable of forming the well-known spores. The parasite is now called an encysted zygote or oöcyst. The oöcysts of some other members of the Coccidiidea, *e.g.*, *Eimeria avium*, can form their walls prior to fertilization. In such cases, a weak spot is left at one place in the cyst wall, forming a micropyle, that permits of the entry of the male, immediately after which the micropyle is closed.

The reduced nucleus of the macrogamete elongates on the entry of the microgamete, and becomes a fertilization spindle to which the male pronucleus (from the microgamete) becomes attached (fig. 67, XIV and XV). Thereupon the spindle divides into two daughter nuclei (fig. 67, XVI) which assume a round shape. The protoplasm at this stage may at once divide, or another segmentation of the daughter nuclei may first occur. In the former case the two halves divide again, so that finally four nucleated segments, the sporoblasts, are formed, whereas in the latter case the four sporoblasts appear simultaneously (fig. 67, XVII). In both cases a residual body of varying size is separated from the protoplasm of the oöcyst. As a rule the oöcysts have already been discharged from the body of the host, and in the manner described above, form the sporoblasts after a longer or shorter period of incubation.

The sporoblasts are originally naked, but each soon secretes a homogeneous membrane, the sporocyst, in which it becomes enveloped (fig. 67, XVIII). After the segmentation of the nucleus the contents divide into two sickle-shaped sporozoites, in addition to which there is generally also a residual body (fig. 67, XIX).

This terminates the development. The spores are intended for the infection of other hosts. If they reach the intestine of suitable hosts, either free or enclosed in the oöcyst wall, the action of the intestinal juices causes them to open and permits the escape of the sporozoites (fig. 67, XX). The latter move exactly like the merozoites and soon make their way into epithelial cells (fig. 67, I), where they become schizonts, and thus repeat the life cycle.

Although our knowledge of the development of the coccidia is but of recent date, yet it already extends to a large number of species, which exhibit various deviations from the cycle of development described above. For instance, in addition to differences in the gametocytes, the schizonts of *Adelea* and *Cyclospora* also show differentiation and give rise to macromerozoites and micromerozoites, whilst in *Adelea* and *Klossia* a precocious association of the gametocytes precedes the true copulation of the ripe gametes.

The classification of the Coccidiidea is based chiefly on the number of sporozoites found in each spore, and the number of sporocysts (spores) found in one oöcyst. Léger[1] recognises two great legions, the Eimeridea and the Adeleidea, the former comprising the greater number of genera, including the genus of most economic importance, *Eimeria*. It must be noted that, though a member of

[1] *Arch. f. Protistenkunde* (1911), xxii, p. 71.

this genus may be frequently referred to as *Coccidium*, strictly it should be termed *Eimeria*, that name having priority. The name of the disease resulting from the action of such parasites is, however, established and remains as coccidiosis.

Certain of the more important of the Coccidiidea may now be considered.

Genus. **Eimeria**, Aimé Schneider, 1875.

Syn.: *Psorospermium*, Rivolta, 1878; *Cytospermium*, Rivolta, 1878; *Coccidium*, R. Leuckart, 1879; *Pfeifferia*, Labbé, 1894: *Pfeifferella*, Labbé, 1899.

The Eimeria belong to Léger's old family, the Tetrasporocystidæ, which comprises forms producing oöcysts with four sporocysts, each containing two sporozoites. The cysts are spherical or oval, as are also usually the schizonts. The members of the genus are confined chiefly to vertebrate hosts, the more important economically occurring in mammals and birds. From the mammalian hosts very rarely the parasites may reach man. *Eimeria* (*Coccidium*) *avium* of wild birds and poultry, and *Eimeria stiedæ* parasitic in rabbits, may be considered. There is a general similarity in their life-cycles and each is of great practical importance.

Eimeria avium, Silvestrini and Rivolta.

Eimeria avium is responsible for fatal epizoötics among game birds such as grouse, pheasants and partridges, and domestic poultry such as fowls, ducks, pigeons and turkeys, and can pass from any one of these hosts to any of the others with the same effect. The organism is parasitic in the alimentary tract of the host, affecting more especially the small intestine (duodenum) and the cæca, but in some cases penetrating to the liver and multiplying there (as in turkeys), producing necrotic cheesy patches, that ultimately become full of oöcysts. The gut is rendered very frail by the action of the parasites, its mucous membrane is greatly injured, and is often reduced to an almost structureless pulp, riddled with parasites (fig. 68). Infection is conveyed from host to host by the ingestion of food or drink contaminated with the oöcysts voided in the fæces of infected birds. Oval oöcysts from 24 μ to 35 μ long and from 14 μ to 20 μ broad are the means of infection. The oöcysts develop internally four sporocysts or spores, from each of which two sporozoites are produced. The life-history[1] presents two phases: (1) The asexual multiplicative phase, schizogony, for the increase in numbers of the parasites within the same host; (2) the reproductive phase, following the formation of gametes (gametogony), leading to the production of resistant oöcysts, destined for the transference of the parasite to new hosts (sporogony).

The oöcysts usually reach the duodenum unharmed, with food or drink. Under

---

[1] Fantham, H. B. (1910), "The Morphology and Life History of *Eimeria (Coccidium) avium*, a Sporozoön causing a fatal disease among young Grouse," *Proc. Zool. Soc. Lond.*, 1910, pp. 672-691, 4 plates. Also Fantham, H. B. (1911), "Coccidiosis in British Game Birds and Poultry," *Journ. Econ. Biol.*, vi, pp. 75-96.

the influence of the powerful digestive juices (especially the pancreatic) now encountered, the oöcysts soften, as do the sporocysts, and ultimately two sporozoites emerge from each sporocyst. The sporozoites are from 7 μ to 10 μ long, and each is vermicular with a uniform nucleus (fig. 69, A). After a short period of active movement in the gut, each sporozoite penetrates an epithelial cell (figs. 68 *spz*, 69, B), and once within, gradually becomes rounded (fig. 69, B, C). It grows rapidly, feeding on the contents of the host cell and living as a trophozoite (fig. 69, D). When the parasite is from 10 μ to 12 μ in diameter, usually multiplication by schizogony (fig. 69, E-H) begins. The nucleus of the parent cell, now called a schizont, divides into a number of portions that become arranged at the periphery (fig. 69, E). Cytoplasm collects around each nucleus (fig. 69, E, F) and gradually a group of daughter individuals (merozoites) is produced (fig. 69, G), the nucleus of each merozoite showing a karyosome.

The merozoites of *Eimeria avium* are arranged "en barillet," like the segments of

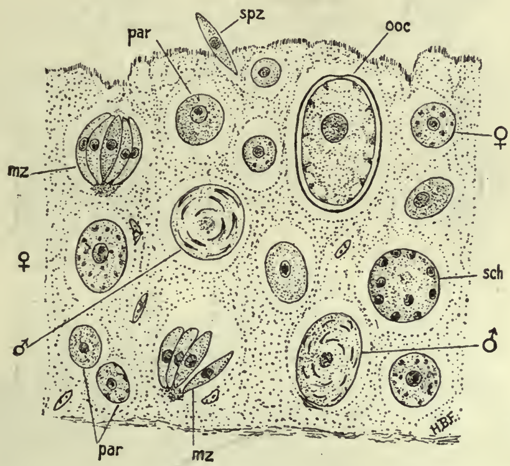


FIG. 68.—Small piece of epithelial lining of gut of heavily infected Grouse chick, showing various stages in life-history of the parasite *Eimeria avium* ; *par*, parasite (trophozoite) ; *mz*, merozoite ; *sch*, schizont ; *spz*, sporozoite ; *ooc*, oöcyst ; ♂, male gametocyte ; ♀, female gametocyte. × 750. (After Fantham.)

an orange (figs. 68 *mz*, 69, G), therein differing from those of *E. schubergi*, which are arranged "en rosace." They separate from one another (fig. 69, H), penetrate other epithelial cells, where they may, in turn, become schizonts. Eight to fourteen merozoites are usually formed by each schizont, twenty have been found, while in cases of intense infection when space has become limited, the number may be only four.

After a number of generations of merozoites have been formed, a limit is reached both to the multiplicative capacity of the parasite and to the power of the bird to provide the invader with food. Consequently, resistant forms of the parasite are necessary, and the trophozoites begin to show sexual differentiation instead of forming schizonts, that is, gametogony commences.

Certain trophozoites store food and become large and granular. These are macrogametocytes (fig. 69, I, ♀). The microgametocytes (fig. 69, I, ♂) are smaller and far less granular. The macrogametocyte continues to grow, and becomes loaded with chromatoid and plastinoid granules (fig. 69, J, ♀), while the microgametocyte has its nucleus divide to form a number of bent, rod-like portions (fig. 69, J, ♂). The macrogametocyte gives rise to a single macrogamete, which forms a cyst wall for itself, leaving a thin spot (micropyle) for the entry of the male (fig 69, K, ♀). The microgametocyte gives rise to numerous small, biflagellate microgametes (fig. 69, K, ♂) around a large, central residual mass, from which they ultimately break free, and swim away. When a macrogamete is reached, the microgamete enters through the micropyle (fig. 69, L)—which then closes, thus excluding the other males—and applies itself to the female

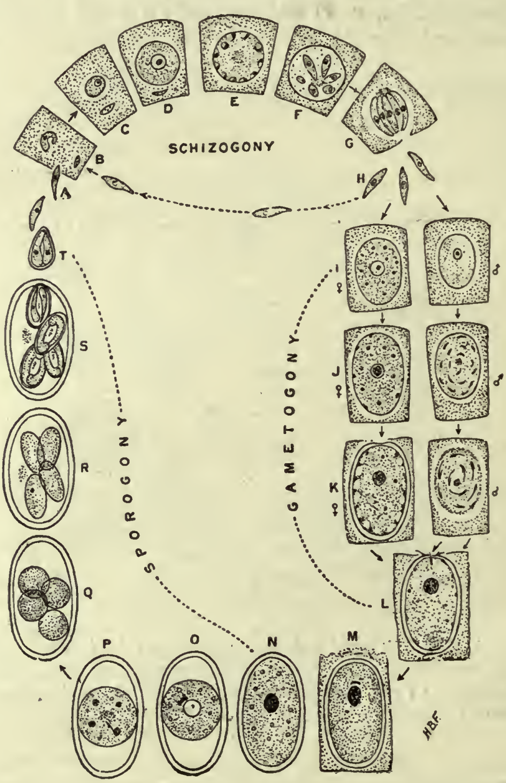


FIG. 69.—*Eimeria avium*. Diagram of life-cycle. For explanation see text. (After Fantham.)

nucleus (fig. 69, M). Nuclear fusion occurs, the oöcyst (encysted zygote) being thus produced. Sporogony then ensues. The oöcyst (fig. 69, N) at first has its contents completely filling it. They then concentrate into a central spherical mass (fig. 69, O) which gradually becomes tetranucleate (fig. 69, P). Cytoplasm collects around each nucleus, and four sporoblasts are thus formed (fig. 69, Q). Each sporoblast becomes oval (fig. 69, R) and produces a sporocyst. Ultimately two sporozoites are formed in each sporocyst or spore, at first lying tête-bêche (fig. 69, S), but finally twisting to assume the position most convenient for emergence (fig. 69, T) when they reach a new host. The period of the life-cycle of *Eimeria avium* (as well as the details of the life-cycle) was determined by Fantham to be from eight to ten days, of which period schizogony occupies four to five days.

The method of infection[1] is contaminative, by way of food or drink. Young birds are especially susceptible to infection. Certain birds, particularly older ones, may act as reservoirs of oöcysts, being continuously infected themselves, without showing any marked ill effects from the parasite, but being highly infectious to other birds. Much moisture retards the development of sporocysts considerably. The duration of vitality of the infective oöcysts has been determined experimentally to extend well over two years, and in certain cases longer. *Eimeria avium* is the causal agent of "white diarrhœa" or "white scour" in fowls, and of "blackhead" in turkeys.

Eimeria avium of birds and *E. stiedæ* of rabbits closely resemble one another, but are not the same parasite, for *E. avium* is not infective to rabbits, nor *E. stiedæ* to poultry.

Eimeria stiedæ, Lindemann, 1865.

Syn.: *Monocystis stiedæ*, Lindemann, 1865; *Psorospermium cuniculi*, Rivolta, 1878; *Cytospermium hominis*, Rivolta, 1878; *Coccidium oviforme*, Leuckart, 1879; *Coccidium perforans*, Leuckart, 1879; *Coccidium cuniculi*.

Eimeria stiedæ is parasitic in the gut epithelium (fig. 70), liver, and epithelium of the bile ducts of rabbits, and is usually considered to

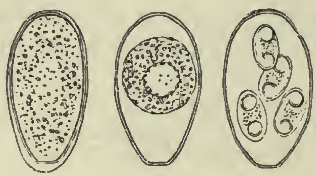
FIG. 70.—*Eimeria stiedæ*. Section through an infected villus of rabbit's intestine. × 260.

be the parasite very occasionally found in man. The life-cycle resembles that of *Eimeria avium* in its general outlines (see fig. 69) and therefore will not be detailed in full here. The oöcysts (fig. 71) are large, elongate-oval, greenish in fresh preparations and vary in size from 24 μ to 49 μ long and 12·8 μ to 28 μ broad, the gut forms being usually smaller than those occurring in the liver, owing to the

[1] Fantham, H. B. (1910), "Experimental Studies on Avian Coccidiosis, especially in relation to young Grouse, Fowls and Pigeons," *Proc. Zool. Soc. Lond.*, 1910, pp. 722-731, 1 plate.

more confined space in which they are formed. Formerly, the parasites in the liver were described under the name of *Coccidium oviforme*, while those from the intestine were termed *Coccidium perforans*. This distinction has now broken down.

The oöcysts[1] are thick-walled, somewhat flattened at one pole, where a large micropyle is present. Four egg-shaped spores (sporocysts) are formed within, each about 12 μ to 15 μ long and 7 μ broad



a b c

FIG. 71.—*Eimeria stiedæ*, from the liver of the rabbit, oöcysts in various stages of development. (After Leuckart.)

a b c

FIG. 72.—*a*, *b*, spores of *Eimeria stiedæ* (Riv.), with two sporozoites and residual bodies; *c* represents a free sporozoite. (After Balbiani.)

(fig. 72). The oöcysts are voided with the fæces. Sporogony takes, in nature, about three days in the excrement. Fæcal contamination of the food of rabbits results, and coccidian oöcysts are swallowed. Under the influence of the pancreatic juice of a new host, the sporozoites (fig. 72, *a*—*c*) are liberated from the spores and proceed to attack the epithelium and multiply within it, as in the case of *Eimeria avium*. From the gut, infection spreads to the liver, where multiplication of the parasite goes on actively, resulting in the formation of the whitish coccidial nodules, which may be very conspicuous (fig. 74). Proliferation of the connective tissue may occur around the coccidial nodules, which then contain large numbers of oöcysts in various stages of development. It is said that the oöcysts in the older nodules do not seem to be capable of further development. Schizogony (fig. 73) and gametogony in all stages can be found in both liver and gut.

FIG. 73.—So-called swarm cysts (endogenous sporulation or schizogony) of the Coccidium of the rabbit. The daughter forms are called merozoites. (After R. Pfeiffer.)

[1] For an account of the life-cycle of *Eimeria stiedæ* consult Wasielewski, Th. von (1904), "Studien und Photogramme zur Kenntnis der pathogenen Protozoen," Heft. 1 (Coccidia), 118 pp., 7 plates, Leipzig: J. A. Barth. Also, Metzner, R. (1903), *Arch. f. Protistenk.*, ii, p. 13.

Young rabbits often die of intestinal coccidiosis before infection of the liver occurs. The repeated schizogony of *Eimeria stiedæ* in the gut is sufficient to cause death.

FIG. 74.—*Eimeria stiedæ*. Section through coccidian nodule in infected rabbit's liver. × 55.

The disease of cattle popularly known as "red dysentery" is also ascribed to the action of *Eimeria stiedæ*. The fæces of infected cattle show blood clots of various sizes and in severe cases watery diarrhœa is present. Acute cases end fatally in about two days. Numerous oöcysts, considered to be those of *Eimeria stiedæ*, occur in the fæces, and there is a heavy infection of the gut, especially the large intestine and rectum, all stages of the parasite being found in the epithelium. It is suspected that cattle contract the disease by feeding on fresh grass contaminated with oöcysts. The disease is recorded from Switzerland and from East Africa.

As before mentioned, *Eimeria stiedæ* is considered to be the organism found in a few cases in man, possibly acquired by eating the insufficiently cooked livers of diseased rabbits. These cases may now be described.

(*a*) Human Hepatic Coccidiosis.

(1) Gubler's Case. A stone-breaker, aged 45, was admitted to a Paris hospital suffering from digestive disturbances and severe anæmia. On examination the liver was found to be enlarged and presented a prominent swelling, which was regarded as being due to Echinococcus. At the autopsy of the man, who succumbed to intercurrent peritonitis, twenty cysts were found averaging 2 to 3 cm. in diameter, and one measuring 12 to 15 cm. The caseous contents consisted of detritus, pus corpuscles, and oval-shelled formations, which were considered to be Distoma eggs, but which, in accordance with Leuckart's conjecture, proved to be Coccidia.[1]

(2) Dressler's Case (Prague). Relates to three cysts, varying from the size of a hemp-seed to that of a pea, and containing Coccidia, found in a man's liver.[2]

(3) Sattler's Case (Vienna). Coccidia were in this case observed in the dilated biliary duct of a human liver.[3]

(4) Perls' Case (Giessen). Perls discovered Coccidia in an old preparation of Sömmering's agglomerations.[4]

(5) Silcock's Case (London).[5] The patient, aged 50, who had fallen ill with serious symptoms, exhibited fever, enlarged liver and spleen, and had a dry, coated tongue. At the autopsy numerous caseous centres, mostly immediately beneath the surface, were found, while the contiguous parts of the liver were inflamed. Microscopical examination demonstrated numerous Coccidia in the hepatic cells as well as in the epithelium of the biliary ducts. A deposit of Coccidia was likewise found in the spleen, which the parasites had probably reached by means of the bloodstream.[6]

(*b*) Human Intestinal Coccidiosis.

In two cadavers at the Pathological Institute in Berlin, Eimer[7] found the epithelium of the intestine permeated by Coccidia. Railliet and Lucet's case may be traced back to intestinal Coccidia, which were found in the fæces of a woman and her child, who had both suffered for some time from chronic diarrhœa.[8] In other cases (Grassi, Rivolta), where only the existence of Coccidia in the fæces was known, it is doubtful whether the parasites originated in the intestine or in the liver.

---

[1] Gubler, A., "Tumeurs du foie déterm. par des œufs d'helm . . . ." *Mem. Soc. Biol.*, Paris, 1858, v, 2; and *Gaz. med. de Paris*, 1858, p. 657; Leuckart, R., *Die menschl. Paras.*, 1863, 1st edition, i, pp. 49, 740.

[2] Leuckart, R., *Die menschl. Paras.*, 1863, 1st edition, i, p. 740.

[3] Leuckart, R., *Die Paras. d. mensch.*, 1879, 2nd edition, p. 281.

[4] Leuckart, R., *ibid.*, p. 282.

[5] Silcock, "A Case of Parasit. by Psorospermia," *Trans. Path. Soc.*, London, 1890, xli, p. 320.

[6] Pianese has confirmed the fact that Coccidia actually occur in the blood of the hepatic veins of infected rabbits.

[7] *Die ei- u. kugelf. Psorosp. d. Wirbelt.*, 1870, p. 16.

[8] Railliet and Lucet, "Obs. s. quelq. Cocc. intest.," *C. R. Soc. Biol.*, Paris, 1890, p. 660; Railliet, *Trait. Zool. med. et agric.*, 2e éd., 1895, p. 140.

(*c*) Doubtful Cases.

To these belong Virchow's case [1] where, in the liver of an elderly woman, a thick walled tumour measuring 9 to 11 mm. was found. Among the contents of this tumour there were oval formations 56 μ long, surrounded by two membranes and enclosing a number of round substances. Virchow considered these foreign bodies to be eggs of pentastomes in various stages of development, others consider them to be Coccidia.

The Coccidia which Podwyssotzki claims to have seen in the liver of a man, not only in the liver cells, but also in the nuclei, are also problematic.[2] The parasite was called *Caryophagus hominis*.

Again, other explanations can be given to an observation by Thomas, on the occurrence of *Coccidium oviforme* in a cerebral tumour of a woman aged 40. The growth was as large as a pea and surrounded by a bony substance.[3]

Genus. **Isospora**, Aimé Schneider, 1881.

Syn.: *Diplospora*, Labbé, 1893.

Belonging to the section *Disporea*, that is, forming only two spores, each with four sporozoites.

Isospora bigemina, Stiles, 1891.

Syn.: "*Cytospermium villorum intestinalium canis et felis*," Rivolta, 1874; "*Coccidium Rivolta*," Grassi, 1882; *Coccidium bigeminum*, Stiles, 1891.

This parasite lives in the intestinal villi of dogs, cats, and the polecat (*Mustela putorius*, L.). According to Stiles,[4] the oöcyst divides into two equal ellipsoidal portions or sporoblasts which become spores and then each forms four sporozoites. The oöcysts of this species vary from 22 μ to 40 μ in length and from 19 μ to 28 μ in breadth. Each spore is 10 μ to 18 μ long and contains four sporozoites. The parasites live and multiply, not only in the gut epithelium, but also in the connective tissue of the intestinal submucosa. Wasielewski has seen merozoites in the gut of the cat.

Isospora bigemina (fig. 75) appears to occur also in man, for Virchow published a case which was communicated to him by Kjellberg, and attributed the illness to this parasite.[5] Possibly also it would be more correct to ascribe the observation of Railliet and Lucet, which is mentioned under "Human Intestinal Coccidiosis," p. 148, to this species, as the Coccidia in that case were distinguished

---

[1] *Arch. f. path. An.*, xviii, 1860, p. 523.

[2] Podwyssotzki, "Ueb. d. Bedeut. d. Coccid. in d. Path. Leber des Menschen," *Centralbl. f. Bakt.*, vi, 1889, p. 41.

[3] Thomas, J., "Case of Bone Formation in the Human Brain, due to the Presence of *Coccidium oviforme*," *Journal Boston Soc. Med. Sc.*, iii, 1899, p. 167; *Centralbl. f. Bakt.* [1] xxviii, 1900, p. 882.

[4] "Notes on Paras.," No. 11, *Journ. of Comp. Med. and Vet. Sci.*, 1892, xiii, p. 517.

[5] *Arch. f. path. An.*, 1860, xviii, p. 527.

by their diminutive size (length 15 μ, breadth 10 μ). The case communicated by Grunow may also possibly refer to *Isospora bigemina*.[1]

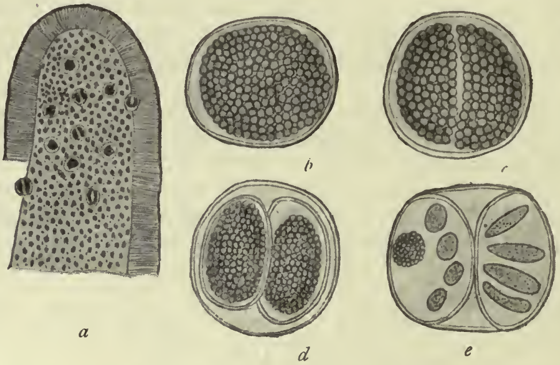


FIG. 75.—*Isospora bigemina*, Stiles (from the intestine of a dog). *a*, Piece of an intestinal villus beset with Isospora, slightly enlarged ; *b*, *Isospora bigemina* (15 μ in diameter), shortly before division ; *c*, divided ; *d*, each portion encysted forming two spores ; *e*, four sporozoites in each part, on the left seen in optical section, together with a residual body—highly magnified. (After Stiles.)

Roundish or oval structures of 6 μ to 13 μ in diameter occurred in the mucous membrane of the gut and in the fæces of a case of enteritis.

DOUBTFUL SPECIES.

In literature many other statements are found as to the occurrence of Coccidia-like organisms in different diseases of man. In some of the cases the parasites proved to be fungi. This was the case with the parasites of a severe skin disease of man, formerly called *Coccidioides immitis* and *Coccidioides pyogenes.* Other statements are founded on misapprehensions, or are still much disputed. If reference is here made to "*Eimeria hominis*," R. Blanchard, 1895, this is done on the authority of the investigator mentioned. The structures in question are nucleated spindle-shaped bodies of very different lengths (18 μ to 100 μ), which either occurred isolated or were enclosed in large globular or oval cysts, alone or with a larger tuberculated body ("residual body"). These formations were found by J. Künstler and A. Pitres in the pleural exudation removed from a man by tapping. The man was employed on the ships plying between Bordeaux and the Senegal River.

Blanchard looks upon the fusiform bodies as merozoites and the cysts as schizonts of a Coccidium. On the other hand, Moniez declares the spindle bodies to be the ova and the supposed residual bodies to be "floating ovaries" of an Echinorhynchus.

Severi's "monocystid Gregarines," which were taken from the lung tissue of a still-born child, are also quite problematical.

No less doubtful are the bodies which Perroncito calls *Coccidium jalinum*, and which he found in severe diseases of the intestine in human beings, pigs, and guinea-pigs ; Borini also reported another case.

[1] Grunow, "Ein Fall von Protozoën (Coccidien?) Erkrankung des Darmes," *Arch. f. exper. Path. und Pharm.*, 1901, xlv, p. 262.

Order. **Hæmosporidia,** Danilewsky emend. Schaudinn.

The Hæmosporidia are a group of blood parasites, comprising forms differing greatly among themselves. Some of the forms need much further investigation. However, there are certain true Hæmosporidia which present close affinities with the Coccidia, leading Doflein to use the term **Coccidiomorpha** for the two orders conjoined.

The Hæmosporidia present the following general characteristics :—

(1) They are parasites of either red or white blood corpuscles of vertebrates during one period of their life-history.

(2) They exhibit alternation of generations—asexual phases or schizogony alternating with sexual phases or sporogony—as do the Coccidia.

(3) There is also an alternation of hosts in those cases which have so far been completely investigated. The schizogony occurs in the blood or internal organs of some vertebrate while the sporogony occurs in an invertebrate, such as a blood-sucking arthropod or leech.

(4) Unlike the Coccidia, resistant spores in sporocysts are not generally produced, such protective phases in the life-cycle being unnecessary, as the Hæmosporidia are contained within either the vertebrate or invertebrate host during the whole of their life.

The Hæmosporidia may be considered for convenience under five main types :—

(1) The *Plasmodium* or *Hæmamœba* type. This includes the malarial parasites of man and of birds. The asexual multiplicative or schizogonic phases occur inside red blood corpuscles and are amœboid. They produce distinctive, darkish pigment termed melanin or hæmozoin. Infected blood drawn and cooled on a slide may exhibit "exflagellation" of the male gametocytes, *i.e.*, the formation of filamentous male gametes. The invertebrate host is a mosquito. The malarial parasites of man are discussed at length on p. 155. Similar pigmented hæmamœboid parasites have been described in antelopes, dogs, and other mammals, and even reptiles.

(2) The *Halteridium* type. The trophozoite stage inside the red blood corpuscle is halter-shaped. Pigment is produced, especially near the ends of the organism. The parasites occur in the blood of birds. The invertebrate host of *H. columbæ* of pigeons in Europe, Africa, Brazil and India, is a hippoboscid fly, belonging to the genus *Lynchia.*

Halteridium parasites are common in the blood of passerine birds, such as pigeons, finches, stone owls, Java sparrows, parrots, etc. The Halteridium embraces or grows around the nucleus of the host red cell without displacing the nucleus. Young forms and multiplicative stages of *H. columbæ* have been found in leucocytes in the lungs of the pigeon (fig. 76, *8-12*). Male and female forms (gametocytes) are seen in the blood (fig. 76, *3a*, *3b*). The cytoplasm of the male gametocytes is pale-staining and the nucleus is elongate, while the cytoplasm of the females is darker and the nucleus is smaller and round. Formation of male gametes from male gametocytes (the so-called process of "exflagellation") may occur on a slide of drawn infected blood, also fertilization, and formation of the oökinete, as first seen by MacCallum. The correct generic name for Halteridia is, apparently, *Hæmoproteus*. Wasielewski (1913), working

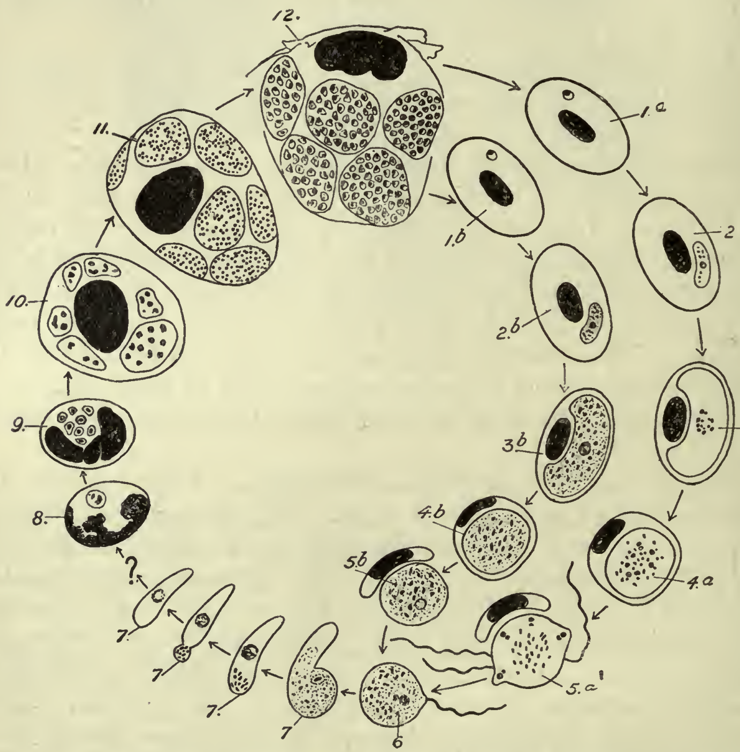


FIG. 76—*Hæmoproteus* (*Halteridium*) *columbæ*. Life-cycle diagram: 1, 2, stages in red blood corpuscle of bird; 3, 4, gametocytes (3*a* ♂, 3*b* ♀); 5*a*, formation of microgametes; 6, fertilization (in fly's gut); 7, oökinete; 8-12, stages in mononuclear leucocytes in lungs. (After Aragão.)

on *H. danilewskyi* (var. *falconis*), in kestrels, finds that the halteridium may be pathogenic to nestlings. The cycle of *H. noctuæ* described by Schaudinn (1904) lacks confirmation. The account of the life-cycle of *H. columbæ* given by Aragão (1908) is illustrated in fig. 76. It agrees with the work of Sergent (1906-7) and Gonder (1915). Mrs. Adie (1915) states that the cycle in *Lynchia* is like that of a *Plasmodium*.

(3) The *Leucocytozoön* type. The trophozoites and gametocytes occur within mononuclear leucocytes and young red cells (erythro-

blasts) in the blood of birds. Laveran and França consider that the Leucocytozoa occur in erythrocytes. The host cells are often greatly altered by the parasites, becoming hypertrophied and the ends usually drawn into horn-like processes (fig. 77), though some remain rounded. Leucocytozoa are limited to birds, and very rarely produce pigment. Male and female forms (gametocytes) are distinguishable in the blood (fig. 77), and the formation of male gametes ("ex-flagellation") may occur in drawn blood.

The Leucocytozoa were first seen by Danilewsky in 1884. They are usually oval or spherical. It is not easy sometimes to distinguish the altered host cell from the parasite, as the nucleus of the former is pushed to one side by the leucocytozoön. The cytoplasm of the female parasite stains deeply, and the nucleus is rather small, containing a karyosome. In the male the cytoplasm stains lightly and the nucleus is larger, with a loose, granular structure.

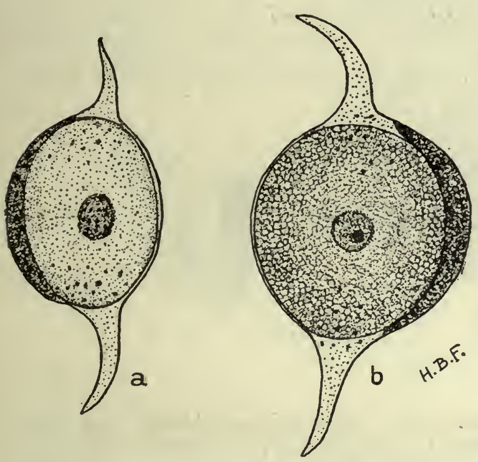


FIG. 77.—*Leucocytozoon lovati.* *a*, Male parasite (microgametocyte), within host cell, whose ends are drawn out; *b*, female parasite (macrogametocyte) from blood of grouse. × 1,800. (After Fantham.)

Many species of Leucocytozoa are recorded, but schizogony has only been described by Fantham (1910)[1] in *L. lovati* in the spleen of the grouse (*Lagopus scoticus*), and by Moldovan[2] (1913) in *L. ziemanni* in the internal organs of screech-owls.

M. and A. Leger[3] (1914) propose to classify Leucocytozoa, provisionally, according as the host cells are fusiform or rounded.

(4) The *Hæmogregarina* type. Included herein are many parasites of red blood corpuscles, with a few (the leucocytogregarines) parasitic in the white cells of certain mammals and a few birds. They are not amœboid but gregarine-like, vermicular or sausage-shaped (fig. 78). They do not produce pigment. They are widely distributed among the vertebrata, but are most numerous in cold-blooded vertebrates (fishes, amphibia and reptiles). The hæmogregarines of aquatic hosts are transmitted by leeches, those of terrestrial hosts by arthropods.

---

[1] *Annals Trop. Med. and Parasitol.*, iv, p. 255.
[2] *Centralbl. f. Bakt.*, Orig., lxxi, p. 66.
[3] *Bull. Soc. Path. Exot.*, vii, p. 437.

The nucleus of hæmogregarines is usually near the middle of the parasite, but may be situated nearer one end. The body of the parasite may be lodged in a capsule ("cytocyst"). There is much variation in size and appearance among hæmogregarines. Some are small (*Lankesterella*); some attack the nucleus of the host cell (*Karyolysus*); others have full grown vermicules larger than the containing host corpuscle, and so the hæmogregarines bend on themselves in the form of U (fig. 78, *b*). Schizogony often occurs in the internal organs of the host, sometimes in the circulating blood.

The hæmogregarines occurring in the white cells (mononuclears or polymorphonuclears) of mammals have been referred to a separate genus, *Leucocytogregarina* (Porter) or *Hepatozoön* (Miller). Such leucocytogregarines are known in the dog (fig. 79), rat, mouse, palm-squirrel, rabbit, cat, etc. Schizogony of these forms occurs in the internal organs, such as the liver, lung and bone-marrow of the hosts.

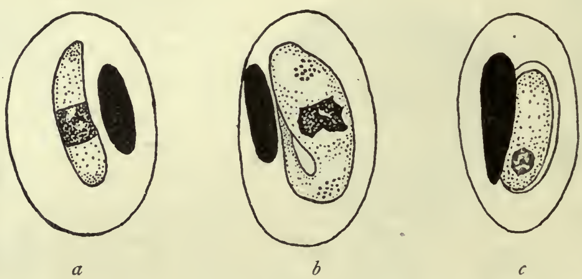


FIG. 78.—Hæmogregarines from lizards. *a*, *H. schaudinni*, var. *africana*, from *Lacerta ocellata*; *b*, *H. nobrei* from *Lacerta muralis*; *c*, *H. marceaui* in cytocyst, from *Lacerta muralis*. (After França.)

They are apparently transmitted by ectoparasitic arthropods, such as ticks, mites, and lice.

A few hæmogregarines are known to be parasitic in the red blood corpuscles of mammals. Such are *H. gerbilli* in the Indian field rat, *Gerbillus indicus*; *H. balfouri* (*jaculi*) in the jerboa, *Jaculus jaculus*, and a few species briefly described from marsupials. These parasites do not form pigment.

Strict leucocytic gregarines have been described from a few birds by Aragão and by Todd.

The sporogony of hæmogregarines is only known in a few cases, and in those affinity with the Coccidia is exhibited. In fact, the Hæmogregarines are now classified by some authors with the Coccidia.

(5) The *Babesia* or *Piroplasma* type. These are small parasites of red blood corpuscles of mammals. They do not produce pigment. They are pear-shaped, round or amœboid in Babesia, bacilliform

and oval in other forms referred to this group. Piroplasms are transmitted by ticks. These parasites are described at length on p. 172.

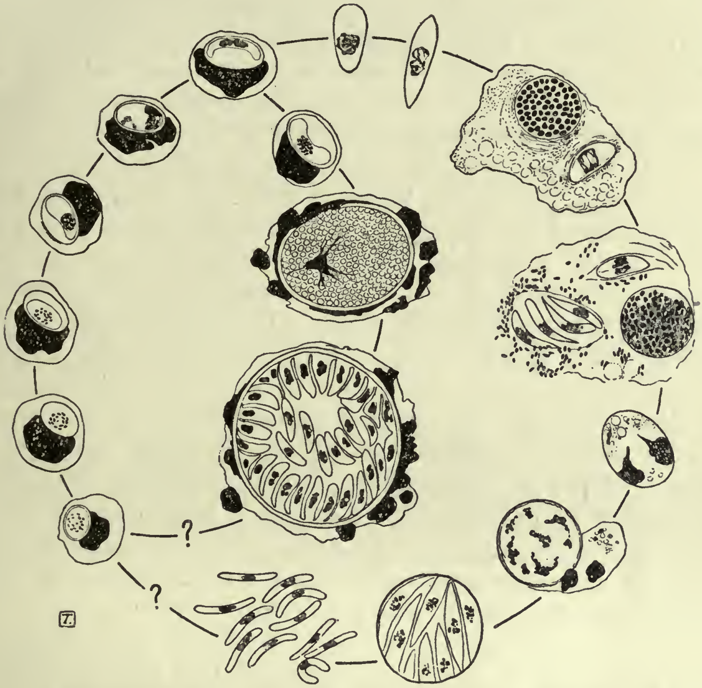


FIG. 79.—*Leucocytogregarina canis*. Life-cycle diagram. Constructed from drawings by Christophers. (After Castellani and Chalmers.) Schizogony occurs in the bone-marrow. The parasite is transmitted from dog to dog by the tick, *Rhipicephalus sanguineus*, development in which, so far as known, is shown on the right.

THE MALARIAL PARASITES OF MAN.

Malaria, otherwise known as febris intermittens, chill-fever, ague, marsh fever, paludism, etc., is the name given to a disease of man, which begins with fever. It has been known since ancient times and is distributed over almost all the world, although very unevenly, but does not occur in waterless deserts and the Polar regions. In many places, especially in the civilized countries of Central Europe, the disease is extinct or occurs only sporadically, and large tracts of land have become free from malaria.

The rhythmical course of the fever is characteristic. It begins apparently suddenly with chilliness or typical shivering, whilst the temperature of the body rises, the pulse becomes low and tense and the number of beats of the pulse increases considerably. After half to two hours the heat stage begins. The patient himself feels the rise of his temperature (shown by feeling of heat, dry tongue, headache, thirst). The temperature may reach 41° C or more. At the same time there is sensitiveness in the region of the spleen and enlargement of that organ. After four to six hours an improvement takes place, and with profuse perspiration the body temperature falls rapidly, not often below normal. After the attack the patient feels languid, but otherwise well until certain prodromal symptoms (heaviness in the body, headache) which were not noticed at first, denote the approach of another attack of fever, which proceeds in the same way.

The intervals between the attacks are of varying length which permit of a distinction in the kinds of fever. If the attacks intermit one day, occurring on the first, third and fifth days of the illness and always at the same time of day, it is termed *febris tertiana;* if two days occur between fever days, it is called *febris quartana.* In the case of the fever recurring daily, later writers speak of typical *febris quotidiana.* But a quotidian fever may arise when two tertian fevers differing by about twenty-four hours exist at the same time (*febris tertiana duplex*). The patient has a daily attack, but the fever of the first, third and fifth days differs in some point (hour of occurrence, height of temperature, duration of cold or hot stage) from the fever of the second, fourth and sixth days. Similarly, two or three quartan fevers which differ by about twenty-four hours each may be observed together (*febris quartana duplex* or *triplex*); in the latter case the result is also a quotidian fever.

Two kinds of tertian fever are differentiated—a milder form occurring especially in the spring (spring tertian fever), and a more severe form appearing in the summer and autumn in warmer districts, especially in the tropics (*summer or autumn fever, febris æstivo-autumnalis, febris tropica, febris perniciosa*). The latter often becomes a quotidian fever.

All the afore-mentioned infections are termed acute. They are distinguished from the very different *chronic malarial infection* by the frequent occurrence of relapses, which finally lead to changes of some organs and particularly of the blood. The relapses are then generally marked by an irregular course of fever.

The term masked malaria is used when any disturbance of the state of health of a periodic character shows itself and disappears after treatment with quinine.[1] Generally it is a question of neuralgia.

That intermittent fever was an infectious disease, although not one which was transmitted direct from man to man, had been assumed for a long time. Therefore it was natural, at a time when bacteriology was triumphing, to look for a living agent causing infection in malaria, which search was, seemingly, successful (Klebs, Tomasi-Crudeli, 1879). Hence it was not surprising that the discovery of the

---

[1] Quinine is still almost exclusively the remedy used in the treatment of malaria. It is prepared from the bark of the cinchona tree. This important remedy was introduced into Europe in 1640 from Ecuador by Juan del Vego, physician of the Countess del Cinchon.

real malarial parasites in November, 1880, by the military doctor A. Laveran[1] in Constantine (Algeria), at first met with violent opposition, even after Richard (1882) had confirmed it and Marchiafava, Celli, Grassi and others, had further extended it. Not that the existence of structures found in the blood of malaria patients by Laveran and Richard was denied ; on the contrary, the investigations of the opponents furnished many valuable discoveries, but the organisms were differently interpreted and considered to be degeneration products of red blood corpuscles. Only when Marchiafava and Celli (1885) saw movements in the parasites, which Laveran called *Oscillaria malariæ* and later *Hæmatozoön malariæ*, was their animal nature admitted and the parasites were named *Plasmodium malariæ*. Shortly before this, Gerhardt (1884) had stated that the disease could be transmitted by the injection of the blood of a malarial patient to a healthy person.

This supplied the starting point for further investigations, which were made not exclusively, but principally, by Italian investigators (Golgi, Marchiafava and Celli, Bignami and Bastianelli, Grassi and Feletti, Mannaberg, Romanowsky, Osler, Thayer and others). In 1885 Golgi described the asexual cycle in the blood, in the case of the quartan parasite. These investigations, after attention had been drawn by Danilewsky (1890) to the occurrence of similar endoglobular parasites in birds, were extended to the latter (Grassi and Feletti, Celli and Sanfelice, Kruse, Labbé and others).

The result was as follows : Malaria in man (and birds) is the result of peculiar parasites included in the *Sporozoa* by Metchnikoff, which parasites live in the erythrocytes, grow in size and finally "sporulate," that is, separate into a number of "spores" which leave the erythrocytes and infect other blood corpuscles. Morphologically and biologically several species (and respectively several varieties) of malarial parasites may be distinguished, on which the different intermittent forms depend. Transmission of the blood of patients to healthy people produces a malarial affection which corresponds in character to the fever of the patient from whom the inoculation was made. The combined types of fever (tertiana duplex, quartana duplex or triplex) are explained by the fact that the patient harbours two or three groups of parasites which differ in their development by about twenty-four hours, whilst the irregular fevers depend on deviation from the typical course of development of the parasites. In addition to stages of the parasites which could easily be arranged in a developmental series concurrent with the course of the disease, other phases of the parasites also became known, such as spheres, crescents, polymitus forms, which seemed not to be included in the series and, therefore, were very differently interpreted.

The decision reached at the beginning of the last decade of the last century, which found expression in comprehensive statements (Mannaberg, Ziemann and others), only concerned a part of the complete development of the malarial parasites. No one could with any degree of certainty demonstrate how man became infected, nor were there reliable hypotheses based on analogy with other parasites concerning the exit of the excitants of malaria from the infected person and their further behaviour. Numerous hypotheses had been advanced, but none was able to elucidate the

---

[1] The discovery of Laveran is in no way lessened by the fact that one investigator or another (according to Blanchard [*Arch. de Paras.*, vii, 1903, p. 152], P. F. H. Klencke in 1843) had seen, mentioned and depicted malarial parasites. (*Neue phys. Abhandl. auf. selbständ. Beob. gegr.*, Leipzig, 1843, p. 163, fig. 25). In 1847 Meckel had recognized that the dark colour of the organs in persons dead of malaria was due to pigment. Virchow in 1848 stated that this pigment occurred in blood cells. Kelsch in 1875 recognized the frequency of melaniferous leucocytes in the blood of malarial patients. Beauperthuy (1853) noticed that in Guadeloupe there was no malaria at altitudes where there were no "insectes tipulaires," and suggested that the disease was inoculated by insects.

various observations made from time to time in dealing with malaria. One hypothesis only seemed to have a better foundation. Manson (1894), who knew from his own experience the part played by mosquitoes in the development of Filaria from the blood of man, applied this also to the malarial parasites living in the blood, whereby at least the way was indicated by which the Hæmosporidia could leave man. The parasites were said finally to get into water through mosquitoes which had sucked the blood of malarial patients, and the germ spread thence to men who drank the water. In some cases the parasites were supposed to reach man by the inhaling of the dust of dried marshes. On the other hand, Bignami believed that the mosquitoes were infected in the open air by malarial parasites which occurred there in an unknown stage and the insects transmitted the germs to man when biting. R. Koch combined both hypotheses, without, however, producing positive proof. R. Ross, then (1897-8) an English military doctor in India, was the first to succeed in this. He had been encouraged by Manson to study the fate of malarial *Plasmodia* which had entered the intestine of mosquitoes with malaria-infected blood, especially in the case of the *Plasmodium* (*Proteosoma*) living in the blood of birds. He showed that the *Proteosoma* penetrate the intestinal wall of the mosquitoes, grow and develop into large cysts which produce innumerable rod-like germs, which burst into the body cavity and penetrate the salivary glands. Ross allowed mosquitoes to suck the blood of birds affected by malaria, and some nine days later, let the infected mosquitoes which had been isolated suck healthy birds. After five to nine days *Proteosoma* were found to occur in the blood of the birds used. The *Proteosoma* and *Halteridium* of birds were also further investigated by MacCallum (1897-8), Koch and others, and important results followed.

In any case Ross (1898) had clearly established the importance of mosquitoes in the spread of malaria among birds. It was now only a question of proving whether, and how far, mosquitoes were concerned with human malaria. Ross himself worked to this end. Here the experiments of Italian investigators (Bignami, Bastianelli, Grassi)[1] were of importance. These investigators studied the fate of malarial parasites in man, produced malaria in men experimentally by the bites of infected mosquitoes, and established that only mosquitoes belonging to the genus *Anopheles* were concerned, and not species of *Culex*. These latter are only able to transmit *Proteosoma* to birds. It is true that *Culex* can ingest the human malarial parasites, but the latter do not develop in them. Development only occurs in species of *Anopheles*. In *Anopheles* (and similarly for *Proteosoma* in *Culex*) sexual reproduction takes place; crescents, spheres and polymitus forms are necessary stages of development in the mosquito.

With these discoveries the campaign against malaria became more definite. It was directed partly against the transmitters, whose biology and life-cycle were more thoroughly investigated, instead of merely against the infection of the adult *Anopheles*. The latter do not, as was believed for some time, transmit the malarial germs to their offspring. They always infect themselves from human beings, whereby the relapses appearing in early summer, and the latent infection, especially of children of natives, play a principal part (Stephens and Christophers, Koch). Further, the crusade was directed against the infection of man by the bites of *Anopheles*. Important results have been obtained in these directions. Low and Sambon in 1900 lived in a mosquito-screened hut in a malarial part of the Roman Campagna for three of the most malarious months and did not contract the disease. In the same year Dr. P. T. Manson was infected with malaria by infected mosquitoes sent from Italy. The rôle of mosquitoes having been proved, it may be hoped that ultimately the eradication of malaria, or at least a considerable restriction of it, will be achieved.

---

[1] Grassi, B. (1901), "Die Malaria," 250 pp., 8 plates. G. Fischer, Jena.

It is of importance to record that, although malarial parasites occur in mammals (monkeys, bats, etc.) the human ones are not transmissible to mammals, not even to monkeys. The species, therefore, are specific to the different hosts (Dionisi, Kossel, Ziemann, Vassall).

An important work dealing with the modern applications of the mosquito-malaria theory in all parts of the Tropics was published by Sir Ronald Ross in 1911. It is entitled "The Prevention of Malaria" (John Murray, London, 21s.).

DEVELOPMENT OF THE MALARIAL PARASITES OF MAN.

The commencement of the developmental cycle and of the infection of man, is the sporozoites (fig. 80, *1*) which are passed into the blood of a person by the bite of an infected mosquito. Prior to this the parasites collect in the excretory ducts of the salivary glands (fig. 80, *27*) of the *Anopheles*. The sporozoites are elongate and spindle-shaped, 10 μ to 20 μ long and 1 μ to 2 μ broad, with an oval nucleus situated in the middle. They are able to glide, perform peristaltic contractions, or curve laterally. Schaudinn has studied the penetration of the red blood corpuscles (fig. 80, *2*) by the sporozoites in the case of the living tertian parasite. The process takes forty to sixty minutes in drawn blood. After its entrance the parasite, which is now called a trophozoite, contracts, and becomes an active amœbula (fig. 80, *3*). It develops a food vacuole and grows at the expense of the invaded blood corpuscle (fig. 80, *4*), which is shown by the appearance of pigment granules (transformed hæmoglobin) in it. When the maximum size is attained, multiplication by schizogony (fig. 80, *5-7*) begins with a division of the nucleus, which is followed by further divisions of the daughter nuclei, the number of which varies up to 16 or even 32, depending on the species of the parasite. Then the cytoplasm divides into as many portions as there are nuclei, the result being a structure suggestive of the spokes of a wheel or of a daisy, the centre of the resulting rosette being occupied by dark pigment. Finally, the parts separate from one another, leaving behind a residual body containing the pigment, and the daughter forms issue into the blood plasma as merozoites (fig. 80, *7*). They are actively amœboid (fig. 80, *8*) and soon begin to enter other blood corpuscles of their host, for the entry into which thirty to sixty minutes are necessary, according to Schaudinn's observations.[1]

Here they behave like sporozoites which previously entered and

[1] It should be remembered that some authors (Laveran, Argutinsky, Panichi, Serra) argue against the intra-globular position of malarial parasites and state that they only adhere outwardly to the red blood corpuscles. These views have recently been revived by Mary Rowley-Lawson, and she states that the malarial parasite is "extracellular throughout its life-cycle and migrates from red corpuscle to red corpuscle destroying each before it abandons it." (*Journ. Exper. Med.*, 1914, xix, p. 531.)

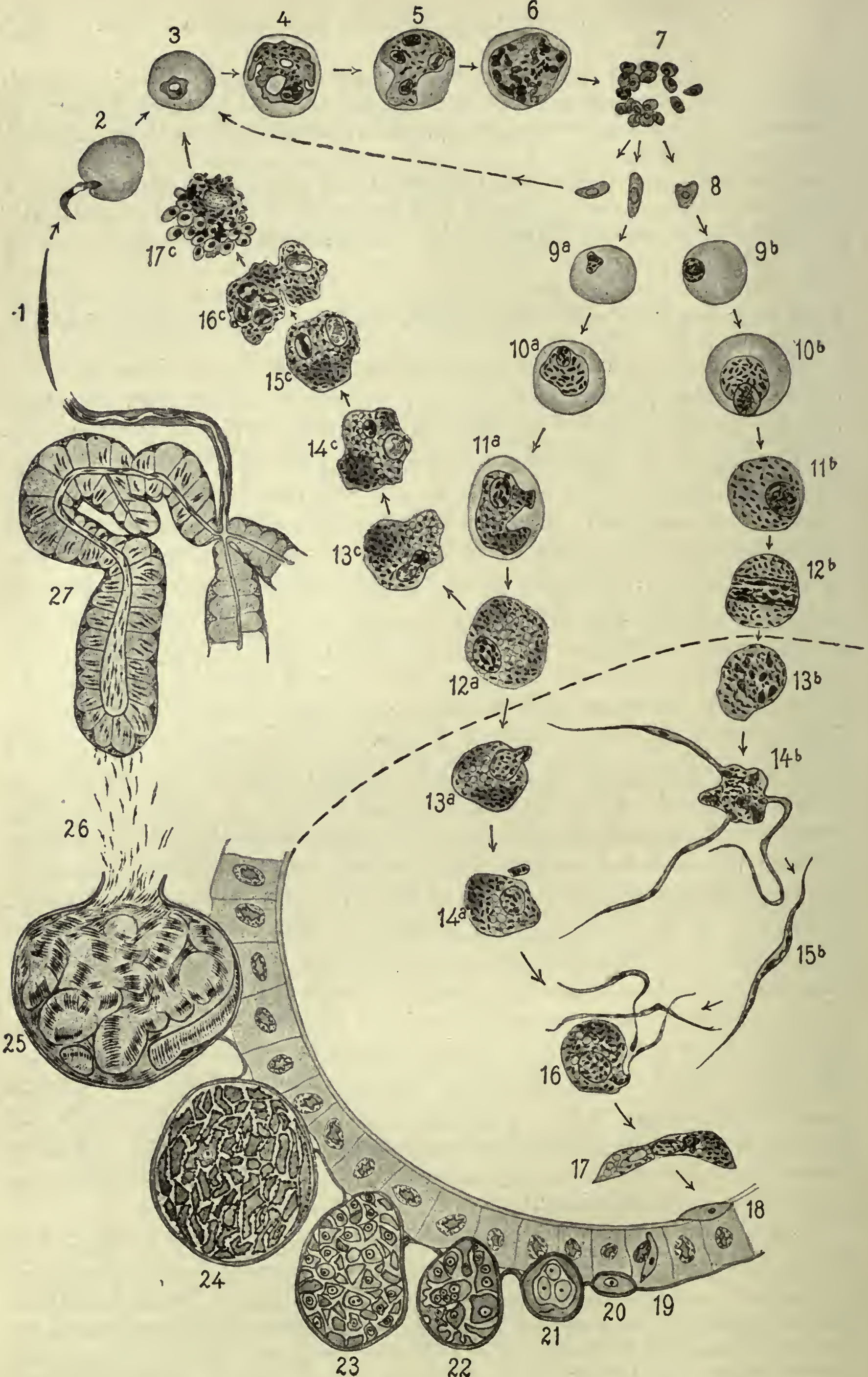


FIG. 80.—Life-cycle of the tertian parasite (*Plasmodium vivax*). Figs. 1 to 17, × 1,200; figs. 18 to 27, × 600. (After Lühe, based on figures by Schaudinn and Grassi.) 1, sporozoite; 2, entrance of the sporozoite into a red blood corpuscle; 3, 4, growth of the parasite, now

again produce merozoites. This process is repeated until the number of parasites is so large that, at the next migration of the merozoites, the body of the person infected reacts with an attack of fever,[1] which is repeated with the occurrence of the next or following generations.

The growth and schizogony last different times, according to the species of the parasite, about forty-eight hours in the case of the parasite of febris tertiana or tropica, and seventy-two hours for the quartan parasite. The various intermittent forms produced by them depend on this specific difference in the malarial parasites.

The schizogony can, however, only be repeated a certain number of times, supposing that the disease has not been checked prematurely by the administration of quinine, which is able to kill the parasites. It appears that after a number of attacks of fever the conditions of existence in man are unfavourable for the malarial parasites, and this brings about the production of other forms which have long been known, but also long misunderstood (spheres, crescents, polymitus). The merozoites in this case no longer grow into schizonts, or at least not all of them, but become sexual individuals called gametocytes (fig. 80, *9—12*), which only start their further development when they have reached the intestine of *Anopheles*. This does not take place in every case, nor with all the gametocytes which exist in the blood of patients with intermittent fever. Of those parasites which remain in the human blood the male ones (microgametocytes) soon perish, the females (macrogametocytes) persist for some long time, and perhaps at last acquire the capacity of increasing by schizogony. They might thus form merozoites which behave in the body as if they had proceeded from ordinary schizonts (fig. 80, *13c—17c*). If their number increases sufficiently, in course of time the patient, who was apparently recovering, has a new series of fever attacks, or relapses, without there having been a new infection. This is the view of Schaudinn, who from researches of his own concluded that relapses were brought about by a sort of parthenogenetic reproduction of macrogametocytes. R. Ross, on the contrary, believes that in the

---

sometimes called a trophozoite; 5, 6, nuclear division in schizont; 7, free merozoites; 8, the merozoites which have developed making their way into blood corpuscles, (arrow pointing to the left) and increase by schizogony (3—7); after some duration of disease the sexual individuals appear; 9*a*—12*a*, macrogametocytes; 9*b*—12*b*, microgametocytes, both still in the blood-vessels of man. If macrogametocytes (12*a*) do not get into the intestine of *Anopheles* they may perhaps increase parthenogenetically according to Schaudinn (12*a*; 13*c*—17*c*). The merozoites which have arisen (17*c*) become schizonts 3—7. The phases shown underneath the dotted line (13—17) proceed in the stomach of *Anopheles*. 13*b* and 14*b*, formation of microgametes; 13*a* and 14*a*, maturation of the macrogametes; 15*b*, microgamete; 16, fertilization; 17, oökinete; 18, oökinete in the walls of the stomach; 19, penetration of the epithelium of the stomach; 20—25, stages of sporogony on the outer surface of the intestinal wall; 26, migration of the sporozoites to the salivary gland; 27, salivary gland with sporozoites.

[1] The incubation period, that is, the time between infection and the first attack of fever, is ten to fourteen days; with severe infection fewer days (minimum 5 to 6) are needed.

relatively healthy periods the number of parasites in the blood falls below that necessary to provoke febrile symptoms; relapses then result merely from increase in the numbers of the parasites present in the individual. Ross's view is now generally accepted.

If the gametocytes, which are globular, or in the pernicious or malignant tertian parasite crescentic (fig. 81), gain access to the

FIG. 81.—Stages of development of pernicious or malignant tertian parasites in the intestine of *Anopheles maculipennis*. (After Grassi.) *a*, macrogametocyte (crescent) still attached to human blood corpuscles; *b*, macrogametocyte (sphere) half an hour after ingestion by the mosquito; *c*, microgametocyte (crescent) attached to the blood corpuscle; *d*, microgametocyte (sphere) half an hour after ingestion; the nucleus has divided several times; *e*, microgametes attached to the residual body (polymitus stage).

intestine of an Anopheline,[1] they mature. The macrogametocytes extrude a part of their nuclear substance (fig. 80, *13a*, *14a*) and thereby become females or macrogametes. The microgametocytes, on the other hand, undergo repeated nuclear division, preparation for this being made apparently whilst in the blood of man. This results

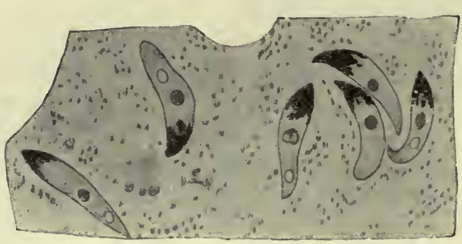


FIG. 82.—Oökinete of the malignant tertian parasite in the stomach of *Anopheles maculipennis*, thirty-two hours after ingestion of blood. (After Grassi.)

in the formation of threadlike bodies which move like flagella and finally detach themselves from the residual body (fig. 80, *13b*, *14b*). These are the males or microgametes[2] (fig. 80, *15b*).

Copulation takes place in the stomach of the Anopheline (fig. 80, *16*). A microgamete penetrates a macrogamete and coalesces with it. The

[1] Schizonts ingested about the same time perish in the intestine of the mosquito.

[2] If the microgametocytes are sufficiently mature the formation of microgametes occurs in the blood of man as soon as it is taken from the blood-vessel and has been cooled and diluted. Such a stage is called a *Polymitus* form, and the process has been called "exflagellation."

fertilized females elongate very soon and are called oökinetes or "vermicules" (figs. 80, *17*; 82). They penetrate the walls of the stomach, pierce the epithelium (fig. 80, *18*, *19*), and remain lying between it and the superficial stratum (tunica elastico-muscularis). Then they become rounded and gradually develop into cysts which grow larger and are finally visible to the naked eye, being called oöcysts (figs. 80, *20-24*; 83). Their size at the beginning is about 5 μ, the maximum that they attain is 60 μ, only exceptionally are they larger.

FIG. 83.—Section of the stomach of an *Anopheles*, with cysts (oöcysts) of the malignant tertian parasite. (After Grassi).

The sporulation (figs. 80, *21—25*; 84), which now follows, begins with repeated multiple fission of the nucleus. Long before the definitive number of nuclei, which varies with the individual, is attained the protoplasm, according to Grassi, begins to segment around the individual large nuclei but without separating completely into cell areas. According to Schaudinn, however, there is a condensation of the outstanding protoplasmic strands. It is certain that the number of nuclei increases with simultaneous decrease in size. They soon appear on the surface of the strands or sporoblasts, surround themselves with some cytoplasm and then elongate (fig. 84). In this manner the sporozoites are formed and break away from the unused remains of the cytoplasmic strands of the sporoblasts (fig. 80, *26*). The number of the sporozoites in an oöcyst varies from several hundreds to ten thousand.

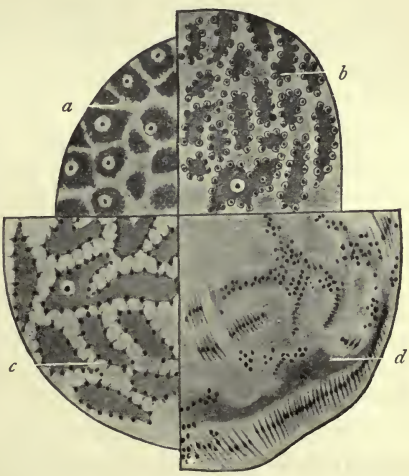


FIG. 84.—Four different sporulation stages of malarial parasites from *Anopheles maculipennis*, much magnified. *a—c*, of the malignant tertian parasite; *a*, four to four and a half days after sucking; *b* and *c*, five to six days after sucking; *d*, of the tertian parasite, eight days after sucking. (After Grassi.)

The sporulation is influenced in its duration by the external temperature (Grassi, Jansci, Schoo). In the tertian parasite it takes place quickest at a temperature of 25° to 30° C. and takes eight to nine days. A temperature a few degrees lower has a retarding effect (eighteen to nineteen days at 18° to 20° C). A still lower one has a restraining or even destructive effect. Temperatures over 35° C. also exercise a harmful effect. The malignant tertian parasite seems to need a somewhat higher temperature and the quartan parasite a lower one.

The sporozoites of the various malarial parasites show no specific differences. They were stated by Schaudinn to occur in three forms, and these were described as indifferent (neuter), female and male. There is, however, little or no evidence for this hypothetical differentiation. The last were said to perish prematurely, that is, in the oöcyst. The others after the rupture of the oöcysts enter the body cavity of the Anophelines, whence they are carried along in the course of the blood. Finally they penetrate the salivary glands (fig. 80, *27*) probably by their own activity, break through their epithelia and accumulate in the salivary duct (fig. 80, *27*). At the next bite by the mosquito they are transmitted to the blood-vessels of man.

The Species of Malarial Parasites of Man.

In view of the differences in opinion regarding "species" and "varieties," the dispute whether the malarial parasites of man represent one species with several varieties, or several species is almost superfluous. If necessary two genera may be distinguished.

The parasites of the tertian and quartan fever are alike in that their gametocytes have a rounded shape (figs. 80, *12*, *13*), whilst the corresponding stages of the pernicious or malignant tertian parasites are crescentic (figs. 81, 88). These differences are used by some writers as the distinguishing characteristic of two genera: *Plasmodium*, Marchiafava and Celli, 1885, for the first mentioned species; *Laverania*, Grassi and Feletti, 1889, for the pernicious or malignant tertian parasite. Whether there is a genuine quotidian fever and accordingly a special quotidian parasite is still disputed.

These parasites are treated in practical detail in Stephens and Christophers' "Practical Study of Malaria," 3rd edition, 1908.

Plasmodium vivax, Grassi and Feletti, 1890.

Syn.: *Hæmamœba vivax*, Grassi and Feletti, 1890; *Plasmodium malariæ* var. *tertianæ*, Celli and Sanfelice, 1891; *Hæmamœba laverani* var. *tertiana*, Labbé, 1894; *Hæmosporidium tertianum*, Lewkowitz, 1897; *Plasmodium malariæ tertianum*, Labbé, 1899; *Hæmamœba malariæ* var. *magna*, Laveran, 1900, p.p.; *Hæmamœba malariæ* var. *tertianæ*, Laveran, 1901.

This species, *P. vivax*,[1] is the causal agent of the simple or spring tertian fever and is, therefore, named directly the tertian or benign tertian parasite (figs. 80, *3-8*; 85). During the afebrile period in the patient, the young trophozoites or amœbulæ appear on or in the red blood corpuscles as pale bodies of 1·5 μ to 2 μ diameter which at first show only slow amœboid movements. Their nucleus is difficult to recognize in the early stage. Soon the food vacuole is formed and this grows concomitantly with the trophozoite and the parasite has a ring-like appearance. Afterwards the vacuole diminishes, and at this

[1] See Schaudinn, F. (1902), *Arb. a. d. kaiserl. Gesundheits.*, xix, pp. 169-250, 3 plates.

period the first brownish melanin granule appears. From this time the activity and number of the pigment granules increase with continuous growth. When the parasite has grown to about one-third the diameter of the erythrocyte the latter shows characteristic red Schüffner's dots or "fine stippling," after staining with Romanowsky's solution. Later, after about twenty-four hours, the blood corpuscles begin to grow pale, then to increase in size, and after thirty-six hours, that is, about twelve hours before the next attack of fever, schizogony of the parasite is initiated by the division of the nucleus. The parasite at this time occupies half to two-thirds of the enlarged blood corpuscle. The daughter nuclei continue dividing until sixteen, and occasionally twenty-four, daughter nuclei are produced. The pigment which, up till now lies nearer the periphery, moves to the middle, while the nuclei lie nearer the surface.

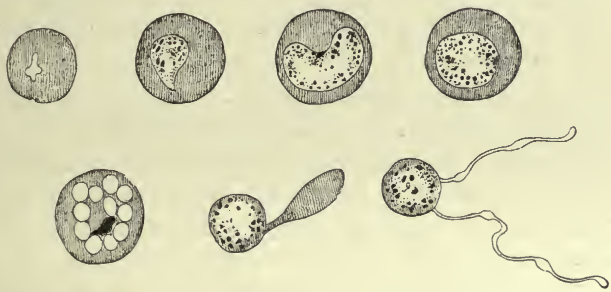


FIG. 85.—Development of the tertian parasite in the red blood corpuscles of man; on the right a "Polymitus." (After Mannaberg.) See also fig. 80, *3—7*.

Around each nucleus a portion of cytoplasm collects and thus young merozoites are produced. These separate from each other and from the little residual masses [1] which contain the melanin and pass from the blood corpuscles, which now can hardly be recognized, to the blood plasma, where they soon attack new erythrocytes.

The migration of the merozoites initiates a new attack of fever and two groups of tertian parasites in the blood, differing in development by about twenty-four hours, are the conditions for febris tertiana duplex.

After a lengthy duration of fever the gametocytes (figs. 80, *9—12*) appear. They are uninucleate. The microgametocytes are about the size of fully developed schizonts, the macrogametocytes are somewhat larger. Their further development takes place in Anophelines.

[1] The pigment masses (melanin or hæmozoin) are taken up by the leucocytes, particularly the mononuclear ones, and are carried especially to the spleen, and also to the liver and the bone-marrow. From this circumstance arises the well-known pigmentation of the spleen in persons who have suffered from malaria.

The chief distinctive characteristics of the simple tertian parasite, as seen in infected blood, are :—(1) The infected red-cell is usually enlarged ; (2) the presence of fine red granules known as Schüffner's dots in the red blood corpuscles, after Romanowsky staining ; (3) the fragile appearance of the parasite compared with other species. Large forms are pigmented, irregular and "flimsy-looking," sometimes appearing to consist of separate parts. Irregularity of contour is common.

Ahmed Emin[1] (1914) has described a small variety of *P. vivax.*

Plasmodium malariæ, Laveran.

Syn. : *Oscillaria malariæ*, Laveran, p.p., 1883 ; *Hæmamœba malariæ*, Gr. et Fel., 1890 ; *Plasmodium malariæ* var. *quartanæ*, Celli et Sanfel., 1891 ; *Hæmamœba laverani* var. *quartana* Labbé, 1894 ; *Hæmosporidium quartanæ*, Lewkowitz, 1897 ; *Plasmodium malariæ quartanum*, Labbé, 1899 ; *Plasmodium golgii*, Sambon, 1902 ; *Laverania malariæ*, Jancso, 1905 nec Grassi et Fel. 1890 ; *Hæmamœba malariæ* var. *quartanæ* ; Lav., 1901.

Plasmodium malariæ is the parasite of quartan malaria (fig. 86). The trophozoites of the quartan parasite differ from the corresponding stages of the tertian parasite in that their motility is less and soon ceases. They differ also in their slower growth, by the early disappearance of the food vacuole, by the more marked formation of the dark brown pigment, and by the fact that the red blood corpuscles attacked are not altered either in colour or size.

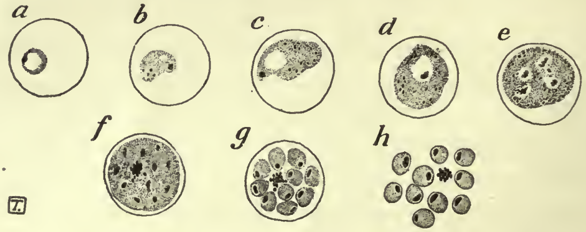


FIG. 86.—Development of the quartan parasite in the red corpuscles of man—asexual stages. (After Manson.)

When the parasites have grown almost to the size of the erythrocytes schizogony occurs. The pigment granules arrange themselves in lines radiating towards the centre and the merozoites are also radially disposed in groups of 6, 8, 10 or even 12, but are often arranged less regularly. The whole development, growth and schizogony, occupies seventy-two hours.

[1] *Bull. Soc. Path. Exot.*, vii, p. 385.

The appearance of quartana duplex or triplex is conditional on the presence in the blood of the patient of two or three groups of *Plasmodia* differing in their development by twenty-four hours.

The chief distinctive characters of the quartan parasite are : (1) The erythrocyte is unchanged in size ; (2) the rings are compact and show pigment early ; in the larger forms the chromatin is dense and relatively plentiful ; (3) the pigment, which is relatively well-marked, may be arranged at the periphery.

Laverania malariæ, Grassi and Feletti, 1890 = Plasmodium falciparum, Welch, 1897.

Syn. : *Plasmodium malariæ* var. *quotidianæ*, Celli et Sanf., 1891 ; *Hæmamœba malariæ præcox*, Gr. et Fel., 1892 (nec *H. præcox*, Gr. et Fel., 1890) ; *Hæmamœba laverani*, Labbé, 1894 ; *Hæmatozoön falciparum*, Welch, 1897 ; *Hæmosporidium undecimanæ and H. sedecimanæ and H. vigesimo-tertianæ*, Lewkowitz, 1897 ; *Hæmamœba malariæ parva*, Lav., 1900 ; *Plasmodium præcox*, Dofl., 1901 ; *Plasmodium immaculatum*, Schaud., 1902 ; *Plasmodium falciparum*, Blanch., 1905.

The names most commonly used for the parasite of malignant tertian malaria are *Plasmodium falciparum* and *Laverania malariæ*.

The summer and autumn fever (febris æstivo-autumnalis), also called malignant tertian or sub-tertian, is caused by a malarial parasite which is distinguished by the small size of its schizont, while the gametocytes are crescentic (figs. 81, 88).

Most authors identify this kind of fever or the parasites which cause it (*Laverania malariæ*) with the pernicious malaria of the tropics. Ziemann, however, repeatedly has drawn attention to certain small but definite differences between the usual malignant tertian or pernicious parasites which occur in the tropics and the tropical parasites of some malarial districts, particularly of West Africa, and insists that at least two varieties or sub-species occur. Other investigators distinguish from this or these forms a quotidian parasite. On the other hand, the assertion is made that there are no specific differences, but that the malignant or pernicious tertian parasite which normally needs forty-eight hours for its development in the blood of man, can also develop in twenty-four hours. The establishment of the duration of the development is a matter of especial difficulty, because the stages of schizogony are far less numerous in the peripheral blood than in that of the internal organs. It is also stated that the tropical parasite very seldom forms crescentic but rather rounded gametocytes. According to such an observation the organism would belong to *Plasmodium* and not to *Laverania.* The question whether the tropical fevers are caused by two different parasites does not seem to be definitely settled.

The young trophozoite of the malignant, pernicious tertian, or sub-tertian parasite (fig. 87) are but slightly active and are very small, even after the formation of the comparatively large food vacuole, which makes the body appear annular ("signet ring" stage). Often two and even more parasites are found in one blood corpuscle.

Fully grown they only attain two-thirds or less of the diameter of the erythrocytes, which display an inclination to shrink and then appear darker than the normal (brass-coloured). In the early stage dots or stippling—sometimes called Maurer's dots—appear on the blood corpuscles as in those attacked by the ordinary tertian parasite (*Plasmodium vivax*), but the Maurer's dots are relatively coarse and few, and are not easily stained. These dots were first described by Stephens and Christophers in 1900, and subsequently by Maurer in 1902.

About thirty hours after the entrance into the blood corpuscles, the parasites are rarely found in the peripheral blood, but they are present in the internal organs, and especially in the spleen. The schizogony, which now begins in the internal organs, proceeds on the same lines as that of the quartan parasite, that is, usually with the merozoites radially arranged around a central agglomeration of dark brown pigment.

FIG. 87.—The pernicious malignant or sub-tertian parasite in the red corpuscles of man, asexual stages. (After Manson.)

The number of merozoites formed is quoted differently, *e.g.*, 8 to 24, on an average 12 to 16. However, according to the recent cultural researches of J. G. and D. Thomson[1] (1913) the number of merozoites of *P. falciparum* is 32. D. Thomson, from examination of spleen smears at autopsy, also concludes that the number of merozoites may reach 32. During their formation the blood corpuscle which is attacked gets paler and disintegrates.

FIG. 88.—The crescents of the malignant tertian parasite. (After Mannaberg.) See also fig. 81.

The gametocytes which finally appear are attenuated, curved bodies, rounded at each end and known as crescents (figs. 81, 88), and are provided with a nucleus and with coarse pigment masses. In the males the pigment is more scattered than in the females, where it is around the nucleus. Their length is 9 μ to 14 μ, and their breadth is

[1] *Proc. Roy. Soc.*, B, lxxxvii, p. 77.

2 μ to 3 μ. At first they are still in the pale blood corpuscles, later they free themselves and are found in numbers in the peripheral blood in cases of pernicious malaria of Southern Europe and the tropics, while, on the other hand, they occur much more rarely in the peripheral blood in West African malignant tertian. Their further development takes place under the same conditions as in the other malarial parasites.

FIG. 89.—Section through a tubule of the salivary gland of an *Anopheles* with sporozoites of the malignant tertian parasites; on the left at the top a single sporozoite greatly magnified. (After Grassi).

D. Thomson (1914),[1] from studies of autopsy smears, has shown that crescents develop chiefly in the bone-marrow and spleen, and take about ten days to grow into the adult state in the internal organs. He believes that crescents are produced from ordinary asexual spores. Quinine, he states, has no direct destructive action on crescents, but it destroys the asexual source of supply.

The sporozoites of *Laverania malariæ* (*P. falciparum*) are represented in fig. 89.

The principal distinctive characters of the malignant tertian parasite are: (1) The ring forms are very small, occasionally bacilliform, and may be marginal ("accolé" of Laveran); (2) the larger trophozoites are often ovoid, and about one-third or one-half of the erythrocyte in size; (3) the infected red cells sometimes show coarse

[1] *Annals Trop. Med. and Farasitol.*, viii, p. 85.

stippling (Maurer's dots); (4) the gametocytes, or sexual forms, are crescentic in shape.

J. W. W. Stephens (1914) has described a new malarial parasite of man; it is called *Plasmodium tenue.* It is very amœboid, with scanty cytoplasm and much chromatin, sometimes rod-like or irregular. The parasite was described from a blood-smear of an Indian child. The creation of a new species for this parasite has been criticized by Balfour and Wenyon, and by Craig.

Plasmodium relictum, Sergent, 1907.

Syn.: *Plasmodium præcox*, Grassi and Feletti, 1890; *Plasmodium danilewskyi*, Gr. et Fel., 1890; *Hæmamœba relicta*, Gr. et Fel., 1891; *Proteosoma grassii*, Labbé, 1894.

Hæmamœboid, pigment-producing, malarial parasites are often found in birds. Like the human malarial parasites they have been variously named. Labbé created the genus *Proteosoma* for them, and this name is still often used as a distinctive one unofficially. The correct name is stated to be either *Plasmodium relictum* or *P. præcox*, or possibly even *P. danilewskyi*, assuming that there is only one species. The nomenclature of the malarial parasites is most confused. The avian malarial parasites are transmitted by Culicine mosquitoes.

The organism was discovered by Grassi in the blood of birds in Italy, and causes a fatal disease in partridges in Hungary. Sparrows are affected in India, and it was this Plasmodium in which Ross first traced the development of a malarial parasite in a mosquito. The parasite may be transmitted from bird to bird by blood-inoculation, canaries being very susceptible.

The principal stages of the avian plasmodium closely resemble those of the malarial parasites of man. In its earliest stage *P. relictum* is unpigmented, but soon the trophozoite grows and becomes pigmented, meanwhile displacing the nucleus of the avian red-blood corpuscle, a characteristic feature, distinguishing it from *Halteridium.* Schizonts are formed, each of which gives rise to about nine merozoites in the circulating blood. Sexual forms or gametocytes also occur in the blood. These develop in *Culex fatigans*, *C. pipiens* and *C. nemorosus.* Oökinetes or vermicules are formed in twelve to fifteen hours in the stomach of the mosquito, and in one to two days well-developed round oöcysts may be seen. In three to four days sporoblasts have formed within the oöcysts and young sporozoites begin to develop. In nine to ten days the oöcysts are mature, being filled with sporozoites. The oöcysts then burst and the sporozoites travel through the thoracic muscles to the salivary glands of the Culicine.

Neumann, experimenting with canaries, found that *Stegomyia fasciata* could transmit the infection, but less efficiently than species of *Culex.*

The Cultivation of Malarial Parasites.

The successful cultivation of malarial parasites *in vitro* was first recorded by C. C. Bass and by Bass and Johns (1912).[1] Since then, J. G. and D. Thomson,[2] and McLellan (1912-13), Ziemann[3] and others have repeated the experiments.

[1] *Journ. Exptl. Med.*, xvi, p. 567.

[2] *Annals Trop. Med. and Parasitol.*, vi, p. 449; vii, pp. 153, 509.

[3] *Trans. Soc. Trop. Med. and Hyg.*, vi, p. 220.

DIFFERENTIAL CHARACTERS OF THE HUMAN MALARIAL PARASITES.

Character	*Plasmodium malariæ* (Quartan)	*Plasmodium vivax* (Benign tertian)	*Laverania malariæ* = *Plasmodium falciparum* (Malignant tertian)
Schizogony	Complete in seventy-two hours	Complete in forty-eight hours	Complete in forty-eight hours or less
Trophozoite	Smaller than *P. vivax*, larger than *L. malariæ*. Pseudopodia not marked or long	Young trophozoite large. Long pseudopodia	Young trophozoite small
Movements	Rather slow in immature forms	Active amœboid movements	Sometimes actively motile
Pigment	Coarse granules, peripherally arranged, little movement	Fine granules, with active movement	Granules fine and scanty, movement oscillatory
Schizont	Smaller than red corpuscle	Larger than red blood corpuscle	Smaller than red corpuscle
Merozoites	6 to 12 forming rosette	15 to 20 regularly arranged	8 to 32 (according to different authors) arranged irregularly
Gametocytes	Spherical	Spherical	Crescentic
Distribution of parasites in vertebrate host	About equal numbers in peripheral and visceral blood	Larger numbers in visceral blood	Scanty in peripheral blood compared with the enormous numbers in the internal organs. The latter part of the cycle (schizogony) may occur in the internal organs only
Alterations in erythrocytes	Almost normal	Pale and hypertrophied. Schüffner's dots seen in deeply stained specimens	Corpuscle may be shrunken and dark, or may be colourless. Maurer's coarse dots sometimes seen

Essentially the method of cultivation, as used by Thomson, is as follows: 10 c.c. of infected blood are drawn from a vein and transferred to a sterile test tube, in which is a thick wire leading to the bottom of the tube. One-tenth of a cubic centimetre of a 50 per cent. aqueous solution of glucose or dextrose is placed in the test tube, preferably before adding the blood. The blood is defibrinated by stirring gently with the wire. When defibrination is complete the wire and the clot are removed, and the glucose-blood is transferred, in portions, to several smaller sterile tubes, each containing a column of blood about one inch in height. The tubes are plugged and capped and then transferred, standing upright, to an incubator kept at a temperature of 37° C. to 41° C. The blood corpuscles soon settle, leaving a column of serum at the top, to the extent of about half an inch in each tube. The leucocytes need not be removed by centrifugalization. J. G. Thomson (1913) and his collaborators did not find it necessary to destroy the complement in the serum, and they found that the malarial parasites developed at all levels in the column of corpuscles, and not merely on the surface layer of the corpuscles as first stated by Bass and Johns.

So far only the asexual generation of the malarial parasites has been grown *in vitro*. Thomson rarely observed hæmolysis in the cultures. Clumping of the malignant tertian parasites occurred. In cultures of the benign tertian parasite (*Plasmodium vivax*) clumping was not observed. J. G. and D. Thomson consider that this difference as regards clumping explains why only young forms of malignant tertian are found in peripheral blood, as the clumping tendency of the larger forms causes them to be arrested in the finer capillaries of the internal organs. It also explains the tendency to pernicious symptoms, such as coma, in malignant tertian malaria. Further it was found from cultures that *P. falciparum* was capable of producing thirty-two spores (merozoites) in maximum segmentation, while *P. vivax* produced sixteen spores (merozoites) as a rule, though the number might be greater than sixteen. (Quartan parasites produce eight spores or merozoites in schizogony.)

It may also be mentioned here that *Babesia* (*Piroplasma*) *canis* has been successfully cultivated *in vitro* by Bass's method. This has been accomplished by Thomson and Fantham,[1] Ziemann, and Toyoda in 1913. J. G. Thomson and Fantham used the simplified Bass technique recorded above, namely, infected blood and glucose, incubating at 37° C. In one of the *B. canis* cultures, starting with heart blood of a dog containing corpuscles infected with one, two, or, exceptionally, four piroplasmata, Thomson and Fantham succeeded in obtaining a maximum of thirty-two merozoites in a corpuscle. The cultures are infective to dogs and sub-cultures have been obtained.

Family. **Piroplasmidæ**, França.

The parasites included in this provisional family or group belong to the Hæmosporidia. They are minute organisms, sometimes amœboid, but usually possessing a definite form. They are endoglobular, being contained within mammalian red blood corpuscles, but they produce no pigment. The true Piroplasmata, belonging to the genus *Babesia*, destroy the host corpuscles, setting free the

---

[1] *Annals Trop. Med. and Parasitol.*, vii, p. 621.

hæmoglobin, which is excreted by the kidneys of the cow, sheep, horse, dog, etc., acting as host. The disease produced, variously called piroplasmosis or babesiasis, is consequently characterized by a red coloration of the urine known as hæmoglobinuria, or popularly as "red-water." One of the best known piroplasms is *Piroplasma bigeminum* or *Babesia bovis* (probably the latter name is correct), which is the causal agent of "Texas fever" or "red-water" in cattle and is spread by ticks.

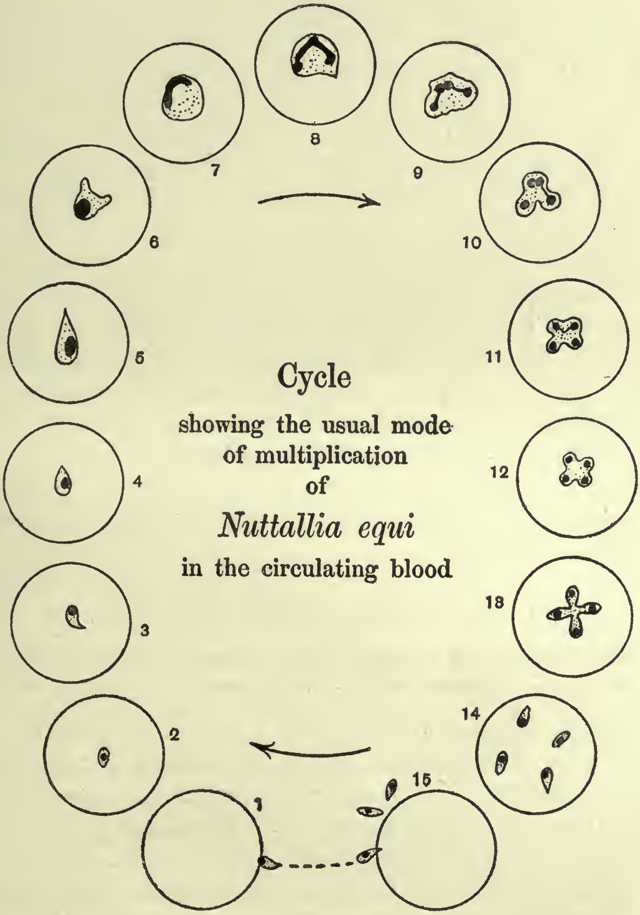


FIG. 90.—*Nuttallia equi*, life-cycle as seen in red blood corpuscles in stained preparations of peripheral blood. (After Nuttall and Strickland.)

Of recent years, researches on the morphology of these blood parasites has led to their separation into various genera and species. However, our knowledge is still very far from complete. The various genera recognized by França[1] (1909), and placed in a provisional family, Piroplasmidæ, may be listed, though further research may lead to emendations:—

(1) *Babesia* (Starcovici) or *Piroplasma* (Patton). Pyriform parasites, dividing by a special form of budding or gemmation with chromatin forking, as well as by direct binary fission. Parasitic in oxen, dogs, sheep, horses, etc.

(2) *Theileria* (Bettencourt, França and Borges). Rod-shaped and oval parasites occurring in cattle and deer. *T. parva* is the pathogenic agent of African East Coast fever in cattle.

(3) *Nuttallia* (França). Oval or pear-shaped parasites, with multiplication in the form of a cross. *N. equi*[2] (fig. 90) of equine "piroplasmosis" (nuttalliosis). *N. herpestidis* in a mongoose.

(4) *Nicollia* (Nuttall). Oval or pear-shaped parasites with characteristic nuclear dimorphism, and with quadruple division at first fan-like, then like a four-leaved clover. *N. quadrigemina* from the gondi.

(5) *Smithia* (França). Pear-shaped, single forms stretching across the blood corpuscle. Multiplication into four in the form of a cross. *S. microti* from *Microtus arvalis*, *S. talpæ* from the mole.

(6) *Rossiella* (Nuttall). This belongs to the family Piroplasmidæ of França. It is intracorpuscular and non-pigment forming, occurring singly, in pairs, or occasionally in fours. It is usually round and larger than Babesia. The parasite multiplies by binary fission. *R. rossi* in the jackal.

The genus *Babesia* is the best known and most important, and will be considered next.

Genus. **Babesia**, Starcovici, 1893.

Syn.: *Pyrosoma*, Smith and Kilborne, 1893; *Apiosoma*, Wandolleck, 1895; *Piroplasma*, W. H. Patton, 1895; *Amœbosporidium*, Bonome, 1895.

The organisms belonging to this genus are pyriform, round or amœboid. The characteristic mode of division is as follows: Just before division the parasite becomes amœboid and irregular in shape, (fig. 91, *1*—*5*) with a compact nucleus. The latter gives off a nuclear bud. This nuclear bud divides into two by forking (fig. 91, *6*, *7*) The chromatin forks grow towards the surface of the body of the rounded parasite, and then two cytoplasmic buds grow out. The forking nuclear buds, which are Y-shaped, pass into the cytoplasmic outgrowths[3] (fig. 91, *8*, *9*). The buds gradually increase in size at

[1] *Arch. Inst. Bact. Camara Pestana*, iii, p. 11.

[2] *Parasitology*, v (1912), p. 65.

[3] Nuttall and Graham-Smith, *Journ. Hyg.*, vii, p. 232.

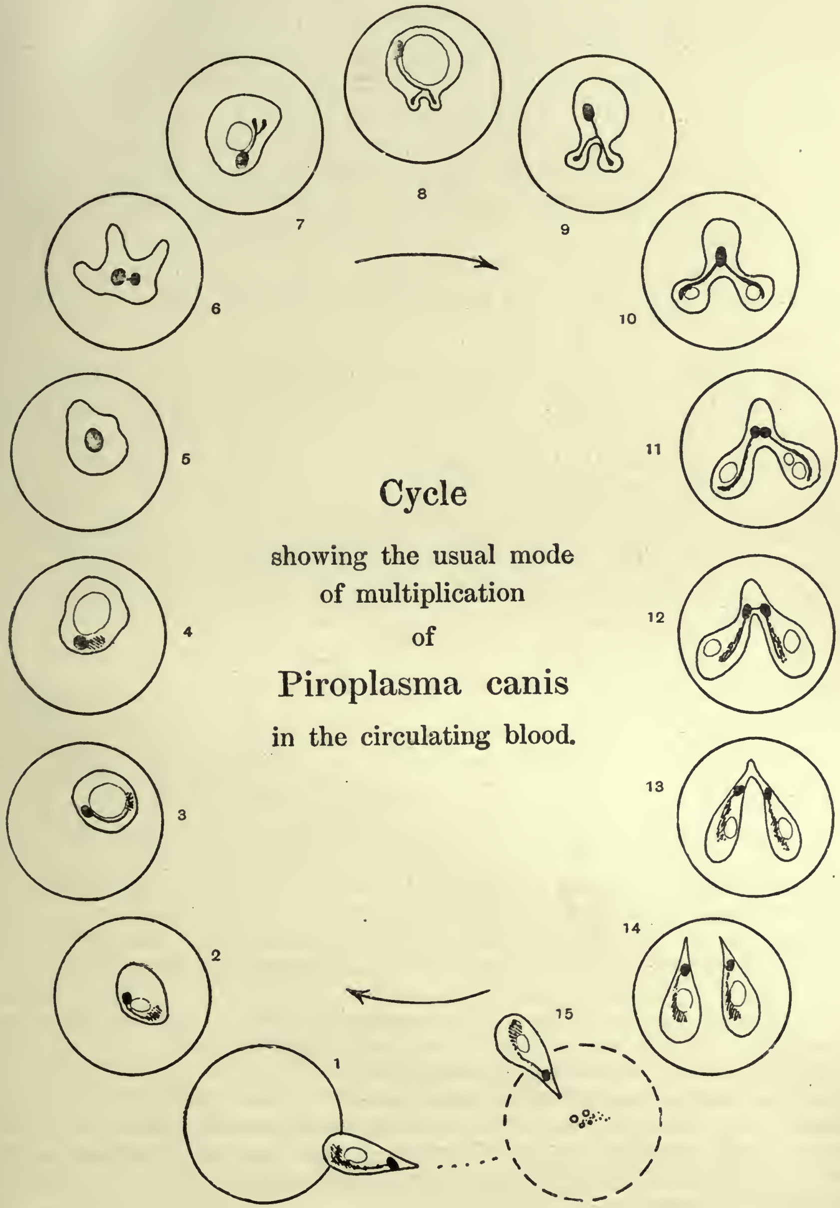


FIG. 91.—*Babesia* (*Piroplasma*) *canis*, life-cycle in stained preparations of infected blood of dog. (After Nuttall and Graham-Smith.)

the expense of the parent form until they become two pear-shaped parasites joined at their pointed ends. The connecting strand shrinks and the two daughter forms separate (fig. 91, *10—14*). The pyriform parasites after having exhausted the blood corpuscle escape from it (fig. 91, *15*), and seek out fresh host corpuscles, entering by the rounded, blunt end (fig. 91, *1*). It is the pyriform phase of the parasite which penetrates red blood corpuscles, not rounded forms, which die if set free. The pyriform parasite, however, becomes rounded (fig. 91, *2, 3*), soon after its entry into a fresh host cell. This interesting mode of division by gemmation and chromatin forking has been made diagnostic of the genus *Babesia* by Nuttall.[1] Rounded forms of *Babesia* divide by binary fission, and this direct method can also be adopted by the other forms of *Babesia*.

The distribution of the chromatin in the pear-shaped *Babesia*, as seen in *B. canis* and *B. bovis*, is interesting. The main nuclear body consists of a karyosome surrounded by a clear area. There is also a loose (chromidial) mass of chromatin representing the remains of the chromatin forks seen during the formation of the parasite as a daughter form by gemmation. Occasionally there is a small dot or point, the so-called "blepharoplast" of Schaudinn and Lühe. This minute dot is not a flagellate blepharoplast, for there is no flagellate stage in the life-history of Babesia. These nuclear phenomena have been described by Nuttall and Graham-Smith and Christophers (1907)[2] for *B. canis*, by Fantham (1907)[3] for *B. bovis*, and by Thomson and Fantham (1913) from glucose-blood cultures of *B. canis*.

Babesia are tick borne, as was first shown by Smith and Kilborne (1893). The developmental cycle in the tickis in completely known. The best accounts are those of Christophers (1907)[4] for *B. canis* and Koch (1906) for *B. bovis*, and these accounts are supplementary. The principal stages, so far as known, may be summarized thus :—

(1) The piroplasms taken by the tick in feeding on blood pass into the tick's stomach. The pyriform parasites, which alone are capable of further development, are set free from the blood corpuscles. In about twelve to eighteen hours they become amœboid, sending out long, stiff, slender, pointed pseudopodia. The nucleus of each parasite divides unequally into two. Similar forms have been obtained in cultures. These stellate forms may be gametes, and according to Koch fuse in pairs.

(2) A spherical stage follows, possibly representing the zygote. This grows, and a uninucleate globular mass results. This form is found in large numbers on the third day, according to the observations of Koch.

(3) A club-shaped organism is next formed. This may represent an oökinete stage. The club-shaped bodies are motile and gregarine-like, and are about four times the size of the blood forms. These club-shaped bodies and subsequent stages were described by Christophers in the development of *B. canis* in the dog-tick, *Rhipicephalus sanguineus*.

---

[1] "Piroplasmosis," Herter Lectures, *Parasitology*, vi, p, 302.
[2] *Sci. Mems. Govt. India*, No. 29.
[3] *Quart. Journ. Microsc. Sci.*, li, p. 297.
[4] *Sci. Mems. Govt. India*, No. 29.

(4) The club-shaped bodies pass from the gut of the tick into the ovary, and so get into the ova. There they become globular, and later are found in the cells of the developing tick-embryo. The parasites are, then, transmitted hereditarily. Similar globular bodies are found in the tissue cells of the body of tick nymphs which have taken up piroplasms. The globular stage was called the "zygote" by Christophers, but it may correspond to the oöcyst of Plasmodia.

(5) The globular body divides into a number of "sporoblasts," which become scattered through the tissues of the larval or nymphal tick, as the case may be.

(6) The sporoblasts themselves divide into a large number of sporozoites, which are small uninucleate bodies, somewhat resembling blood piroplasms. The sporozoites collect in the salivary glands of the tick. They are inoculated into the vertebrate when the tick next feeds.

The chief species of *Babesia* and their pathogenic importance may be listed thus :—

(1) *Babesia bovis* (Babes) produces infectious hæmoglobinuria of cattle in Europe and North Africa. It is transmitted by *Ixodes ricinus*. A similar parasite also occurs in deer.

(2) *Babesia bigemina* (Smith and Kilborne) produces Texas fever, tristeza, or red-water in cattle in North and South America, South Africa and Australia. It is transmitted by *Boöphilus annulatus* in North America, by *B. australis* in Australia, South America, and the Philippines, and by *B. decoloratus* in South Africa.

The parasite is from 2 μ to 4 μ long, and from 1·5 μ to 2 μ broad.

Babesia bigemina may be the same parasite as *B. bovis*.

(3) *Babesia divergens* (MacFadyean and Stockman) is a small parasite. It is found in cattle suffering from red-water in Norway, Germany, Russia, Hungary, Ireland, Finland, and France, and is transmitted by *Ixodes ricinus*.

(4) *Babesia canis* (Piana and Galli-Valerio) gives rise to malignant jaundice or infectious icterus in dogs in Southern Europe, India, and other parts of Asia and North Africa, where it is transmitted by *Rhipicephalus sanguineus*. In Africa generally, especially South Africa, the disease is transmitted by *Hæmaphysalis leachi*. *Babesia canis* varies from 0·7 μ to 5 μ, the size depending partly on the number of parasites within the corpuscle. It averages about 3 μ. It has been cultivated in Bass' medium (glucose and infected blood), see p. 172.

In India *Piroplasma gibsoni* (Patton) infects hunt dogs and jackals. It is annular or oval in shape.

(5) *Babesia ovis* (Babes) produces "Carceag," a disease of sheep in Roumania, the Balkan Peninsula, Italy, and Transcaucasia. It varies in size from 1 μ to 3 μ. It is transmitted by *Rhipicephalus bursa*. The parasite has recently been recorded from Rhodesia.

(6) *Babesia caballi* (Nuttall and Strickland) causes "biliary fever" in equines. The parasite occurs in Russia, Roumania, and

Transcaucasia. It varies in size from 1 μ to 2 μ. It is transmitted by *Dermacentor reticulatus.*

It should be mentioned that *Nuttallia equi* also causes "piroplasmosis" in equines, with symptoms of hæmoglobinuria and jaundice in Italy, Sardinia, many parts of Africa, Transcaucasia, India, and Brazil. In Africa it is transmitted by *Rhipicephalus evertsi.* It has been shown experimentally that a horse recovered from *Babesia caballi* was susceptible to the inoculation of *Nuttallia equi* blood.

(7) *Babesia pitheci* (P. H. Ross) was found in a monkey, *Cercopithecus* sp., in Uganda. The pear-shaped forms measure 1·5 μ by 2·5 μ.

(8) *Babesia muris* (Fantham)[1] was found in white rats. The pyriform parasites are 2 μ to 3 μ long and 1 μ to 1·5 μ broad; oval forms are 0·5 to 1·5 μ diameter.

The usual symptoms of babesiasis (piroplasmosis) are high fever, loss of appetite, hæmoglobinuria, icterus, anæmia, paralysis, and death in about a week in acute cases. In chronic cases there is anæmia, and hæmoglobinuria is less marked. When animals recover, there are still some piroplasms left in the blood. "Recovered" or "salted" animals are not susceptible to reinfection, but ticks feeding on them acquire piroplasms, and are a source of danger to freshly imported animals.

Treatment.—Trypan-blue is the best drug, as shown by Nuttall and Hadwen[2] (1909). It should be administered intravenously in 1 to 1·5 per cent. aqueous solution. A dose of 5 to 10 c.c. is curative for dogs, one of 100 to 150 c.c. for horses and cattle. Unfortunately, the tissues are coloured blue by the drug. The "salted" animals, after trypan-blue treatment, still harbour the parasites in their blood for years.

Genus. **Theileria**, Bettencourt, França and Borges, 1907.

The organisms belonging to this genus are rod-like or bacilliform, and coccoid or round.

The best known of the species of Theileria is *T. parva*, the pathogenic agent of East Coast fever or Rhodesian fever in cattle in Africa.

Theileria parva, Theiler, 1903.

Syn.: *Piroplasma parvum.*

In the blood corpuscles of infected cattle minute rod-like and oval parasites are seen. Some are comma shaped and others are clubbed (fig. 92, *1-12*). The rod-like forms measure 1 μ to 3 μ in length by 0·5 μ in breadth; the oval forms are 0·7 μ to 1·5 μ in diameter. The intracorpuscular parasites are said by R. Gonder (1910) to be gametocytes, the rod-like forms being thought to be males, the oval forms to be females. Free parasites are practically never seen in the blood. It is known that it is impossible to

---

[1] *Quart. Journ. Microsc. Sci.*, l, p. 493.

[2] *Parasitology*, ii, p. 156.

produce the disease in a healthy animal by blood inoculation, but only by intraperitoneal transplantation of large pieces of infected spleen (Meyer). There may be as many as eight parasites in a corpuscle. The chromatin is usually at one end of the organism. In some parasites the appearance of the chromatin suggests division, but such division, if it takes place, must be very slow, as it has not been actually seen in progress. The red blood corpuscles appear merely to act as vehicles for the parasites (Nuttall, Fantham, and Porter).[1]

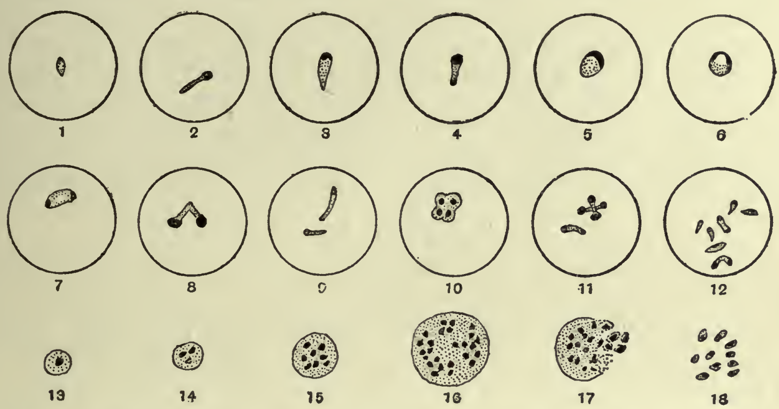


FIG. 92.—*Theileria parva.* 1-12, intracorpuscular parasites, stained. (After Nuttall and Fantham); 13-18, Koch's blue bodies, from stained spleen smear; 17-18, breaking up of Koch's body. (After Nuttall.)

In the internal organs, especially the lymphatic glands, spleen and bone-marrow, are found multinucleate bodies known as Koch's blue bodies (fig. 92, *13-18*). These are schizonts, according to Gonder.[2] The actual Koch's blue bodies are said to be extracellular, but similar multinucleate bodies, schizonts, occur in lymphocytes. The schizonts divide and the merozoites resulting probably invade the red blood corpuscles in the internal organs. Gonder considers that the sporozoites injected by the tick collect in the spleen and lymphatic glands, penetrate the lymphocytes and give rise to the schizonts.

Gonder has studied the cycle of *T. parva* in the tick. He states that the gametocytes leave the host corpuscles and give rise to gametes, then conjugation occurs producing zygotes. The zygotes are then said to become active to form ookinetes, and to enter the salivary glands of the tick. Multiplication is said to occur therein, producing a swarm of sporozoites. This work needs confirmation.

T. parva is transmitted by *Rhipicephalus appendiculatus*, *R. simus*, *R. evertsi*, *R. nitens*, and *R. capensis*. The parasites are not hereditarily transmitted in *Rhipicephalus*, but when taken by the transmitter at one stage of its development the tick is infective in its next stage (*e.g.*, if the larva becomes infected, then the nymph is infective; if the nymph becomes infected, then the adult is infective).

An animal recovered from *Theileria parva* is incapable of infecting ticks, but few animals recover from East Coast fever. Animals suffering therefrom do not show hæmoglobinuria.

---

[1] *Parasitology*, ii, p. 325; iii, p. 117.

[2] *Zeitschr. f. Infekt. paras. Krankh. u. Hyg. d. Haustiere*, viii, p. 406.

Theileria mutans, Theiler, 1907.

Syn.: *Piroplasma mutans*.

This is transmissible experimentally by blood inoculation. It occurs in cattle in South Africa and Madagascar and is apparently non-pathogenic. No Koch's blue bodies are formed. It is transmitted by ticks.

Theileria annulata (Dschunkowsky and Luhs) occurs in cattle in Transcaucasia.

A Theileria (*T. stordii*) has been found in a gazelle (França, 1912).

Genus. **Anaplasma**, Theiler, 1910.

This genus[1] may be mentioned here. The organisms included therein are, according to Theiler, coccus-like, consisting of chromatin, and are devoid of cytoplasm. They occur in the red blood corpuscles of cattle, causing a disease characterized by destruction of red cells, fever and anæmia, but with yellow urine. The disease is tick transmitted. The bodies now called *Anaplasma marginale* were formerly described as marginal points. They multiply by simple fission. They are said by Theiler to cause gall-sickness in cattle in South Africa. Some authors doubt whether these bodies are organismal.

Genus. **Paraplasma**, Seidelin, 1911.

Under this generic name Seidelin described certain bodies found by him in cases of yellow fever in 1909. The type species is *P. flavigenum*,[2] and is claimed by Seidelin to be the causal agent of yellow fever.

Paraplasma flavigenum occurs in the early days of the disease as small chromatin granules with or without a faint trace of cytoplasm. The bodies are usually intracorpuscular. Also, somewhat larger forms, with distinct cytoplasm, are seen in small numbers. During the later days of the disease still larger forms are found, and these occur also in sections of organs (*e.g.*, kidney) made post-mortem. Some of these larger forms are perhaps schizonts. In the second period of the disease possible micro- and macro-gametes may be found, some of which are extracorpuscular. Some small free bodies have been seen. Recently schizogony has been stated to occur in the lungs, and it is said that guinea-pigs can be inoculated with *Paraplasma flavigenum*, and show yellow pigment in the spleen.

Seidelin places *Paraplasma* in the *Babesiidæ*, with resemblances more particularly to *Theileria*. V. Schilling-Torgau and Agramonte have criticized these findings; the former considers them to be the resultant of certain blood conditions.

P. subflavigenum was found by Seidelin in 1912 in a man suffering from an unclassified fever in Mexico.

Further, it is now known that a Paraplasma occurs naturally in guinea-pigs. More researches are needed on these matters, as some writers (*e.g.*, Wenyon and Low) claim that the bodies are not organismal.

---

[1] *Bull. Soc. Path. Exot.*, iii, p. 135. [2] *Yellow Fever Bulletin*, i, p. 251.

Sub-class. NEOSPORIDIA, Schaudinn.

Sporozoa in which growth and spore formation usually go on together.

Order. **Myxosporidia,** Bütschli.

These parasites, which were discovered by Johannes Müller (1841), live principally in fishes, and occasionally cause destructive epizoötics amongst their hosts. Müller first observed them in the form of whitish-yellow pustules on the skin or on the gills of various fishes. These pustules contained masses of small shell-covered bodies with or without tails ("psorosperms," see fig. 93). Similar bodies were also found in the air bladders of certain fish. Creplin (1842) demonstrated the resemblance of the cysts ("psorosperm tubes") harbouring the psorosperms to the "pseudonavicella-cysts" of a gregarine, as described by v. Siebold. Dujardin (1845) considered that there was possibly some connection between the protoplasmic "psorosperm tubes" and the spores they contained, and the developmental stages of monocystid gregarines from the

Paraplasma flavigenum.—The Yellow Fever Commission (West Africa) in their third report, dated 1915, have come to the conclusion that there is no evidence that the bodies termed *Paraplasma flavigenum* are of protozoal nature or that they are the causal agents of yellow fever.

Face p. 180.

(natural size), with two myxosporidia. Lower figures, *a*, *b*, *d*, spores of myxosporidia from a pike, *Esox lucius*. *c*, Spore from *Platystoma fasciatum*. (After J. Müller.)

Myxobolus mülleri, with the polar bodies and their nuclei and the sporozoite. (After Bütschli.)

placed on a firmer basis by Leydig (1851) and Lieberkühn. The former found numerous forms in marine fish, and he discovered in species which live free in the gall bladder of cartilaginous fishes that the psorosperms originated in a manner similar to the gregarines. Lieberkühn (1854) studied the Myxosporidia in the bladder of the pike (fig. 93, *a*, *b*, *d*), and observed their amœboid movements, as well as the formation of the spores, from each of which a small amœboid body escaped, a discovery that was confirmed by Balbiani. The same author also found that spiral filaments were enclosed in the so-called polar body, *i.e.*, the polar capsule of the psorosperm spores, and that these could be protruded (fig. 93, *d*, and fig. 95).

The term Myxosporidia, which at the present day is universally applied to the "psorosperm tubes," was introduced by Bütschli in 1881, who studied not only the structure and development of the spores, but also the protoplasmic body of the

Theileria mutans, Theiler, 1907.

Syn.: *Piroplasma mutans*.

This is transmissible experimentally by blood inoculation. It occurs in cattle in South Africa and Madagascar and is apparently non-pathogenic. No Koch's blue bodies are formed. It is transmitted by ticks.

Theileria annulata (Dschunkowsky and Luhs) occurs in cattle in Transcaucasia.

A Theileria (*T. stordii*) has been found in a gazelle (França, 1912).

Genus. Anaplasma, Theiler, 1910.

This genus[1] may be mentioned here. The organisms included therein are, according to Theiler, coccus-like, consisting of chromatin, and are devoid of cytoplasm. They occur in the red blood corpuscles of cattle, causing a disease characterized by destruction of red cells, fever and anæmia, but with yellow urine. The disease is tick transmitted. The bodies now called *Anaplasma marginale* were formerly described as marginal points. They multiply by simple fission. They are said by Theiler to cause gall-sickness in cattle in South Africa. Some authors doubt whether these bodies are organismal.

Recently schizogony has been stated to occur in the lungs, and it is said that guinea-pigs can be inoculated with *Paraplasma flavigenum*, and show yellow pigment in the spleen.

Seidelin places *Paraplasma* in the *Babesiidæ*, with resemblances more particularly to *Theileria*. V. Schilling-Torgau and Agramonte have criticized these findings; the former considers them to be the resultant of certain blood conditions.

P. subflavigenum was found by Seidelin in 1912 in a man suffering from an unclassified fever in Mexico.

Further, it is now known that a Paraplasma occurs naturally in guinea-pigs. More researches are needed on these matters, as some writers (*e.g.*, Wenyon and Low) claim that the bodies are not organismal.

[1] *Bull. Soc. Path. Exot.*, iii, p. 135. [2] *Yellow Fever Bulletin*, i, p. 251.

Sub-class. NEOSPORIDIA, Schaudinn.

Sporozoa in which growth and spore formation usually go on together.

Order. **Myxosporidia**, Bütschli.

These parasites, which were discovered by Johannes Müller (1841), live principally in fishes, and occasionally cause destructive epizoötics amongst their hosts. Müller first observed them in the form of whitish-yellow pustules on the skin or on the gills of various fishes. These pustules contained masses of small shell-covered bodies with or without tails ("psorosperms," see fig. 93). Similar bodies were also found in the air bladders of certain fish. Creplin (1842) demonstrated the resemblance of the cysts ("psorosperm tubes") harbouring the psorosperms to the "pseudonavicella-cysts" of a gregarine, as described by v. Siebold. Dujardin (1845) considered that there was possibly some connection between the protoplasmic "psorosperm tubes" and the spores they contained, and the developmental stages of monocystid gregarines from the vesiculæ seminales of earth-worms. The relationship of the "fish psorosperms" was

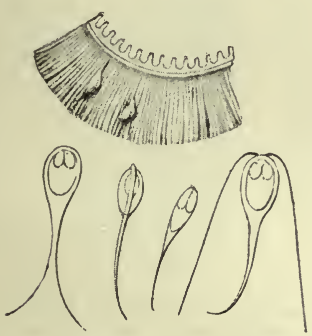


FIG. 93.—Upper figure, part of a gill of a roach, *Leuciscus rutilus* (natural size), with two myxosporidia. Lower figures, *a*, *b*, *d*, spores of myxosporidia from a pike, *Esox lucius*. *c*, Spore from *Platystoma fasciatum*. (After J. Müller.)

FIG. 94.—The tailless spore of *Myxobolus mülleri*, with the polar bodies and their nuclei and the sporozoite. (After Bütschli.)

placed on a firmer basis by Leydig (1851) and Lieberkühn. The former found numerous forms in marine fish, and he discovered in species which live free in the gall bladder of cartilaginous fishes that the psorosperms originated in a manner similar to the gregarines. Lieberkühn (1854) studied the Myxosporidia in the bladder of the pike (fig. 93, *a*, *b*, *d*), and observed their amœboid movements, as well as the formation of the spores, from each of which a small amœboid body escaped, a discovery that was confirmed by Balbiani. The same author also found that spiral filaments were enclosed in the so-called polar body, *i.e.*, the polar capsule of the psorosperm spores, and that these could be protruded (fig. 93, *d*, and fig. 95).

The term Myxosporidia, which at the present day is universally applied to the "psorosperm tubes," was introduced by Bütschli in 1881, who studied not only the structure and development of the spores, but also the protoplasmic body of the parasites (fig. 96), and confirmed the occurrence of numerous nuclei. Many authors have made important additions to our knowledge of the Myxosporidia: Perugia, Thélohan, Mingazzini, L. Pfeiffer, L. Cohn, Doflein, Mercier, Schröder and Auerbach; while the presence of this parasite outside the class of fishes has become known through Lutz, Laveran, and others. The species causing disease in fishes have been described by Ludwig, Railliet, Weltner, L. Pfeiffer, Zschokke, Hofer, Doflein, Gurley, Plehn, Schuberg, Fantham and Porter. With regard to classification the works of Thélohan (1895) and Gurley (1894) may be mentioned.

The Myxosporidia live either free on the epithelial surface of hollow organs (gall or urinary bladder, renal tubules, but never in the intestine), or are enclosed in the tissues of their host. The gills and muscular system are their favourite habitat, but other tissues or organs may be attacked. Species of Myxosporidia are also known from Amphibia, Reptilia, and a few invertebrates.

The free forms, which are often amœboid (fig. 96), move by the aid of variously shaped pseudopodia, have a constant form, or may exhibit contractions of the body. The tissue parasites often reach a considerable size, so that the integument of the

FIG. 95.—Schematic representation of a spore of *Myxobolus*. One polar capsule has protruded its filament; two nuclei and a "vacuole" in the sporozoite. (After Doflein.)

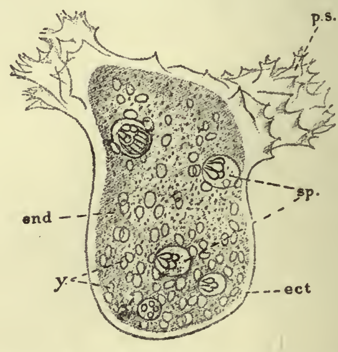


FIG. 96.—*Chloromyxum leydigi*. Active trophozoite (parasitic in gall-bladder of skates, rays, dog-fish). *Ect*, ectoplasm; *ps*, pseudopodia; *end*, endoplasm; *y*, yellow globules in endoplasm; *sp*, spores, each with four polar capsules. × 525. (After Thélohan.)

host forms protuberances over them. They are of a roundish or irregular shape Frequently they are enveloped in a connective tissue covering formed by the host.

The protoplasmic body in the trophic phase (fig. 96) shows a distinct ectoplasm which is finely granular or sometimes striated, and an endoplasm which is coarsely granular and contains many nuclei as well as cell inclusions, such as crystals, pigment grains and fat globules. The nuclei originate by division from the primitive nucleus of the amœboid germ that issues from the spore. This amœbula may or may not live intra-cellularly during the early stages of its existence.

The multinucleate trophozoite of a Myxosporidian forms spores in its endoplasm practically throughout its whole period of growth (fig. 96). Vegetative reproduction by a process of external budding or plasmotomy may also occur, as in *Myxidium lieberkühni* from the urinary bladder of the pike.

The myxosporidian trophozoite may produce two spores within itself, when it is placed in the sub-order *Disporea*, or it may produce numerous spores, which is characteristic of the sub-order, *Polysporea*. The phenomenon of spore formation is not simple (fig. 97), and the spore itself is surrounded by a bivalved shell or sporocyst and contains polar capsules in addition to the amœboid germ (fig. 97, G, H). The valves of the sporocyst and the polar capsules are really differentiated nucleate cells, so that each spore is an aggregate of cells rather than one cell, though only a single amœbula issues from a spore. The accounts of spore formation vary somewhat according to the different workers.

Spore formation is usually very complicated and there are differences of opinion as to the interpretation of various stages, particularly as to whether conjugation occurs therein. The process is initiated by the concentration of cytoplasm around one of the nuclei of the endoplasm, so that a small spherical mass or initial corpuscle is produced, the pansporoblast (Gurley) or primitive sphere (Thélohan). Some authors state that a pansporoblast really results from a conjugation of two initial corpuscles (fig. 97, A—D). Nuclear multiplication occurs within the pansporoblast

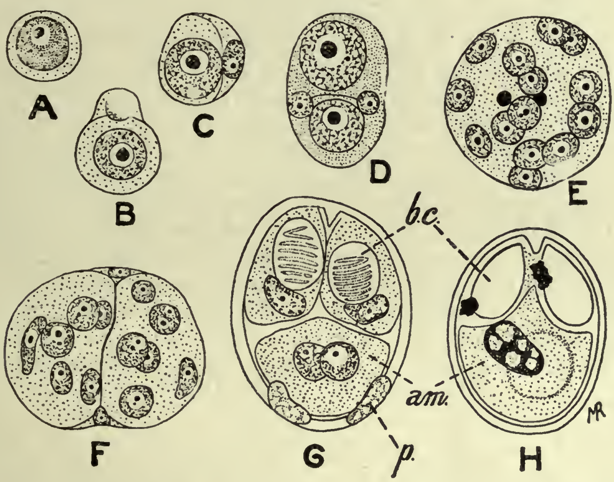


FIG. 97.—*Myxobolus pfeifferi.* Spore formation. A, reproductive cell from plasmodial trophozoite; B, cell divided unequally into two; C, smaller cell forming envelope to larger one; D, pansporoblast formed by union of two forms like C; E, multinucleate pansporoblast, two of the nuclei being those of the envelope; F, pansporoblast divided into two multinucleate sporoblasts; G, spore differentiation; *p*, two parietal cells forming sporocyst; *bc*, polar capsules; *am*, binucleate amœbula; H, ripe spore in which the two nuclei of the amœbula have fused. (After Keysselitz.)

(fig. 97, E), and sooner or later two multinucleate sporoblasts are formed within it (fig. 97, F). Each sporoblast gives rise to a single spore, which consists of a sporocyst or envelope composed of two valves each secreted by a cell, two polar capsules each secreted by a cell, and the sporoplasm or amœbula which becomes binucleate (fig. 97, G). During the process of spore formation (fig. 97) various vegetative and reduction nuclei may be produced, in addition to those which are essentially involved in spore formation, and the sporocyst cells may be developed early.

Each spore contains two (figs. 94, 95) or more polar capsules which are clearly visible in the fresh condition. Each polar capsule is a hollow, more or less pear-shaped body, secreted by a cell and having a well defined contour. Within it, a long, delicate, elastic filament, the polar filament, is formed, and lies spirally coiled in the polar capsule until just before the emergence of the amœbula from the spore (fig. 95). The polar filament is ejected, probably under the influence of the digestive juice, when the spore reaches a new host, and serves to anchor the spore to the tissue with which it is in contact, and thus allow of the emergence of the amœbula in a situation suitable for its development. The polar capsule with its contained polar filament has been compared with the stinging cells or nematocysts of the Cœlentera, but it has a totally different function.

The spores fulfil the purpose of effecting transmission to other hosts. Infection occurs by the ingestion of the parasites per os after their escape by some means from their host. Thélohan and others have demonstrated that the valves of the spores soon open under the influence of the digestive juices, thus allowing the young myxosporidia to escape. Their further history is unknown ; but it may be surmised that they either travel direct to the organs usually affected (gall bladder, urinary bladder), or are distributed in the body by means of the circulatory or lymphatic systems.

The Myxosporidia that invade tissues are often deadly to their hosts. They may be present in a state of "diffuse infiltration" when practically every organ of the body may be infected, as in barbel disease (due to *Myxobolus pfeifferi*). On the other hand, the parasites may be concentrated at one spot, when cysts, either large or small, are produced. Such cysts occur on the gills of many fishes. A few additional important pathogenic forms are *Myxobolus cyprini*, the excitant of "pockenkrankheit" of carp, and *Lentospora cerebralis*, parasitic in the skeleton of Salmonidæ and Gadidæ. The skeletons of the tail, fins and skull particularly are seats of infection, and from the skull the Lentospora can spread to the semicircular canals, resulting in loss of power to maintain its balance on the part of the fish. On this account the malady is termed "drehkrankheit." Young fish are more particularly infected. *Myxobolus neurobius* infects the spinal cord and nerves of trout.

Myxosporidia are divided into two sub-orders—*Disporea* and *Polysporea*—according to whether they form only two or several spores during their growth. The former include two genera limited to fishes, which are easily distinguishable by the shape of the spores : *Leptotheca*, Thél., with a rounded spore, and *Ceratomyxa*, Thél., with a very elongate spore. The larger number of genera belong to the *Polysporea*, which are divided into three families :

(1) Amœboid germ with a vacuole the contents of which do not stain with iodine.
   (*a*) With two polar capsules—*Myxidiidæ.*
   (*b*) With four polar capsules.—*Chloromyxidæ.*

(2) Amœboid germ with a vacuole stainable with iodine. Spores with two polar capsules.—*Myxobolidæ.*

For further subdivisions the differences in the spores are principally utilized.

Order. **Microsporidia.** Balbiani.

These are the organisms discovered in the stickleback by Gluge in 1834, and in *Coccus hesperidum* by Leydig in 1853. They have since been found in numerous other arthropods, especially insects. They acquired particular importance when it was discovered that they were the cause of the "pébrine" disease ("gattina" of the Italians) which caused so much destruction amongst silkworms (*Bombyx mori*). Pasteur (1867-70) and especially Balbiani (1866) participated in the researches on *Nosema bombycis*, and it was the latter who classed the "pébrine bodies" or "psorospermia of the arthropoda" amongst the Sporozoa as Microsporidia (1882).[1] The complete life cycle of *N. bombycis* was described in 1909 by Stempell. The Microsporidia are not confined to insects and arachnoids, they are now known to occur also in crustacea, worms, bryozoa, fishes, amphibians and reptiles. Certain tumours in fishes, similar to those formed by many Myxosporidia, are produced by Microsporidia. Fantham and Porter found that *Nosema apis* was pathogenic to bees

[1] *C. R. Acad. Sci.*, Paris, xcv, p. 1168.

and other insects, and was the causal agent of the so-called "Isle of Wight" disease in bees[1] in Great Britain.

The Microsporidia, as their name implies, form minute spores which usually are oval or pear-shaped. Each spore contains a single polar capsule which is not easily visible in the fresh state (fig. 98, *f*) and a single amœboid germ issues from the spore (fig. 99, *b*).

The life cycle of *Nosema apis*, parasitic in bees, may be taken as an example of that of a microsporidian. The infection of the host is initiated by the ingestion of spores of *N. apis* in food or drink contaminated with the excrement of other infected

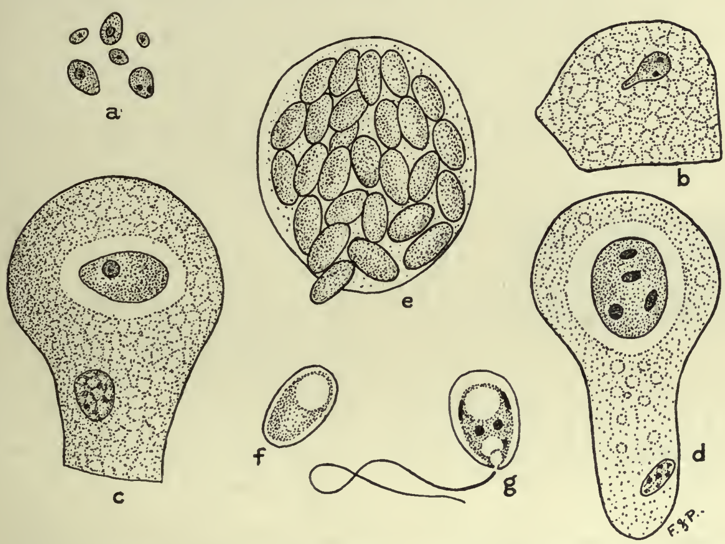


Fig. 98.—*Nosema apis*. Various stages in life-cycle. *a*, planonts or amœbulæ from chyle stomach of bee; *b*, amœboid planont creeping over surface of gut epthelial cell; *c*, uninucleate trophozoite within epithelial cell; *d*, meront with nucleus divided into four, about to form four spores; *e*, epithelial cell crowded with spores; *f*, young spore; *g*, spore showing five nuclei, polar filament ejected, and amœbula, about to issue. × 1,500, *a—e*; × 2,150, *f—g*. (After Fantham and Porter.)

bees. Under the influence of the digestive juice of the bee the spore-coat (sporocyst) softens, the polar filament is ejected and anchors the spore to the gut epithelium, and the minute amœbula contained in the spore emerges. The amœbula is capable of active amœboid movements (fig. 98, *b*) and so is termed the planont or wandering form (fig. 98, *a*). After a short time each planont penetrates between or into the cells of the epithelium of the gut, a few only passing through into the body cavity. Within the cells the amœbulæ become more or less rounded, lose their power of movement, and after a period of growth of the trophozoite (fig. 98, *c*) commence to divide actively, these dividing forms being known as meronts (fig. 98, *d*). Various forms of fission occur, and during this phase, termed merogony, the numbers of the parasite within the host are greatly increased, with concomitant destruction of the epithelium (fig. 98, *e*). After a time sporogony commences. The full-grown meront becomes successively the pansporoblast and sporoblast. Nuclear multiplication and differentiation ensue and five nuclei are ultimately produced. At the same time a sporocyst is secreted, and two vacuoles are produced within. One is the polar capsule, and

[1] *Annals Trop. Med. and Parasitol.*, vi, pp. 145-214, 3 pls.

within it the polar filament is differentiated; the other forms the posterior vacuole (fig. 98, *g*). Between the two vacuoles the body cytoplasm or sporoplasm forms a girdle-like mass. Of the nuclei, one regulates the polar capsule, two control the secretion of the sporocyst, and two remain in the sporoplasm. The polar capsule and polar filament are not usually visible in the fresh condition, but can be demonstrated by the use of various chemical reagents (fig. 100). The sporoplasm ultimately becomes the amœbula (fig. 98, *g*) which issues from the spore after the ejection of the polar filament.

A trophozoite (meront) of *N. apis* becomes a single pansporoblast which gives rise to one sporoblast producing one spore, and this procedure is characteristic of the genus *Nosema*. In other genera the trophozoite may form more than one pansporoblast and each pansporoblast may form a variable number of spores in different cases. Various attempts at classification have been based on these characteristics. It must suffice here to note that in the cases where the trophozoite becomes one pansporoblast, the latter can produce four spores in the genus *Gurleya*, eight spores

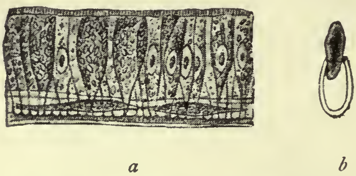


FIG. 99.—*a*, section through the abdominal wall of a silkworm, whose epithelial cells contain Microsporidia (*Nosema bombycis*); *b*, a spore, the contents of which are escaping. (After Balbiani.)

FIG. 100.—*Nosema bombycis*, Naeg. Spores treated with nitric acid, thus rendering the polar capsule perceptible, and the filament has protruded from one of the spores. (After Thélohan.)

in *Thélohania* and many spores in *Pleistophora*. In other cases, where the trophozoites give rise to many pansporoblasts, each of the latter may form many spores, as in the genus *Glugea*.

A few pathogenic microsporidian parasites other than *N. apis* may be mentioned. *N. bombycis*, causing pébrine in silkworms, may infect any or all the tissues of the host (fig. 99). The larvæ of the host, *i.e.*, the "silkworms," may become infected by eating food contaminated with spore-containing excrement of already infected silkworms. In cases of heavy infection the silkworm dies, but should the infection be less intense the larva becomes a pupa in which the parasite persists, so that the moth emerges from the cocoon already infected. Not only is the moth parasitized itself, but the Nosema reaches the generative organs of both sexes and penetrates the ovaries of the female, with the result that the ova are deposited infected. Such infected eggs are capable of developing, so that infection may be transmitted hereditarily as well as by the contaminative method. Infected eggs can be recognized by microscopic examination, as Pasteur showed, and thus preventive measures may be adopted.

A microsporidian parasite is known to occur on the roots of the spinal and cranial nerves of *Lophius piscatorius*, the angler fish. This parasite is variously referred to the genera *Nosema* and *Glugea*.

Thélohania contejeani, parasitic in the muscles of crayfish, is believed by some to be the causal agent of recent epizoötics among them, though others believe the disease to be really due to a bacillus. It may be that the one organism aids in the entry of the other into the host.

Order. **Actinomyxidia**, Stolč.

A brief mention may be made of the Actinomyxidia (fig. 101), which were first described by Stolč in 1899 as parasites of Oligochætes. They have also been investigated by Mrazek, and a detailed study of certain species was made by Caullery and Mesnil (1905). The trophozoite is small and amœboid. The spores are large, and exhibit tri-radiate symmetry. Spore formation is complicated and sexual processes occur therein. Many amœbulæ are set free from each spore.

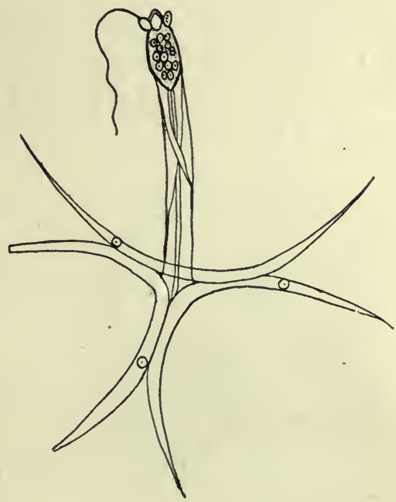


FIG. 101.—Spore of *Hexactinomyxon psammoryctis.* At top of figure three polar capsules, one with polar filament extended. × 450. (After Stolč.)

Order. **Sarcosporidia**, Balbiani.

The first member of this group was discovered by Miescher in 1843. This author found white filaments running parallel with the direction of the fibres in the voluntary muscles of mice. They were visible to the naked eye, and proved to be cylindrical tubes tapering at each end. They were as long as the muscular fibres, were enveloped in a membrane, and contained innumerable elongate or kidney-shaped bodies and a smaller number of little spherical forms. Th. v. Hessling confirmed (1853) the occurrence of these "Miescher's tubes" within the muscular fibres, this author having discovered the same structures in the heart muscles of deer, cattle, and sheep. Both investigators considered them to be pathological transformations of the muscles. v. Siebold, from his own experiences, regarded them as fungus-like entophytes.

Rainey (1858) discovered similar structures in the muscular system of pigs, and considered them to be early stages of *Cysticercus cellulosæ*, which error Leuckart rectified, simultaneously emphasizing their relationship with Myxosporidia. Both these authors found them in the muscular fibres, and both observed that they possessed a thick striated membrane. Manz (1867) published the results of more minute investigations on the structure and contents of the cylinders. This observer also recognized the disease in rabbits and attempted to cultivate the parasites. He also tried to induce experimental infection in guinea-pigs, rats, and mice, but the result was negative.

However, domestic and wild mammals are not the only hosts of Sarcosporidia; these parasites are also harboured by birds. Thus, according to Kühn, they are found in the domestic fowl; according to Rivolta in *Turdus*, *Corvus*, and other birds; according to Stiles in North American birds; while Fantham found Sarcosporidia in the African mouse-bird, *Colius.* Reptiles also are parasitized occasionally. Bertram found them in the gecko, Lühe in the wall-lizard. It was found also that the Sarcosporidia could develop not only in the muscles but also in the connective tissue. This led to the foundation of a new, but provisional, classification by Blanchard, using the generic name *Miescheria* for the parasites in the muscles and *Balbiania* for those in the connective tissue. Finally, Sarcosporidia have also been observed in man.

The relation of these parasites to certain diseases of domestic animals has been studied by veterinary surgeons. Sarcosporidia may cause fatal epizoötics among sheep.

There is still a wide field open for research in regard to the structure and development of these parasites, and the manner in which the hosts become infected.

The Sarcosporidia usually appear as elongate, cylindrical, or fusiform bodies, rounded at both extremities and of various lengths and breadths (fig. 102). In some species they may be from 16 mm. to 50 mm. long, as in the sheep and roebuck. These bodies are the so-called sarcocysts or Miescher's tubes. They lie in transversely

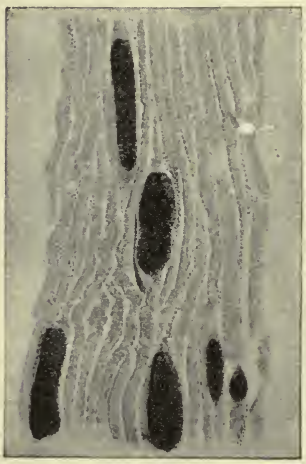


FIG. 102.—Longitudinal section of a muscle of the domestic pig, with *Sarcocystis miescheriana*. × 30. (After Kühn.)

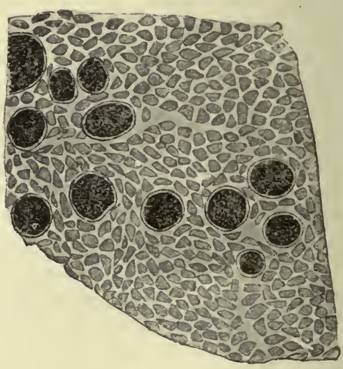


FIG. 103.—Transverse section of the muscle of a pig, with *Sarcocystis miescheriana*. × 38. (After Kühn.)

striated muscular fibres which they distend more or less. The forms found in the connective tissue are apparently parasites which originally inhabited the muscular fibres, and only on disintegration of the fibres reached the connective tissue, where they grow to large oval or globular bodies (fig. 105). The mammalian muscles usually infected are those of the œsophagus, larynx, diaphragm, body-wall, and the psoas muscles. The skeletal muscles may be affected in acute cases, as well as those of the tongue and eye. The heart muscles are sometimes parasitized.

In fresh material cut into thin slices the parasites are frequently recognizable, even with the naked eye, because of their yellowish-white colour. Under the microscope they appear to be coarsely granular (fig. 103). Beginners may find some difficulty in distinguishing them from other foreign bodies, such as dead and calcified encapsuled Trichinæ, or from Cysticerci that have died and become calcified in the early stages, more particularly as the Sarcosporidia also occasionally may become calcified.

The Sarcosporidia are always enveloped in a membrane, which is probably formed at an early stage. In a few cases it remains thin and simple, in other cases a radially striated ectoplasmic layer is present (figs. 104, 108), which has been variously described. From the inner integument, which may be homogeneous or fibrous, thick or thin, membranes or trabeculæ pass into the interior of the body, forming anastomosing partitions, and so producing a system of chambers of various sizes that do not communicate with one another (figs. 104, 108). These chambers are occupied by sickle- or bean-shaped bodies (spores or sporozoites), or various developmental stages of them. The oldest spores are found in the centre of the Miescher's tubes or trophozoites. If they are not liberated they die there, so that the central chambers of the tube are empty and hollow.

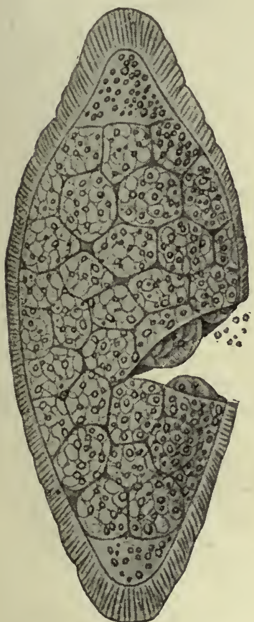


FIG. 104.—*Sarcocystis miescheriana* from pig. Late stage in which body is divided into numerous chambers or alveoli, each containing many spores. (From Wasielewski, after Manz.)

In the youngest Sarcosporidia (40 μ in length) from the muscles of the sheep there occur, according to Bertram, small roundish or oval cells (4 μ to 5 μ), the nuclei of which are half their size, and are embedded in a granular protoplasmic mass. In somewhat larger, and therefore older, cylinders, the investing membrane of which already shows both layers, the cells have become larger (to 7 μ) and are more sharply outlined from each other (fig. 106). These uninucleate cells may be considered as pansporoblasts. In each pansporoblast division of the nucleus occurs (fig. 107), and meanwhile the pansporoblasts become isolated within the chambers, the dividing partitions of which originate from the granular protoplasm which is present between the pansporoblasts. The numerous uninucleate daughter forms produced within the chambers become spores direct (fig. 108).

The process commences in the centre of the cylinders or sarcocysts, and then progresses towards the extremities, the parasites meanwhile increasing in size, and new pansporoblasts being continually formed at the extremities (fig. 107).

The spores (sometimes called Rainey's corpuscles), vary in shape according to the species, but are also of different form individually. They are mostly kidney-, bean- or sickle-shaped (fig. 109), and of small size, sometimes reaching 14 μ by 3 μ to 5 μ. They are apparently surrounded by a thin membrane, and at one extremity (according to the discovery of L. Pfeiffer, confirmed by van Eecke,

FIG. 105.—Transverse section of *Sarcocystis tenella*, Raill. From the œsophagus of the sheep, *Ovis aries*. × 38. *a*, marginal chambers filled with spores; *b*, connective tissue of the œsophagus; *c*, muscles of the œsophagus.

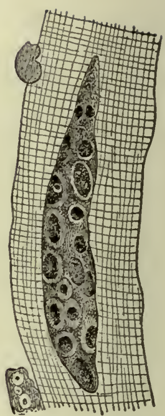


FIG. 106.—Young *Sarcocystis tenella* of the sheep, 47 μ in length. (After Bertram.)

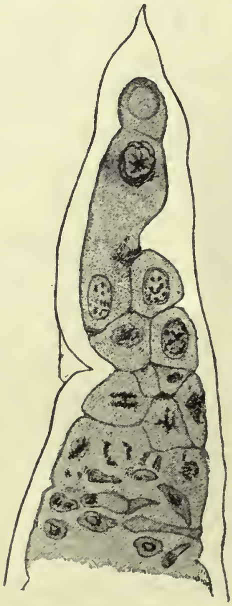


FIG. 107.—End of a trophozoite of *Sarcocystis miescheriana* from the diaphragm of the pig, showing division in pansporoblasts. × 800. (After Bertram.)

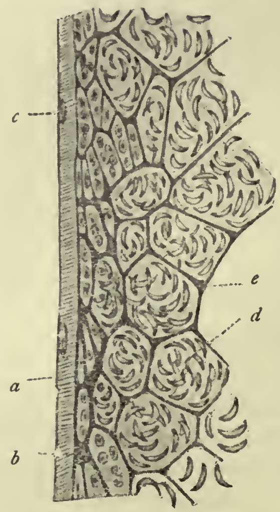


FIG. 108. — *Sarcocystis blanchardi* of the ox. Longitudinal section of sarcocyst or Miescher's tube. *a*, substance of muscle fibre; *b*, envelope of sarcocyst; *c*, muscle nuclei; *d*, spores in chambers; *e*, ground substance. × 400. (From Wasielewski, after van Eecke.)

Laveran and Mesnil) contain an obliquely striated body (fig. 109) often homologized with the polar capsule, while the greater part of the spore is taken up by the nucleate sporozoite. Several authors state that they have also observed filamentous appendages (polar filaments) at one end of the spores, and have seen two kinds of spores in the same Sarcosporidium. Spores of various species of Sarcosporidia may contain metachromatic granules, often centrally placed (fig. 109). These granules may be metabolic or possibly may contain toxin (see below).

The gymnospores of *Sarcocystis muris*, from the mouse, show active boring movements when kept in saline solution warmed to 35° or 37° C. *S. muris* is very deadly to its host. From their structure the spores do not appear to have great powers of resistance to external conditions. They measure 12 μ by 3 μ to 4 μ or less.

Laveran and Mesnil (1899) isolated a toxin from *S. tenella* of the sheep and called it sarcocystin. This substance is especially pathogenic to experimental rabbits.

The duration of life of the Sarcosporidia is a comparatively long one. The affected muscular fibres may remain intact and capable of performing their functions for a long time, but at last they perish, if the host lives long enough. Thus the Sarcosporidia of the muscles are then enveloped only by sarcolemma, and finally, when this likewise disappears, they fall into the intra-muscular connective tissue. In many cases the Sarcosporidia die off within their hosts, this, according to Bertram, being brought about by a disintegration of the spores in the central chambers. In other cases the leucocytes play a part in the destruction of the Sarcosporidia, and sometimes it happens that lime salts are deposited in and around the vacant cylinders.

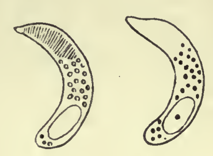


FIG. 109.—Spores of *Sarcocystis tenella*, Raill. *a*, fresh, showing the polar capsule; *b*, stained, showing metachromatic granules and nucleus. × 1,000. (After Laveran and Mesnil.)

In some places pigs, sheep, mice and rats are infected with sarcosporidiosis to a remarkable extent, in certain cases almost reaching 100 per cent. Young animals also are infected, and perhaps infection only takes place during youth.

Although the natural mode of transmission of the Sarcosporidia remains to be determined, yet various experimental researches on the problem are of interest and importance. Theobald Smith (1901) found that mice could be experimentally infected with *S. muris* by feeding them with the flesh of other infected mice. The incubation period was a long one, namely forty to fifty days. Thus, on the forty-fifth day after feeding young Sarcosporidia were found, and seventy days after feeding spore formation began. Ripe spores were found two and a half to three months after the commencement of these experiments. This mode of infection—a cannibalistic one—hardly seems likely to be the natural method for the infection of sheep and ruminants generally. Smith's researches have been confirmed. Nègre[1] (1910) found that the fæces of mice fed on infected muscular tissue were infective to other mice when ingested by them. Negri[2] infected guinea-pigs with *S. muris* by feeding them on infected mouse flesh, and found that the parasite in guinea-pigs showed different characters from those exhibited by it in mice. Darling[3] also succeeded in infecting guinea-pigs with *S. muris*, and Erdmann infected mice with *S. tenella* (from the sheep).

According to Erdmann[4] (1910) the Sarcosporidian spore germinates in the intestine of the host, which has recently ingested infected material. The spore liberates its contained toxin—sarcocystin—which acts upon the adjacent intestinal epithelium, whereby the latter is shed, and an amœbula creeps out of the spore. The amœbula is able to penetrate the denuded area and get directly into the lymph-spaces of the submucous coat of the intestine. The first period of development, lasting some twenty-eight to thirty days, is said to be passed in the lymph-spaces of the intestine. Later the amœbula reaches a muscle fibre. Writing in May, 1914, Erdmann[5] records the appearance of small amœboid and schizogony forms six days after infection of the host. Crawley[6] (1913) controverts some of these statements and considers that the Sarcosporidian spore, still sickle-shaped, bores its way into the epithelial cells of the intestine and comes to rest there. The spore then becomes round or elliptical, and peripheral masses of chromatin appear within it, suggesting schizogony. This happens about twelve hours after feeding, and in twenty-four hours the spores appear to have left the intestine. More recently (May, 1914), Crawley[7] considers that there is sexual differentiation among the Sarcosporidian spores, a few hours after their ingestion by the host.

Interesting discussions have occurred as to the site of the toxic sarcocystin within the spore. Metachromatic granules occur in the middle of the Sarcosporidian spore (fig. 109), and the toxin may be contained in these grains, as they disappear, according to Erdmann, before the amœbula penetrates the denuded intestinal wall. However, a polar capsule, containing a polar filament, may be present at one end of a Sarcosporidian spore. Laveran and Mesnil described a striated area at the more pointed end of the spore of *S. tenella*, which area they consider to represent a polar capsule. Fantham[8] (1913)

---

[1] *C. R. Soc. Biol.*, lxviii, p. 997.

[2] *Centralbl. f. Bakt.*, Orig., xlvii, p. 612; see also xlvii, p. 56; lv, p. 373.

[3] *Journ. Exptl. Med.*, xii, p. 19. [4] *Sitz. Gesell. naturf. Freunde zu Berlin*, p. 377.

[5] *Proc. Soc. Exper. Biol. and Med.*, xi, p. 152. [6] *Science*, xxxvii, p. 498.

[7] *Proc. Acad. Nat. Sci.*, Philadelphia, May, 1914, p. 432.

[8] *Proc. Cambr. Philosoph. Soc.*, xvii, p. 221.

found a vacuole-like, polar capsule area in the spores of *S. colii* from the African mouse-bird. The sarcocystin may be contained in the polar capsule. The nucleus of the spore is generally at the opposite, blunter end.

Again, various authors have stated that Sarcosporidian spores may occur in the blood of the host at times. If so, then an intermediate host may be concerned in their transmission. Perrin suggested that Sarcosporidia might be spread by blow-flies and flesh-flies.

The classification of the Sarcosporidia as proposed by R. Blanchard, which was based on their various habitats, can no longer hold, because the same species may occur in the muscles as well as in the connective tissue. For the present, the few species that are known may be placed in one genus, *Sarcocystis*, Ray Lankester, 1882.

The following species of *Sarcocystis* are of interest :—

S. miescheriana, Kühn, 1865, in the pig.

S. bertrami, Doflein, 1901, in the horse.

S. tenella, Railliet, 1886, in sheep. *S. tenella bubali* in buffaloes in Ceylon and Egypt.

S. blanchardi, Doflein, 1901, in cattle.

S. muris, Blanchard, 1885, in the mouse, to which it is lethal.

S. hueti, Blanchard, 1885, in the seal.

S. colii, Fantham, 1913, in the African mouse-bird, *Colius erythromelon*.

Also various Sarcosporidia from antelopes, monkeys, opossum, birds, the gecko and wall-lizard are known.

The spores of *S. muris*, *S. bertrami*, *S. tenella*, and *S. colii* can multiply by longitudinal fission.

Sarcosporidia observed in Man.

(1) Lindemann[1] found on the valves and in the myocardium of a person who had died of dropsy certain brownish masses, 3 mm. in length and 1·5 mm. in breadth which he regarded as gregarines. If these were actually independent animal organisms it may be suggested that they were Sarcosporidia. Rivolta (1878) named the species *S. lindemanni*.

(2) Rosenberg[2] found a cyst 5 mm. in length and 2 mm. in breadth in a papillary muscle of the mitral valve of a woman, aged 40, who had died from pleuritis and endocarditis. The cyst contained no scolex nor hooklets of tænia. Numerous small refracting bodies, round, oval or kidney-shaped, were found in a daughter cyst, as well

[1] "Ueb. d. hyg. Bdtg. d. Gregarinen," *Dtsche. Ztschr. f. Staatsarzneikunde*, 1868, xxvi, p. 326.

[2] "Ein Befund von Psorosp. in Herzmusk d. Menschen," *Ztschr. f. Hygiene*, 1892, xi, p. 435.

as sickle-shaped bodies. The description hardly appears to indicate Sarcosporidia.

(3) Kartulis[1] observed Miescher's cylinders of various sizes in the liver (?) and in the muscular system, of a Sudanese who had succumbed to multiple abscesses of the liver and abdominal muscles. This may be considered as the first actual case of the occurrence of Sarcosporidia in man. Koch in 1887 described a case in Egypt.

(4) The case reported by Baraban and St. Remy[2] was at once demonstrated as certain. It related to a man who had been executed, and in the laryngeal muscles of whom Sarcosporidia were found; the length of the parasites varied between 150 μ and 1,600 μ, their breadth between 77 μ and 168 μ. The affected muscular fibres were distended to four times their normal thickness. This species was described by Blanchard as "*Miescheria*" *muris*, but according to Vuillemin, it was more probably *Sarcocystis tenella* of the sheep.

(5) Vuillemin has also described a case of Sarcosporidia found in the muscles of a man who died from tubercle at Nancy. The author considered that the parasite corresponded to *S. tenella*.

(6) Darling[3] (1909) found Sarcosporidia in the biceps of a negro from Barbados.

The Myxosporidia, Microsporidia, Actinomyxidia and possibly the Sarcosporidia may be included within the section **Cnidosporidia** (Doflein), since they possess spores containing polar capsules.

Order. **Haplosporidia**, Caullery and Mesnil.

The Haplosporidia are a group of organisms having both a simple structure and life-history. The simplicity may represent a primitive condition or may be due to degradation resultant on parasitism, and thus it is possible that the group is not a homogeneous one. The order Haplosporidia was created by Caullery and Mesnil in 1899, and includes parasites of rotifers, annelids (fig. 110), crustacea, fish, prochordates and man. They may be present in the body cavity or alimentary tract, and can also occur in the septum nasi of man, in the nervous system of Cephalodiscus, and in tumours of fish.

As the name implies, the spores of the Haplosporidia are simple, without polar capsules, and are uninucleate. In some genera, *e.g.*, *Haplosporidium*, *Urosporidium* (fig. 111) there is a spore-coat or sporocyst which may be elongate or spiny. The developmental cycle of a Haplosporidian, such as *Haplosporidium* or *Bertramia*, begins with a small, uninucleate cell, often rounded, possessing a cell membrane that may be prolonged into processes. Growth takes place, coupled with an increase in the number of nuclei, so that a multinucleate trophozoite is produced. Later, this

---

[1] Kartulis, "Ueb. pathog. Protoz. b. Menschen," *Ztschr. f. Hyg. u. Inf.*, 1893, xiii, p. 1. Compare also Braun, M., *Die Thier. Par. d. Mensch.*, 2nd Edit., Wrzbg., 1895, p. 92; Braun, M., "Z. Vork. d. Sarcosp., b. Menschen," *Centralbl. f. Bakt.* 1895, xviii, p. 13.

[2] "Sur un cas de Tub. Psorosp. ob. chez l'homme," *C. R. Soc. Biol.*, Paris, 1894 (x), I, p. 201. "Le Parasitisme d. Sarcosp. chez l'homme," *Bibliogr. Anat.* 1894, p. 79.

[3] *Arch. Internal Med.*, III, p. 183.

multinucleate trophozoite becomes segmented into a number of ovoid or spherical pansporoblasts, which give rise to few (one to four) spores. Such a spore, when set free, begins the life cycle over again.

More recently (1905-1907) two important organisms have been described and included in this group, namely, *Neurosporidium cephalodisci*[1] (Ridewood and Fantham) from the nervous system of the prochordate, *Cephalodiscus nigrescens*, and *Rhinosporidium kinealyi* (or *seeberi*) from the septum nasi of man. In the case of *Rhinosporidium* and *Neurosporidium*, after the uninucleate spore has grown into

FIG. 110. — *Haplosporidium heterocirri*. Section throughout wall of the Polychæte worm, *Heterocirrus viridis*, showing various developmental stages of the Haplosporidium. × 550. (After Caullery and Mesnil.)

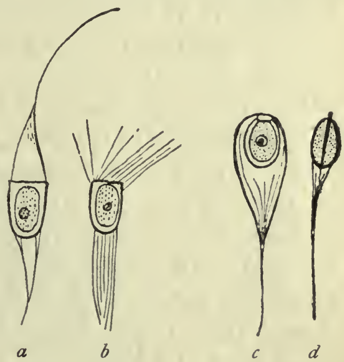


FIG. 111.—Haplosporidian spores. *a. b*, *Haplosporidium heterocirri*. *a*, fresh ; *b*, after immersion in sea water ; *c*, *d*, *Urosporidium fuliginosum*. × 1000. (After Caullery and Mesnil.)

a multinucleate trophozoite, the latter segments into uninucleate pansporoblasts, as in the preceding cases. A difference then occurs, for each pansporoblast enlarges, its nucleus divides and a "spore-morula" is formed. Thus a multinucleate pansporoblast or spore-morula, divided into many uninucleate sporoblasts (spore mother cells) is produced, and each sporoblast without further change becomes a uninucleate spore.

The Haplosporidia have therefore been divided by Ridewood and Fantham (1907)[2] into two sections:—

(1) The *Polysporulea*, wherein the pansporoblast gives rise to a number of spores (nine or more), *e.g.*, *Rhinosporidium*, *Neurosporidium*.

(2) The *Oligosporulea*, wherein the pansporoblasts give rise each to a few (four) spores or to only a single spore, *e.g.*, *Haplosporidium*, *Bertramia*, *Cœlosporidium*, *Ichthyosporidium*.

Rhinosporidium kinealyi, Minchin and Fantham, 1905.

Rhinosporidium kinealyi, parasitic in man, must now be considered in greater detail. This organism was found in nasal polypus in India, and has since been recorded from the ear as small nodules in the external auditory meatus. The Indian cases came from the

[1] *Quart. Journ. Microsc. Sci.*, li, p. 81.

[2] See Fantham, *Brit. Assoc. Reports*, 1907, p. 553.

neighbourhoods of Calcutta and Madras, and the parasite has been seen in Ceylon. Similar structures have since been described from the United States and South America.

The Rhinosporidium polypus is said not to be particularly painful, though nasal forms must interfere with breathing to some extent. The first nasal polyp reported from India formed a vascular pedunculated growth on the septum nasi and was about the size of a large pea or raspberry. It was compared with a raspberry, being red in colour with a number of small whitish dots upon its surface. When the tumour was cut, a number of similar whitish dots were seen within. These were the cysts of Rhinosporidium. According to Minchin and Fantham[1] (1905), they vary considerably in size and measure up to 200 μ or 250 μ in diameter. Each possesses a cyst wall which varies in thickness in different cysts. Its outer wall is always firm and distinct, the inner limit being less definite at times. Each large cyst is filled with numbers of spherical or oval bodies, showing every gradation between small ones at the periphery and large ones at the centre (fig. 112). Roughly, three zones of parasites can be distinguished in a large cyst, a peripheral set consisting of the youngest parasites, an intermediate group and a central, oldest zone. A large cyst may possess a pore for the egress of its contents. Some of the cysts show polar distribution of the zones.

The youngest forms of Rhinosporidium are difficult to detect. They are small, granular masses, round, ovoid or irregular and at times even amœboid in appearance. These are young trophozoites. They increase in size, but encystment occurs early, the outer layer becoming firm so that the organisms have a definite contour. Each is soon multinucleate and the cytoplasm segments around the nuclei. The cyst thus becomes full of uninucleate pansporoblasts or sporonts, with a peripheral layer of undifferentiated protoplasm. The pansporoblasts grow in size. In the larger cysts the formation of pansporoblasts progresses at the expense of the peripheral layer of protoplasm, which, however, continues to grow, so that the cyst as a whole increases in size. The pansporoblasts at first are uninucleate (fig. 112, *a*), and then undergo nuclear multiplication. This is well seen in the intermediate zone of parasites, where the pansporoblasts show first one, then two, then four or more spores (fig. 112, *b*), while in the oldest centrally placed pansporoblasts, about a dozen or sixteen closely packed spores (fig. 112, *c*), can be seen. The spore is small and rounded, and its nucleus is clear and distinct. The fully formed pansporoblast or spore morula becomes surrounded by a membrane.

Certain of the cysts have been found in a ruptured condition,

---

[1] *Quart. Journ. Microsc. Sci.*, xlix, p. 521.

whereby the spores have been liberated into the surrounding tissue. It is almost certain that the spores serve for the auto-infection of the host, for though the tumours of Rhinosporidium seemed to have been removed entirely, it has been found that they recur, some minute fragment of the parasite having probably been left behind. The method whereby the parasite reaches new hosts has not yet been determined, and it would be of interest if its life-history could be more fully investigated.

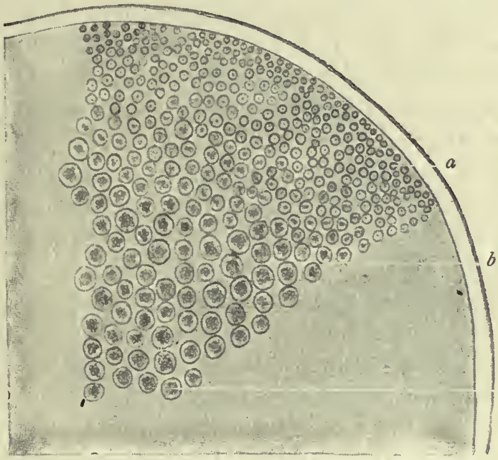


FIG. 112.—*Rhinosporidium kinealyi.* Protion of ripe cyst containing pansporoblasts of various ages. × 480. (After Minchin and Fantham.)

The Asiatic specimens of *R. kinealyi* were first described in detail by Minchin and Fantham (1905) from material briefly reported to the Laryngological Society of London in 1903, by O'Kinealy. Material obtained by Dr. Nair, of Madras, was described by Beattie[1] in 1906. This material came from Cochin. Castellani and Chalmers have found similar polypi in Ceylon.

Wright[2] has described the parasite from Memphis, Tennessee. Seeber[3] in 1896 described nasal polypi in Buenos Ayres, and in 1900 Wernicke named the parasite therein *Coccidium seeberi*. Seeber's parasite is a Rhinosporidium, *R. seeberi*, and may ultimately be found to be the same as *R. kinealyi*. Ingram[4] reports Rhinosporidium cysts, with pores in the cyst walls, in conjunctival polypus and in papilloma of the penis in India. Zschokke has reported the presence of *Rhinosporidium* in horses in South Africa.

[1] *Journ. Pathol. and Bacteriol.*, xi, p. 270; and *Brit. Med. Journ.*, Nov. 16, 1907, p. 1402.
[2] *New York Med. Journ.*, December 21, 1907, p. 1149.
[3] *La Ciencia Medica* (Buenos Ayres), 1912. [4] *Lancet*, September 3, 1910, p. 726.

Class IV. **INFUSORIA**, Ledermüller, 1763.

The Infusoria (or Heterokaryota, Hickson, or Ciliophora, Doflein) include the Ciliata and the Suctoria. A few authorities, including Braun, raise the Suctoria (or Acinetaria) to separate rank as a class, but this is not widely followed.

The body of the Ciliata usually is bilaterally symmetrical and is enveloped in a cuticle which has numerous openings for the protrusion of the cilia. Most kinds have a fixed shape, whilst changes in the form of others are brought about by the contractions of the body substance. The latter exhibits hyaline ectoplasm, in which myonemes, and occasionally also trichocysts (minute spindle-shaped bodies) appear, and granular endoplasm which may contain numerous vacuoles. The cilia, on whose various arrangements the classification is based, are always processes of the ectoplasm. Their form varies; they may be hair-like, or more rarely thorn-like, spur-like, or hook-shaped; undulatory membranes also may occur, which are probably composed of fused cilia.

With the exception of some of the parasitic species, an oral cavity, peristome or cytostome, is always present. It is frequently beset with cilia or provided with undulatory membranes, which help to waft the food inwards; sometimes there is an anal aperture (cytopyge) generally placed at the opposite pole of the organism. A cytopharynx fringed with cilia or sometimes with a specialized supporting apparatus is connected with the peristome. Vacuoles form round the ingested food, and in many species a constant rotation goes on in the endoplasm. Often one, and sometimes two contractile vacuoles are present, the frequency of the pulsations of which depends on the surrounding temperature. Sometimes special conducting channels lead to the vacuoles, or there are outlet channels leading to the exterior.

There is in almost every case a large nucleus (macronucleus), and lying close up to it a small nucleus (micronucleus). The form of the large nucleus varies according to the species. Numerous nuclei are not very common, but these occur in *Opalina*, which lives in the hind-gut of amphibia, and is also distinguished by the absence of an oral aperture.

Reproduction is effected by binary fission; less commonly, after encystment, by multiple division, or by budding. The divisions can be repeated many times, but finally cease, and then the conjugation of two specimens brings about a regeneration, particularly of the nuclei. Numerous examinations (Bütschli, Hertwig, Maupas, Calkins) have demonstrated that after two individuals have associated by homologous parts of the body, the micronucleus separates from the macronucleus, becomes larger and divides twice by mitosis, so that four micronuclei are present in each one of the two individuals forming the couple. Three of these nuclei perish and become absorbed, the fourth gradually passes to the portion of protoplasm connecting the two conjugants, which has originated by absorption of the cuticle at the point of contact of the conjugants. After a further division one micronucleus of each conjugant passes over into the other conjugant, and fusion ensues between the two micronuclei of each individual. Complicated changes and divisions may occur, but only the main principles can be noted here. A new nuclear body is thus formed in each conjugant, and soon divides into two. Of the segments thus produced one becomes a micronucleus, and one or several of the others, as the case may be, form or amalgamate into a new macronucleus, the old macronucleus usually perishing or becoming absorbed during the conjugation. Usually, sooner or later, the two conjugants separate, or may have separated already, and again multiply independently by fission until a series of divisions by simple fission is again followed by conjugation. The theoretical significance of conjugation cannot be dealt with fully here. It may be remarked, however, that the macronucleus plays no part in it, but governs entirely the metabolism of the Infusorian, whereas the micronucleus is essentially a generative nucleus from which macro- and micro-nuclei are again and again produced.

Encystment amongst the Infusoria is very general, and is essentially a means of protection when the surrounding medium dries up. Doubtless these cysts are frequently carried long distances by the wind, which explains the wide geographical distribution of most species. Also, multiplication often takes place in the encysted condition.

Some Infusoria live a free life, others are sedentary; the latter form colonies in fresh as well as in salt water. Numerous species are parasites of various lower and higher animals,[1] and a few also are parasitic in man.

The Prague zoologist, v. Stein, introduced a classification of the Infusoria that has been almost universally adopted. It is founded on the different position of the cilia on the body. Though, no doubt, artificial, it is a convenient system. Bütschli has compiled a better one. But for our purpose Stein's system is sufficient :—

Order 1. *Holotricha*, Infusoria with cilia that are evenly distributed over the entire body.

---

[1] It may be stated that numerous peculiarly shaped species live in the stomach of ruminants, others in the colon of horses. Several species are found in the rectum of frogs and toads; others, again, on the surface of the bodies of fishes; and various other species exist in and on the bodies of invertebrate animals.

[2] Bronn's *Cl. u. Ordn. d. Thierr.*, i, Protozoa, Part 3, Infusoria.

Order 2. *Heterotricha*, ciliated all over like the *Holotricha*, but having stouter cilia about the peristome.
Order 3. *Hypotricha*, only ciliated on the ventral surface.
Order 4. *Peritricha*, with only a ring of spiral cilia, mostly sedentary.

The Infusoria observed in man belong to the order *Heterotricha*, with few exceptions.

Genus. **Balantidium**, Claparède et Lachmann.

Heterotrichous Infusoria of oval or bag-like form and almost circular on transverse section; the anterior extremity narrowed, the posterior end broad and rounded off, or also narrowed; the peristome starting at the anterior end is broadest there and becomes narrower as it gradually obliquely approaches towards the posterior extremity. There are coarse cilia along the entire left border and the anterior part of the right border. Longitudinal striation is distinct and regular. There are two contractile vacuoles on the right, and occasionally also two or more to the left. The anus (cytopyge) is terminal. The macronucleus is usually horse-shoe or kidney-shaped, sometimes oval; the micronucleus contiguous. Reproduction is by binary fission and conjugation, and encystment occurs. The cysts are spherical or oval. These ciliates are parasitic in the large intestine of human beings and pigs, in Amphibia, and in the body cavity of polychæte Annelida.

Balantidium coli, Malmsten, 1857.

Syn.: *Paramœcium coli*, Malmsten, 1857.

The body is oval, 60 μ to 100 μ in length (up to 200 μ according to Janowski), and 50 μ to 70 μ in breadth. The peristome is funnel-shaped or contracted, the anterior end being then broadened or

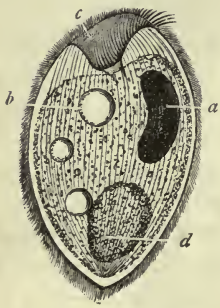


FIG. 113.—*Balantidium coli.* *a*, nucleus; *b*, vacuole; *c*, peristome; *d*, bolus of food. (After Leuckart.)

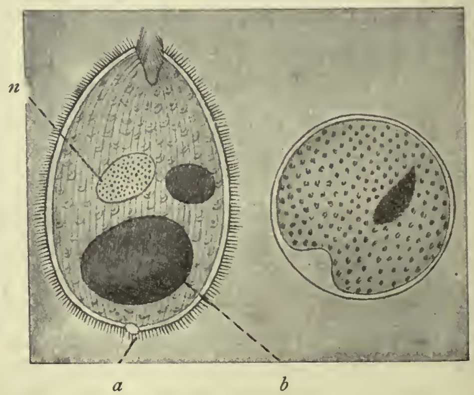


FIG. 114.—*Balantidium coli*, free and encysted; *a*, anus or cytopyge; *n*, macronucleus; *b*, bolus of food. (After Casagrandi and Barbagallo.)

pointed according to the degree of contraction (figs. 113, 114). The ecto- and endo-plasm are distinct, the latter is granular, containing drops of fat and mucus, granules of starch, bacteria, and occasionally also red and white blood corpuscles. There are usually two contractile vacuoles, seldom more. The anus (cytopyge) opens at the posterior extremity. The macronucleus is bean- or kidney-shaped, rarely oval; the micronucleus is spherical.

Balantidium coli lives in the large intestine of man, in the rectum of the domestic pig, and has been found in monkeys. It propagates by transverse division, but conjugation and encystment are known to take place.[1] Transmission to other hosts is effected by the cysts of the parasite (fig. 114).

Balantidium coli, first seen by Leeuwenhoek, was described by Malmsten in 1857 in a man aged 35 years, who had two years previously suffered from cholera, and since then had been subject to diarrhœa. The examination showed an ulcer in the rectum above the mid sphincter ani, in the sanguineous purulent secretion of which numerous Balantidia were swimming about. Although the ulcer was made to heal, the diarrhœa did not cease and the stools contained numerous Balantidia, the number of which could only be decreased by extensive enemas of hydrochloric acid.

The second case related to a woman who was suffering from severe colitis, and who died ten days after admission. The malodorous, watery evacuations contained innumerable Balantidia, in addition to pus, and at the autopsy the anterior portion of the large intestine was found to be infested with them.

Subsequently this parasite has often been observed in human beings, and various cases have been recorded. These occurred in Russia, Scandinavia, Finland, Cochin China, Italy, Germany, Serbia, Sunda Islands, Philippine Islands, China, and in other parts of Asia and in America. Other cases were reported by Askanazy, Ehrnroth, Klimenko, Nagel, Koslowsky, Kossler, Waljeff, Strong and Musgrave, Glaessner[2] and others. Sievers found *B. coli* very common in Finland.

In the majority of the cases described by Sievers from Finland, and in other cases from Central Europe, the patients suffered from obstinate intestinal catarrh, which did not always cease even after the Balantidia had disappeared. On the other hand, Balantidia have occasionally still been found to persist, though in small numbers, after the catarrh has been cured. Some authors, nevertheless, do not

---

[1] According to Gourvitch ("Bal. coli. Darmk. d. Menschen," *Russ. Arch. f. Path., klin. med. u. Bact.*, Petrograd, 1896), the conjugated Balantidia are supposed to fuse with each other and form oval cysts two or three times the size of the free organisms, and to divide into numerous globules within the cystic membrane; the process, however, has hitherto not been confirmed. The supposed Balantidium cysts appeared in two patients who were simultaneously suffering from *Dibothriocephalus latus*, after the administration of anthelminthics. It therefore seems, according to the description, that in reality these forms were actually abnormally large, possibly swollen, young eggs of the tape-worm mentioned.

[2] *Centralbl. f. Bakt.*, Orig., xlvii, p. 351.

regard Balantidia as the primary cause of the various diseases of the large intestine, which often commence with the development of ulcers, but they consider that they may aggravate these diseases and render them obstinate. According to Solowjew, Askanazy, Klimenko and Strong and Musgrave, however, the parasites penetrate the intestinal wall, and give rise to ulcerations which may extend deeply into the submucosa, and even be found in the blood and lymphatic vessels of the intestinal wall. According to Stokvis, *B. coli* occurs also in the lung; at all events this author states that he found one living and several dead paramæcia (?) in the sputum of a soldier, returned from the Sunda Islands, who was suffering from a pulmonary abscess. Sievers has shown that *B. coli* might occur in persons not suffering from intestinal complaints, but E. L. Walker [1] (1913) states that every person parasitised with *B. coli* is liable sooner or later to develop balantidian dysentery.

Since Leuckart confirmed the frequent presence of *B. coli* in the rectum of pigs, and corresponding observations were made in other countries, the pig is universally considered to be the means of the transmission of Balantidium to man. The encysted stages only serve for transmission, because, according to all observations, the free parasites have a very small power of resistance. They perish when the fæces have become cool; they cannot live in ordinary, slimy, or salt water. As they are killed by acids even when much diluted, they cannot pass through the normal stomach alive except under the most unusual circumstances. The pigs, in whose intestines the Balantidium appears to cause little or no disturbance, evacuate numerous encysted Balantidia with the fæces, and their occasional transference to man brings about their colonization there, but perhaps only when a disease of the colon already exists.

Experimental transmission of the free parasites to animals (per os or per anum) yielded negative results, even in the case of pigs. Casagrandi and Barbagallo (1896), however, had positive, as well as negative, results. They employed healthy young cats, or cats in which catarrhal entero-colitis had been artificially induced (which in other experiments is apt to cause the death of the animals experimented upon in about six or seven days), or finally cats that had dilatation of the rectum with alkaline reaction of the fæces. An attempt to infect three healthy cats by injecting human fæces containing Balantidium into the rectum proved negative, in so far as the fæces of the experimental animals had an acid reaction and contained no Balantidia, but at the autopsy performed eight days after infection a few encysted parasites were found in the mucus of the ileum. In the case of four cats

[1] *Philip. Jl. Sc.*, Sec. B, viii, p. 333.

suffering from entero-colitis, into which human fæces containing Balantidia were introduced per os, Balantidium cysts were found in the fæces three days after the last ingestion. Great numbers, moreover, were found in the cæcum and the posterior part of the small intestine at the autopsy of the animals, which died about eight days after the commencement of the experiments. Actual colonization, therefore, was not effected in either series of experiments. Free or encysted Balantidia of pigs were used for further experiments. The experiments proved negative when fæces containing cysts were injected into the rectum of healthy cats (three experiments), or cats (two) suffering from spontaneous intestinal catarrh, or when such material was introduced per os into three healthy cats. In the case of two cats with intestinal catarrh artificially produced, a small number of the active Balantidia injected into the rectum remained alive. Larger quantities of fæces containing encysted Balantidia were introduced into two other cats affected with the same complaint. These, certainly, did not appear in the fæces, but small numbers, free and alive, were found in the cæcum. Similarly, encysted Balantidia were introduced into two cats with dilated rectum, and whose fæces had an alkaline reaction. In these cases no parasites appeared in the fæces, but three and five days later, when the two animals were examined, a very small number were discovered free in the large intestine. Klimenko did not succeed in infection experiments with *B. coli* on young dogs, whose intestines had been artificially affected by disease.

More recent experiments by Brumpt have shown that young sucking pigs can be infected with Balantidium from infected monkeys (*Macacus cynomolgus*) and suffer heavily from the same, whereas the Balantidium of the pig is rarely harmful to its host. This and previous experiments may be thought to suggest that there are perhaps several pathogenic species, and also that harmless strains of Balantidium may occur. At the same time, it must be remembered that a large proportion of the cases recorded of Balantidian colitis occur among swineherds and butchers, that is, among people in frequent contact with pigs. Morphologically, there are practically no differences between the Balantidia found in man, monkeys and pigs, and it is probable that one species only, under slightly different environmental conditions, may be responsible for the colitis observed. In any case, efficient prophylactic measures should be taken against balantidiasis in countries where it may occur, by confining the pigs and not allowing them to run in yards and dwellings.

E. L. Walker (1913) has given a good summary of work on balantidiasis. His own researches in the Philippines showed that monkeys could be infected by Balantidia both from pigs and men. Parasites may appear in the stools only at infrequent intervals. He believes that the ciliates are the primary etiologic factor in the symptoms and lesions of balantidian dysentery.

Behrenroth (1913) has given an interesting account of *Balantidium coli* and its pathogenic significance.

Balantidium minutum, Schaudinn, 1899.

The body is of oval form, with the anterior extremity pointed, and posterior extremity broad and rounded (fig. 115). The length is 20 μ to 32 μ, and the breadth is 14 μ to 20 μ. The peristome, which is fissure-like, extends to the centre of the body (fig. 115). The right lateral border of the peristome is beset with cilia the same length as those of the body, the left side terminates in a thin hyaline membrane that extends towards the back, and can pass over to the right side. A row of longer and stronger cilia (cirri) are on the left border of the peristome. The cuticle is refractile, the ectoplasm hyaline and the endoplasm granular, with numerous food vacuoles.

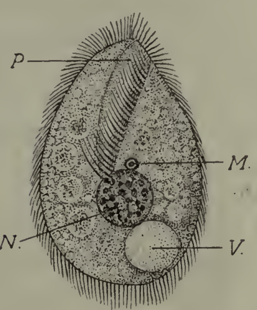


FIG. 115.—*Balantidium minutum.* *P*, peristome; *N*, nucleus; *M*, micronucleus; *V*, contractile vacuole. Food vacuoles are represented in the endoplasm. (After Schaudinn.)

A single contractile vacuole lies dorsally and to one side at the posterior extremity. The macronucleus, which is always spherical, is central and is 6 μ to 7 μ in diameter. The micronucleus, close in front of it, only measures 1 μ (fig. 115). The cysts are oval.

These parasites were found in numbers in the evacuations of a man aged 30, who was born in Germany and had repeatedly travelled between Hamburg and North America, where he made long stays. The patient came to the Charité in Berlin to seek advice for constipation alternating with diarrhœa accompanied by abdominal pain.

A second case (the parasite of which was described as *Colpoda cucullus* by Schulz) was observed in a patient in the same institution.

As, in both cases, the parasites only appeared during the diarrhœa, and disappeared as soon as the fæces had assumed a normal consistency, or could only be demonstrated in a few encysted specimens, it may be assumed that the small intestine or the duodenum is their habitat.

Genus. Nyctotherus, Leidy, 1849.

Flat, heterotrichous Infusoria, kidney- or bean-shaped. The peristome commences at the anterior pole of the body and extends along the concave side to the middle, where the oral aperture is situated. The cytopharynx is oblique and is more or less curved. The cytopyge is at the posterior extremity, where a single contractile vacuole is also situated. The macronucleus is almost in the centre of the parasite. The members of this genus live parasitically in the intestine of amphibia, insects and myriapods, and at least one species is found in man.

Nyctotherus faba, Schaudinn, 1899.

The body is bean-shaped, and a little flattened dorso-ventrally. It is 26 μ to 28 μ long, 16 μ to 18 μ broad, and 10 μ to 12 μ thick (fig. 116). The peristome is on the right border and extends to the middle; at the left there are large adoral cilia, the cilia on the right border not being larger than those on the body. The cytopharynx is short, slightly curved and turned backwards. The contractile vacuole is large, spherical, situated at the posterior extremity, and its contents are voided through the anus at its left. The macronucleus is in the centre of the body; it is globular (6 μ to 7 μ in size), and contains four or five chromatin masses. The micronucleus lies close to it, and is spherical or somewhat elongate measuring 1 μ to 1·5 μ (fig. 116). The cysts are oval.

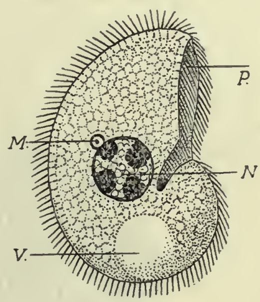


FIG. 116.—*Nyctotherus faba.* *P*, peristome; *N*, nucleus; *M*, micronucleus; *V*, contractile vacuole. (After Schaudinn.)

This species has hitherto only been seen once in the same patient in whom *Balantidium minutum* was discovered.

Nyctotherus giganteus, P. Krause, 1906.

Under the name *Balantidium giganteum* n. sp., P. Krause described an Infusorian which was repeatedly observed with *Trichomonas intestinalis* in the alkaline evacuations of a typhoid patient in Breslau. The body is ovoid, narrower and rounded anteriorly and broader and stunted posteriorly. The peristome lies to one side; the macronucleus is bean-shaped, the micronucleus small and globular; one or two vacuoles are present. The anus is at the farther end. The organism is 90 μ to 400 μ long, 60 μ to 150 μ broad (fig. 117). After a prolonged stay outside the body, it becomes rounded and encystment occurs. In the thermostat the Infusoria remain alive at 37° C. for five weeks.

The species, however, hardly belongs to *Balantidium*, but to all appearances is a *Nyctotherus* and is distinguished from *N. faba* by the difference in size.

[Nyctotherus] africanus, Castellani, 1905.

In the fæces of a native of Uganda who suffered from sleeping sickness and diarrhœa and had in his intestine *Ascaris lumbricoides*, *Trichocephalus trichiurus* and *Ancylostoma duodenale*, Castellani found a curiously shaped Infusorian, 40 μ to 50 μ long, and 35 μ to 40 μ broad, with spherical macro- and micronucleus and a contractile vacuole (fig. 118). He included the organism in the genus *Nyctotherus*, perhaps wrongly, or the parasite may have been deformed. After the patient's death the same parasite was found in the intestine and especially in the cæcum.

FIG. 117.—*Nyctotherus giganteus*. (After Krause.)

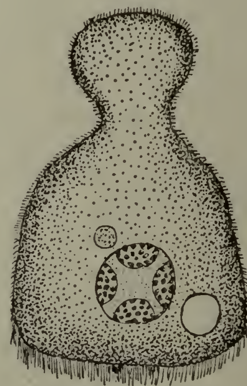


FIG. 118.—*Nyctotherus africanus*. (After Castellani.)

G. Lindner, in Cassel, studied certain peritrichal Infusoria (stalkless Vorticella), and connected them, probably incorrectly, with the most varied diseases of man and domestic animals, even with Sarcosporidia of pigs. It may be mentioned that according to a communication by letter from Schaudinn, Vorticella may be found in freshly evacuated fæces, but always only after the administration of a water enema. In spite of this, several other investigators mention Vorticellæ as intestinal parasites of man.

The *Chilodon dentatus* (Ehrenberg) recorded in 1903 by J. Guiart as a parasite of man, which may be found in all infusions, can hardly have lived in the man from whose fæces it was cultivated, but may represent a chance admixture both in the fæces and the cultivations. *C. uncinatus* was also found as a chance parasite of man by Manson and Sambon. According to Doflein[1] (1911) certain Chilodon-like organisms have been found by Selenew in prostate secretions in gonorrhœa. Other species of the genus *Chilodon* are known, but only as ectoparasites (*e.g.*, *Chilodon cyprini*, Moroff, 1902, from the skin and gills of diseased carp).

A number of other parasitic Ciliates are known, among which *Ichthyophthirius multifiliis*, destructive to fish, is important. It lives in the skin and the layers immediately below it, forming small whitish pustules which may become confluent.

[1] *Lehrbuch der Protozoenkunde*, 3rd ed., p. 963.

The pustules are most common on the head and fins, but occur also on the eyes and gills of the host. The young parasite, which is one of many formed in a cyst, is very small. At first it is free swimming, but soon attaches itself to the skin of a fish. It bores inwards and becomes surrounded by the irritated skin. There it attains a relatively large size, being 500 μ to 750 μ and occasionally more in diameter. The body has a rounded terminal mouth, short cytopharynx and a number of minute contractile vacuoles. The macronucleus is large and horseshoe-shaped ; the small micronucleus is only seen in the very young animal. When full grown, the organism encysts and forces its way to the surface and bursts through, leaving a small, gaping wound behind. The cyst sinks to the bottom of the water, nuclear multiplication occurs and a number of young parasites are produced, which leave the cyst and either attack new hosts or else perish.

Opalina ranarum, parasitic in the rectum and urinary bladder of frogs and toads, shows great degradation and simplification due to parasitism, possessing no separate micronuclei, no cytostome, cytopharynx or cytopyge. It has many macronuclei, and is a large parasite. During summer and autumn nuclear multiplication followed by division of the body occurs, the process being repeated after the daughter forms have grown to the size of their parent. In spring, the Opalina divide rapidly, but do not grow much before dividing again. Finally, tiny forms, containing three to six nuclei, encyst and pass from the host with the fæces. As these latter are greedily devoured by tadpoles, the *Opalina* gain new hosts in which they develop.

THE CHLAMYDOZOA.

The name Chlamydozoa was proposed by Prowazek in 1907 for a number of minute, problematic organisms (fig. 119) believed to be the causal agents of certain diseases in man and animals, such as vaccinia and variola, trachoma, inclusion blenorrhœa in infants, molluscum contagiosum, and bird epithelioma contagiosum. Other diseases possibly due to Chlamydozoa [1] are hydrophobia, measles, scarlet fever, foot-and-mouth disease, the "Gelbsucht" disease of silk-worms, and perhaps even typhus (Prowazek, 1913). The subject is difficult and controversial and can only be briefly discussed here. It is known that the viruses in all these diseases can pass through ordinary bacterial filters, that is, they belong to the group of "filterable viruses." At such periods the organisms are extracellular or free. It is also known that in many of these cases the virus produces definite and characteristic reaction-products or cell-inclusions in the infected cells, during the intracellular phase of the life-history of the organism. As the organisms to be considered are problematic, it will be convenient to summarize their history :—

(1) Cell-inclusions, usually named after their discoverers, have been found in certain diseases, thus : In vaccinia Guarnieri's bodies,

[1] For a detailed account of the Chlamydozoa see Prowazek's *Handbuch der Pathogenen Protozoen*, Bd. i (1911-12). Leipzig, J. A. Barth.

in scarlet fever Mallory's bodies, in hydrophobia Negri's bodies, in trachoma Prowazek's bodies occur.

(2) At first these characteristic cell-inclusions were considered to be actual parasitic organisms causing the diseases in question. The bodies received zoological names and attempts were made to work out their supposed development cycles. The supposed parasites of vaccinia and variola were referred to a so-called genus *Cytoryctes*, those of hydrophobia to *Neuroryctes*, of scarlet fever to *Cyclasterium*, while those of molluscum contagiosum were referred to the Coccidia. Calkins in 1904 studied in detail the cell-inclusions of vaccinia and small-pox, calling them *Cytoryctes variolæ*, Guarnieri. Calkins considered that in the stratified cells of the epidermis they passed through two cycles, the one cytoplasmic, the other intranuclear. The first is the vaccinia cycle, the second the pathogenic (intranuclear) variola cycle. It is hardly necessary to follow all Calkins' stages here.

Negri (1909) described a cycle for *Neuroryctes hydrophobiæ*. Calkins refers both *Cytoryctes variolæ* and *Neuroryctes hydrophobiæ* to the Rhizopoda.

Siegel (1905) described quite different organisms under the name *Cytorhyctes*. He listed several species : *C. vacciniæ* of vaccinia and small-pox, *C. scarlatinæ* of scarlet fever, *C. luis* of syphilis (this is probably the granule stage of *Treponema pallidum*), and *C. aphtharum* of foot-and-mouth disease.

(3) The afore-mentioned views were criticized, and the bodies were not considered to be living organisms but merely reaction products or cell-inclusions due to the effects of the virus on the host cells. Thus Guarnieri's bodies were stated to consist of extruded nucleolar or plastin material, having no developmental cycle. It was further asserted that infection could be produced by lymph in which Guarnieri's bodies had been destroyed. Similar assertions have been made regarding the Negri bodies, and others. The *Cytoryctes*, *Neuroryctes*, etc., are considered, according to these views, to be degeneration products of the nucleus or to be of a mucoid nature.

(4) More recently a positive belief has gained ground that there are true parasitic organisms causing these diseases, and that the parasites are very minute, being termed Chlamydozoa by Prowazek and Strongyloplasmata by Lipschütz.

The Chlamydozoa are characterized by (*a*) their very minute size, smaller than any bacteria, so that they can pass through bacterial filters ; (*b*) they pass through intracellular stages, in the cytoplasm or the nucleus of the host cell, producing therein the reaction products or inclusions in the cell already recorded as characteristic or diagnostic of the diseases produced ; (*c*) they pass through definite developmental cycles. Such a cycle consists essentially of growth and division. The mode of division of the Chlamydozoa resembles that of the centriole of a cell, by the formation of a dumb-bell-shaped figure. Two dots are observed connected by a fine line or strand which becomes drawn out and finally snaps across the middle. Prowazek and Aragão (1909) working on smallpox in Rio de Janeiro found that the chlamydozoal granules passed through a Berkefeld filter and that the filtrate was virulent. But if an "ultra-filter" were used, *i.e.*, one coated with agar, then the granules were retained and the filtrate was no longer virulent. The surface of the ultra-filter was found to contain many granules.

The Chlamydozoa are parasites of epiblastic tissues (*e.g.*, epidermal cells, nerve cells, conjunctival cells).

The life-history of a Chlamydozoön (fig. 119), such as that of

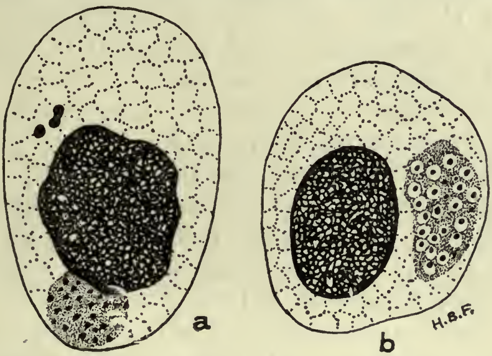


FIG. 119.—Chlamydozoa. Trachoma bodies in infected epithelial cells of the conjunctiva. (*a*) initial bodies (above) and cluster of elementary bodies (touching the nucleus); (*b*) cluster of granules surrounded by mantles. × 2,000 approx. (Original. From preparation by Fantham.)

vaccinia, is, according to Prowazek, Hartmann and their school, as follows:—

1. The infection begins with *elementary bodies* or *elementary corpuscles* which live at first extracellularly. An elementary body is a minute speck of chromatin, apparently devoid of cytoplasm, which can pass through a bacterial filter. It can enter a host cell, but the entry is not a process of phagocytosis.

2. Inside the host cell the elementary body grows in size, and becomes an *initial body* (fig. 119, *a*).

3. A reaction on the part of the host cell results, for nucleolar, plastin substance is extruded from the cell-nucleus and surrounds the parasitic initial body. The latter is thus enveloped in a mantle (hence the name Chlamydozoa, from χλαμύς, a mantle), and the characteristic cell-inclusion (Guarnieri's body, Negri's body, etc.) is produced. The nucleolar, mantle substance probably represents the "cytoplasm" of *Cytoryctes*, described by Calkins.

4. The body next breaks up into a number of smaller bodies known as *initial corpuscles.* These, in their turn, divide by simple division (in the manner already described) into numerous elementary bodies (fig. 119). Thus, the life-cycle is completed.

The Chlamydozoa are, then, the minute granules inside the body of the *Cytoryctes variolæ* or the *Neuroryctes hydrophobiæ*, so that the whole body of the *Cytoryctes* or *Neuroryctes* corresponds to the mantle and parasite of the Chlamydozoön. The Cytoryctes group is said to cause destruction of the host cell. The Cytoöikon group (*e.g.*, trachoma bodies) causes proliferation of the host cell.

In September, 1913, Noguchi[1] described the cultivation of the parasite of rabies in an artificial medium, similar to that used by him for the cultivation of *Spirochæta recurrentis.* The cultures were stated to be infective to dogs, rabbits and guinea-pigs. Levaditi, in December, 1913, stated that he had succeeded in cultivating spinal ganglia of rabid monkeys in monkey plasma.

Noguchi and Cohen (November, 1913)[2] have succeeded in cultivating the so-called trachoma bodies, or at any rate bodies very closely resembling them morphologically. The medium employed was Noguchi's ascitic fluid and rabbit kidney medium, as used for spirochætes. The coarser cultural forms stained blue with Giemsa's solution, the finer ones stained red. Attempts to infect monkeys from the culture tubes failed.

From their behaviour on treatment with such reagents as saponin, bile and sodium taurocholate, Prowazek considers that the Chlamydozoa approach the Protozoa.

PROTOZOA INCERTÆ SEDIS.

Sergentella hominis, Brumpt, 1910.

Et. and Ed. Sergent in 1908 found vermiform bodies about 40 μ long by 1 μ to 1·5 μ broad in the blood of an Algerian suffering from nausea and cold sweats, without other symptoms. The bodies were pointed at each end, with a somewhat ill-defined nucleus in the middle. Their systematic position is doubtful.

---

[1] *Journ. Exptl. Med.*, xviii, p. 314.
[2] *Idem*, p. 572.

B. PLATYHELMINTHES, or Flat Worms.

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

DEFINITION: Bilaterally symmetrical animals without limbs, the form of which is leaf or tape-like, rarely cylindrical, and whose primary body cavity (segmentation cavity) is absent, the cavity being filled by a mesenchymatous tissue (parenchyma).

The mouth is either situated at the anterior end of the body, or is shifted more or less backwards on to the flat ventral surface. The alimentary canal consists of a

NOTE.—An Appendix on Protozoology will be found on pp. 733-752. This has been prepared in order to incorporate a number of new additions to knowledge made since the body of the book was printed off.

To Binder: face p. 210.

the capillary processes of which go on uniting into larger branches, and finally form two large collecting vessels, which, sometimes separately and sometimes united, open to the exterior through one, two, or numerous pores.

Nearly all the Platyhelminthes are HERMAPHRODITIC, and in nearly all there are, in addition to the ovaries producing ova, other glands attached to the female genital apparatus, namely, the vitellaria or yolk glands, which provide a substance termed yolk, which serves as nourishment for the embryo. The fully formed eggs have shells and are "compound," *i.e.*, composed of the egg or ovarian cell, which is surrounded by numerous yolk cells or their products of disintegration. The two sexual openings usually lie close together, frequently in the fundus of a genital atrium; they are rarely separated from one another. Shell glands also usually occur (p. 221).

Reproduction is sexual, often, however, combined with asexual methods of propagation (segmentation, budding). The Platyhelminthes live partly free in fresh or salt water, exceptionally also on land. The greater part, however, live as parasites on or in animals.

4. The body next breaks up into a number of smaller bodies known as *initial corpuscles.* These, in their turn, divide by simple division (in the manner already described) into numerous elementary bodies (fig. 119). Thus, the life-cycle is completed.

The Chlamydozoa are, then, the minute granules inside the body of the *Cytoryctes variolæ* or the *Neuroryctes hydrophobiæ*, so that the whole body of the *Cytoryctes* or *Neuroryctes* corresponds to the mantle and parasite of the Chlamydozoön. The Cytoryctes group is said to cause destruction of the host cell. The Cytoöikon group (*e.g.*, trachoma bodies) causes proliferation of the host cell.

In September, 1913, Noguchi [1] described the cultivation of the parasite of rabies in an artificial medium, similar to that used by him for the cultivation of *Spirochæta recurrentis.* The cultures were stated to be infective to dogs, rabbits and guinea-pigs. Levaditi, in

PROTOZOA INCERTÆ SEDIS.

Sergentella hominis, Brumpt, 1910.

Et. and Ed. Sergent in 1908 found vermiform bodies about 40 μ long by 1 μ to 1·5 μ broad in the blood of an Algerian suffering from nausea and cold sweats, without other symptoms. The bodies were pointed at each end, with a somewhat ill-defined nucleus in the middle. Their systematic position is doubtful.

[1] *Journ. Exptl. Med.*, xviii, p. 314.
[2] *Idem*, p. 572.

B. PLATYHELMINTHES, or Flat Worms.

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

DEFINITION: Bilaterally symmetrical animals without limbs, the form of which is leaf or tape-like, rarely cylindrical, and whose primary body cavity (segmentation cavity) is absent, the cavity being filled by a mesenchymatous tissue (parenchyma).

The mouth is either situated at the anterior end of the body, or is shifted more or less backwards on to the flat ventral surface. The alimentary canal consists of a short fore-gut, which is frequently provided with a muscular pharynx, and of a simple forked or branched mid-gut; there is neither a hind-gut nor an anus; in one class, the Cestodes, the alimentary canal has entirely disappeared except for muscular remnants in the scolex.

The INTEGUMENT OF THE BODY consists either of a ciliated epithelium of only one layer (Turbellaria), or of a cuticle and gland-like cells embedded in the parenchyma, or subcuticular layer (Cestodes, Trematodes). The dermo-muscular layer consists of annular, longitudinal, and even diagonal fibres, while the parenchyma is traversed by dorso-ventral fibres.

The central NERVOUS SYSTEM, which is embedded in the parenchyma of the body, consists of cerebral ganglia, united together in the shape of dumb-bells, and of two or more longitudinal MEDULLARY FASCICLES, often forming transverse anastomoses. Organs of sense usually occur only in the free-living species, more rarely during the free-living stages of a few parasitic species and in a few ecto-parasitic forms.

[In Platyhelminthes simple eye-spots frequently occur, and in a few an auditory vesicle.]

BLOOD-VESSELS and definite RESPIRATORY ORGANS are lacking [except in *Nemertinea*]; the EXCRETORY APPARATUS (formerly termed water-vascular system) is typical of the entire class. It commences in the interstices of the parenchyma, with peculiar terminal cells (ciliated funnels), which will be described later (p. 219), the capillary processes of which go on uniting into larger branches, and finally form two large collecting vessels, which, sometimes separately and sometimes united, open to the exterior through one, two, or numerous pores.

Nearly all the Platyhelminthes are HERMAPHRODITIC, and in nearly all there are, in addition to the ovaries producing ova, other glands attached to the female genital apparatus, namely, the vitellaria or yolk glands, which provide a substance termed yolk, which serves as nourishment for the embryo. The fully formed eggs have shells and are "compound," *i.e.*, composed of the egg or ovarian cell, which is surrounded by numerous yolk cells or their products of disintegration. The two sexual openings usually lie close together, frequently in the fundus of a genital atrium; they are rarely separated from one another. Shell glands also usually occur (p. 221).

Reproduction is sexual, often, however, combined with asexual methods of propagation (segmentation, budding). The Platyhelminthes live partly free in fresh or salt water, exceptionally also on land. The greater part, however, live as parasites on or in animals.

Classification of the Platyhelminthes.

Class I.—**Turbellaria** (or Eddy Worms). Flat worms for the most part, free living, and always covered with a ciliated epithelium.

Order 1.—*Rhabdocœlida*, gut unbranched.

Order 2.—*Tricladida*, gut with three main branches.

Order 3.—*Polycladida*, a central gut with lateral cæca. Development direct or through metamorphosis. They live in fresh and salt water or on land; very seldom as parasites.

Class II.—**Trematoda** (Sucking Worms[1]). [Usually known as Flukes.—F. V. T.] Flat worms, living as ecto- or endoparasites, that are only ciliated in the larval condition, and in their adult state are covered with a cuticle, the matrix cells of which lie in the parenchyma. They have either one, a few, or several suckers,[2] and frequently also possess chitinous fixation and adhesive organs. The intestine is single, but generally bifurcated, and not uncommonly there are transverse anastomoses between the forks or diverticula on them. Excretory organs double, with two orifices at the anterior extremity or a single one at the posterior end. Development takes place by a metamorphosis or alternation of generations (p. 283). These worms are almost always hermaphroditic, with two or more female and one male sexual orifice. They live, almost without exception, as parasites on vertebrate animals, but the intermediate generations are passed in molluscs.

Class III.—**Cestoda** (Tapeworms). Endoparasitic flat worms without an alimentary canal. The larval stages are rarely ciliated, but are usually provided with six spines; the adult worm is covered with a cuticle, the matrix cells of which are embedded in the parenchyma. The body consists of a single segment (Cestodaria) or a chain of segments, in which case it consists of the scolex and the segments containing the sexual organs (proglottides) (Cestodes s. str.). The scolex is provided with various adhesive and fixation organs, and there are calcareous corpuscles in the parenchyma. Excretory organs symmetrical, opening at the posterior end. These worms are always hermaphroditic, and then possess one or two female and one male sexual orifice. During development a larval intermediate stage ("measle") occurs and almost always in a different host to that in which the adult sexual worm lives. The adult stage is parasitic in vertebrate animals, but the larval stage may occur in invertebrates.

Class II. **TREMATODA**, Rud.

These worms are usually leaf- or tongue-shaped, but also barrel-shaped or conical; they vary from 0·1 mm. to almost 1 m.[3] in length; most of them, however, are small (5 mm. to 15 mm.). The surface on which the orifice of the uterus and the male sexual opening are situated is termed the ventral surface; the oral aperture, which also acts as anus, is always at the anterior end in the sub-order *Prostomata* (p. 230), but in the sub-order *Gasterostomata* it is ventral.

---

[1] This grouping goes back to the year 1800, and was made by J. G. H. Zeder, a physician and helminthologist of Forchheim, who divided the helminths, which until 1851 were generally regarded as a special class of animals, into the groups of round, hook, sucker, tape and bladder worms, as which they are recognized up to the present time. In 1809, K. A. Rudolphi gave them the names *Nematodes*, *Acanthocephali*, *Trematodes*, *Cestodes* and *Cystici*.

[2] A sucker or acetabulum (little cup) is a round, cup-shaped muscular organ, the muscles of which are *sharply defined* from those of the body.

[3] *Nematobothrium filarina*, van Bened., on the branchial chamber of the Tunny.

Suckers are always present and occur in varying numbers and positions at the anterior extremities as well as on the ventral surface, and occasionally on the lateral margin and on the dorsum; the beginning of the intestine (mouth) is always surrounded by a sucker in the *Prostomata*.

In or near the suckers there may be chitinous hooks, claws or claspers, or the surface of the body is more or less covered with spines, scales or prickles; in one genus (*Rhopalias*) there are projectile tentacles beset with spines on the sides of the anterior part of the body.

The body of adult Trematodes is covered by a homogeneous layer of varying thickness, which either lies directly over the external layer (basement membrane) of the parenchyma, or over the muscles embedded in the parenchyma. This investing membrane (cuticle) arises from pear-shaped or spindle-shaped cells arranged singly or in groups (which lie between or internal to the diagonal muscles), and is connected with them by processes; these cells one may regard as epithelial cells which have sunk down, or possibly as parenchymatous cells. An epithelium of one layer is also found on the body of young stages, but it disappears during growth, and only occasionally do its nuclei persist until adult life. In its place we then find the cuticle, which, moreover, extends into all the body openings more or less deeply.

It is thus a debatable point whether the "investing layer" of flukes is a cuticle—that is, consists of modified epithelial cells—or whether it is a basement membrane, *i.e.*, compressed and modified connective tissue cells; in this latter case the true epidermis and cuticle have been cast off. In the former case the epidermal cells are the pear-shaped cells referred to above. According to recent authors it consists of two parts, an outer true cuticle and an inner basement membrane. There are also unicellular cuticular glands, lying isolated or in groups, which are termed cephalic, abdominal, or dorsal glands according to the position of their orifice.

The PARENCHYMA is a connective substance, the structure of which is still a matter of dispute. It consists, according to some authors, of multipolar cells, the offshoots from which anastomose with each other so that a network, permeating the entire body and encompassing all the organs, is produced. There exists also, as part of it, a homogeneous matrix, in the form of lamellæ and trabeculæ that border small cavities communicating with each other and filled with fluid. According to other authors, the parenchyma of the Trematodes consisted originally of cells, of which, however, only the cell membranes remain, while the protoplasm has been liquefied except for small residua around the nucleus. Between these cells an intercellular mass has appeared. By partial absorption of the walls, adjoining spaces unite, and the originally flat cell walls become transformed into trabeculæ. According to this view the cavities filled with fluid are *intra*-cellular, according to the former view *inter*-cellular. Pigment cells occur only in a few species.

The MUSCULAR SYSTEM of the Trematodes is composed of (1) a dermo-muscular tube, (2) the dorso-ventral or parenchymal muscles, (3) the suckers, and (4) the special muscles of certain organs.

The dermo-muscular tube, which lies fairly close to the cuticle, consists of annular, diagonal, and longitudinal fibres which surround the entire body in one or several layers, and as a rule are more strongly developed on the ventral surface as well as in the anterior part of the body. The MUSCLES OF THE PARENCHYMA are found chiefly in the

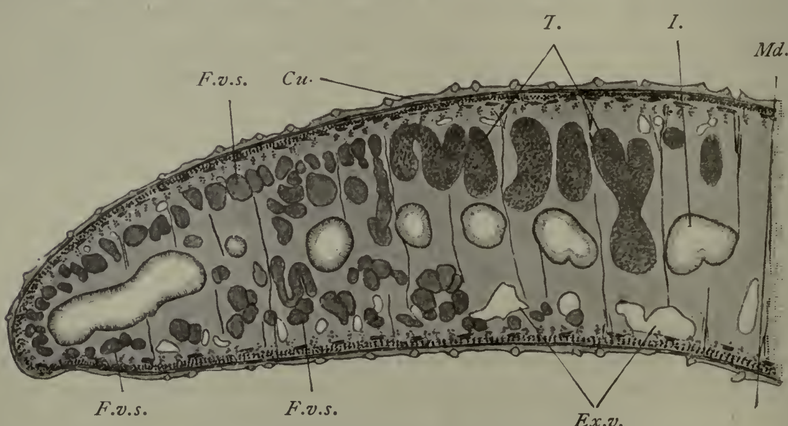


FIG. 120.—Half of a transverse section through *Fasciola hepatica*, L. 25/1. *Cu.*, Cuticle with scales; under the cuticle are circular muscles, and adjoining them the longitudinal and diagonal muscles; internal to the latter are the matrix cells of the cuticle; *I.*, gut; the other similarly contoured cavities are gut diverticula that have been transversely or obliquely sectioned; *F.v.s.*, vitellaria; *Ex.v.*, excretory vessels; *T.*, testes; *Md.*, median plane; the fibres passing from the ventral to the dorsal surface are the muscles of the parenchyma. The parenchyma itself is omitted.

lateral parts of the body and pass through the parenchyma in a dorso-ventral direction; their diverging brush-like ends are inserted on the inner surface of the cuticle (fig. 120).

The suckers are specially differentiated parts of the dermo-muscular tube. Their concave inner surface is lined by the continuation of the cuticle and their convex external surface is covered by a more dense tissue that frequently takes the form of a refractive membrane, thus separating them from the parenchymal muscles.

The principal mass of the suckers consists of muscular fibres which run in three directions — equatorial, meridional and radial. The equatorial fibres correspond to the annular muscles, the meridional fibres to the longitudinal muscles, and the radial fibres to the muscles of the parenchyma; the radial fibres are always the most strongly developed. The function of these muscles is evident from their position ; the meridional fibres flatten the suctorial disc and diminish the depth of its cavity, so that the internal surface may adhere to the object to be held ; if the equatorial fibres now contract, the sucker rises by elongating longitudinally, and its inner surface is drawn in by the contraction of the radial muscles. Thus the sucking disc becomes adherent. Usually also there is a sphincter

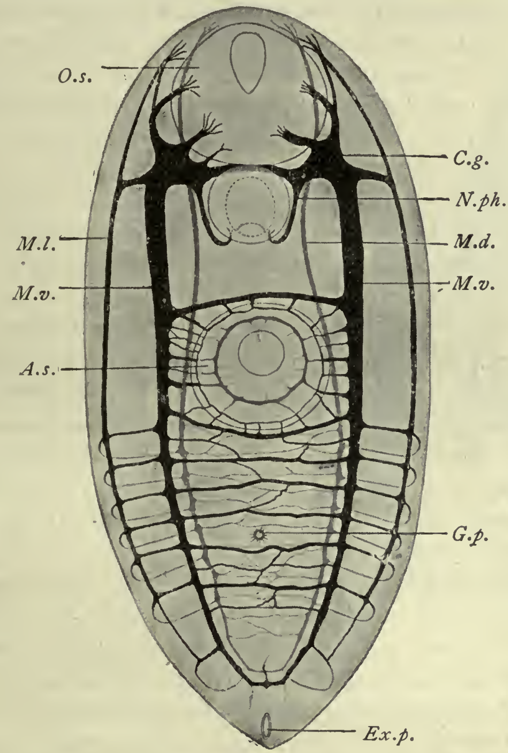


FIG. 121.—*Harmostomum leptostomum*, Olss., an immature specimen from *Helix hortensis*. *Nervous system*, according to Bettendorf. *A.s.*, ventral sucker; *C.g.*, cerebral ganglion; *Ex.p.*, excretory pore; *G.p.*, genital pore; *O.s.*, oral sucker; *M.d.*, dorsal medullary nerve; *M.l.*, lateral medullary nerve; *N.ph.*, pharyngeal nerve; *M.v.*, ventral medullary nerve. Magnified.

at the border of the suckers, which plays its part during the act of adhesion by constricting in a circular manner that part of the mucous membrane to which it is attached. The loosening of the fixed sucker is effected by relaxation chiefly of the radial fibres, by the contraction of the meridional fibres and certain bundles of muscles situated at the base and at the periphery of the suckers. The connective and elastic tissues between the muscles of the suckers probably also take part in the process.

Of the muscles of the organs which have developed from the parenchyma muscles we may briefly mention those bundles that are attached to certain parts of the genital apparatus, to the suckers, to the hooks and claws, and also, at all events in *Fasciola hepatica*, to the spines. The sheaths used for the projection of the tentacles of the *Rhopaliadæ* are also muscular.

The contractile elements consist of fibres of various lengths that are mostly parallel to one another, and frequently anastomose; a cortical substance finely fibrillated can usually be distinguished from an internal homogeneous mass; large nucleated cells of uniform size are always connected with them; these have been variously interpreted, but have been proved to be myoblasts, one or more of their processes constituting the muscular fibres.

The MOVEMENTS of the Trematodes consist in alterations of form and position of the body, as well as in creeping movements.

In the NERVOUS SYSTEM (fig. 121) can be distinguished a cerebral portion as well as strands (medullary strands) running from it, and peripheral nerves. The cerebral portion always consists of two large ganglia situated in the anterior end of the body which pass dorsally over the œsophagus and are connected by means of a broad and thick commissure composed of fibres only. From each ganglion three nerves run anteriorly—the inner and dorsal nerve for supplying the anterior dorsal part of the body; the median and ventral for the oral sucker; and the exterior and lateral likewise for the supply of the sucker.

In a similar manner three strands run backwards from each ganglion—one dorsal, one lateral and one ventral. The dorsal and ventral strands become united and curve backwards; the symmetrical lateral strands are connected by means of transverse commissures, the number of which vary according to the species. Such commissures also exist between the lateral and the two other strands on each side. There are ganglion cells along the entire course of the posterior cords, more particularly at the points of origin of the commissures. There also appears to be in addition a fourth anterior and posterior pair of nerves, the front pair for the oral sucker and the hind pair for the pharynx.

The peripheral nerves, which spring from the posterior strands as well as from the commissures, either pass directly to the muscular fibres or to the sensory cells that are situated at the level of the subcuticular cells, or they reach these after the formation of a plexus situated immediately beneath the dermo-muscular layer; the processes directed outwards terminate in small vesicles in the cuticle.

As to other ORGANS OF SENSE, simple eyes, two or four in number, are known in several ectoparasitic species as well as in a few free-living larval stages (Cercariæ) of endoparasitic forms. In the adult stage, however, they usually undergo complete atrophy.

The ALIMENTARY CANAL commences with an oral aperture, generally terminal or sub-terminal (ventral) at the anterior extremity, which leads into an oral cavity usually surrounded by a sucker; the œsophagus, of various lengths, is directed backwards and is generally surrounded by a muscular pharynx (fig. 122). In some cases there exists between the sucker and pharynx, pharyngeal pouches (præpharynx). Sooner or later the intestine divides into two lateral branches directed backwards, both of which end blindly (cæca) at the same level.[1] In many ectoparasites (*Monogenea* [p. 222]) a connection exists between the genital glands and one of the intestinal branches (ductus vitello-intestinalis [fig. 123]).

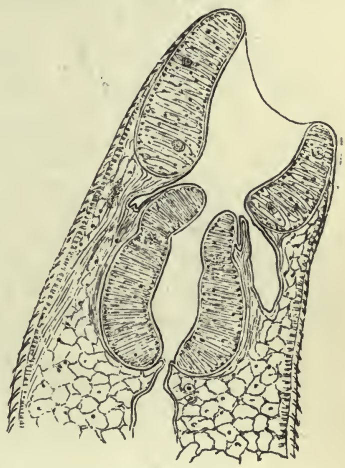


FIG. 122.—Median section through the anterior part of *Fasciola hepatica*: the oral sucker, pharyngeal pouches, pharynx, œsophagus, cuticle with spines, and the body parenchyma.

The oral cavity, pharyngeal pouches, pharynx, and œsophagus are lined with a continuation of the cuticle of the body; the gut cæca are lined with tall cylindrical epithelium (fig. 120). The œsophagus and intestinal branches often have also one layer of annular and longitudinal muscles; the pharynx has essentially the structure of a sucker (fig. 122).

The accessory organs of the alimentary canal consist of groups of unicellular SALIVARY GLANDS that discharge into the œsophagus in front of or behind the pharynx, or even into the pharynx itself.

---

[1] The following conditions represent deviations from this type: (1) In *Gasterostomum* the oral aperture is situated in the middle of the ventral surface, and occasionally is even nearer to the posterior than to the anterior end. There is no proper oral sucker, but the pharynx is thus termed. (2) A few genera, such as *Gasterostomum*, *Aspidogaster*, *Diplozoon*, etc., have only *one* intestinal diverticulum, which is undoubtedly to be taken as representing the primitive condition, as it is also often found in the young stages of the *Trematoda*. (3) The branches of the intestines are curved and united behind (several *Tristomidæ* and *Monostomidæ*), while in *Polystomum integerrimum* (in the bladder of frogs) there are several commissures between the intestinal branches, and in the *Schistosomidæ* the united intestinal branches proceed as one channel towards the posterior end. (4) The termination of the two intestinal branches is not always on a level; they are therefore of different lengths. (5) When the œsophagus is very long the intestinal branches extend both forward and backward, so that the gut exhibits the form of an H. (6) In the broad and flat species the gut-forks form diverticula mostly externally but also internally; these again may branch (fig. 139). (7) In a few cases (*Nematobothrium*, *Didymozoon*) the intestine completely disappears up to the pharynx.

The food of the Trematodes consists of mucus, epithelial cells, the intestinal contents of the hosts, and often also of blood, and this not only in those species living in the vascular system, but also in species

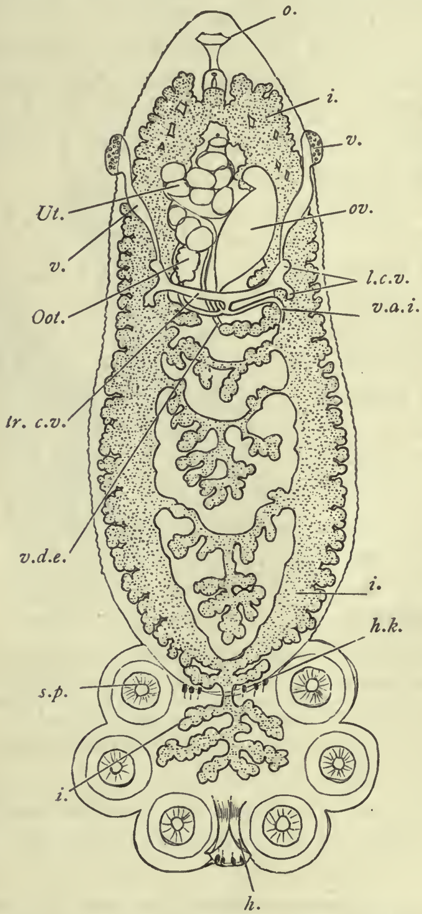


Fig. 123. — *Polystomum integerrimum*, a monogenetic fluke from the urinary bladder of the frog. *i.*, intestine; *h.*, large hooks of the sucking disc; *h.k.*, smaller hooklets; *l.c.v.*, longitudinal vitelline ducts; *o.*, oral orifice; *Oot.*, oötype; *ov.*, ovary; *s.p.*, suckers of the disc; *tr.c.v.*, transverse vitelline ducts; *Ut.*, uterus with ova; *v.*, entrance to the vagina; *v.d.e.*, vas deferens; *v.d.i.*, ductus vitello-intestinalis; the vitellaria and testes are not shown. Magnified. (After Zeller.)

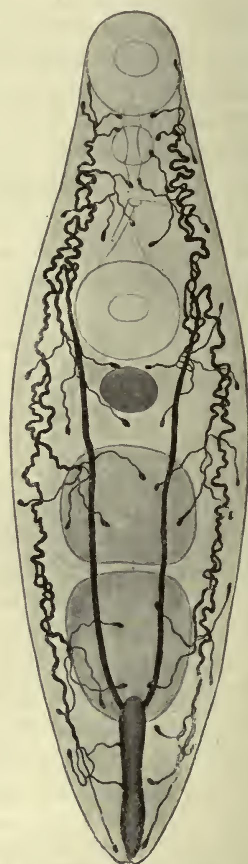


Fig. 124.—*Allocreadium isoporum*, Looss. Excretory apparatus. Of the other organs, the oral sucker, pharynx, genital pore, ventral sucker, ovary and testes are shown; the cylindrical excretory bladder is in the posterior end. 38/1. (After Looss.)

living as ectoparasites or in the intestine or biliary passages of their hosts.

The final products of assimilation dissolved in the fluids of the body are distributed throughout the parenchyma and are thence expelled by a definite tubular system (excretory apparatus, protonephridia, formerly also termed the water-vascular system). This system, which is distributed throughout the entire body (fig. 124), is symmetrically developed, and, in the ectoparasitic Trematodes, it opens, right and left, at the anterior end on the dorsal surface ; in all other flukes, however, it opens singly into the excretory pore (foramen caudale) at the centre of the posterior border; in those cases, however, where a sucker is present at the posterior end, as in the Amphistomata, the excretory pore is situated on the dorsal surface close in front of the sucker.

The EXCRETORY SYSTEM[1] consists of several parts : (1) of the more or less numerous terminal "flame" cells or funnel cells (figs. 124, 125); (2) of the capillaries ending in them ; (3) of larger vessels receiving the capillaries ; and (4) of the excretory bladder. Terminal cells and capillaries may be compared to unicellular glands with long excretory ducts ; the cellular body (fig. 125) is comparatively large, stretched longitudinally, more rarely transversely, and provided with numerous processes, that are lost in the parenchyma ; within is a conical cavity (analogous to the secretory cavity of unicellular glands) which is continued directly into the structureless capillary ; at its blind end is a bunch of cilia projecting into the cavity, and which, during life, shows a flickering motion (ciliary flame). The nucleus is situated in the protoplasm of the terminal cell at its blind end.

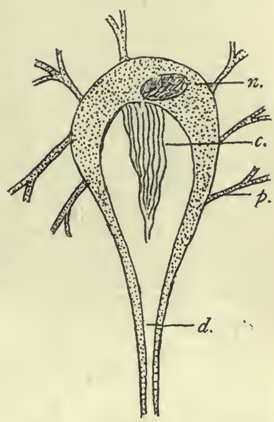


FIG. 125.—Terminal flame cell of the excretory system. *n.*, nucleus of cell ; *c.*, bundle of cilia forming the "flame"; *p.*, processes of cell extending into parenchyma ; *d.*, excretory capillary. (Stephens.)

The entire apparatus thus begins blindly—*i.e.*, within the terminal cells, to which must be ascribed the capacity of taking up from the fluid that permeates the parenchyma the products which are first collected into their own cavities and thence excreted by means of the capillaries and vessels.

The vessels possess definite walls, consisting of a membrane and a nucleated protoplasmic layer. They unite at many points on either side, and again pass into other canals (COLLECTING TUBES), which finally, travelling towards the posterior end, discharge into the excretory bladder (fig. 124).

The form and size of the bladder vary much according to the different species, but it always possesses its own flattened epithelium, surrounded by circular and longitudinal muscles, the circular muscles

[1] The following description relates in the main to the *Distomata*.

forming a sphincter around the opening. Frequently also the structure of the bladder extends to the tubules discharging into it, which therefore are not to be regarded as separate "vessels," but rather as tubular diverticula of the bladder, directed anteriorly. In some few species the diverticula also branch and the branches anastomose, so that a network of tubules ensues which receives the vessels or capillaries. In such cases there are also ciliary tracts in the tubules.

The contents of the entire apparatus usually consist of a clear or sometimes reddish fluid; in some species there are larger or smaller granules, and occasionally also concretions occur.

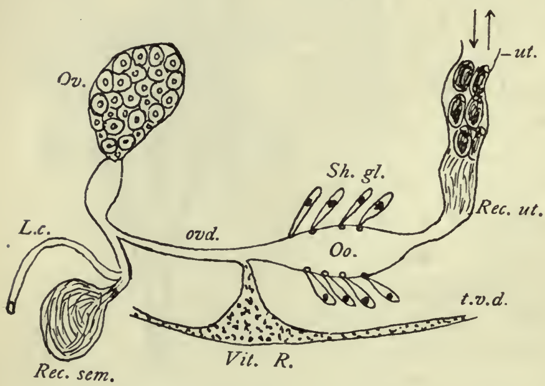


FIG. 126.—Diagram of female genitalia. *Ov.*, ovary; *ovd.*, oviduct; *L.c.*, Laurer's canal; *Rec. sem.*, receptaculum seminis; *Vit. R.*, vitellarian reservoir; *t.v.d.*, transverse vitelline duct; *Oo.*, oötype; *Sh. gl.*, shell gland; *Rec. ut.*, receptaculum uterinum; *ut.*, uterus. (The various parts are not to the same scale.) (Stephens.)

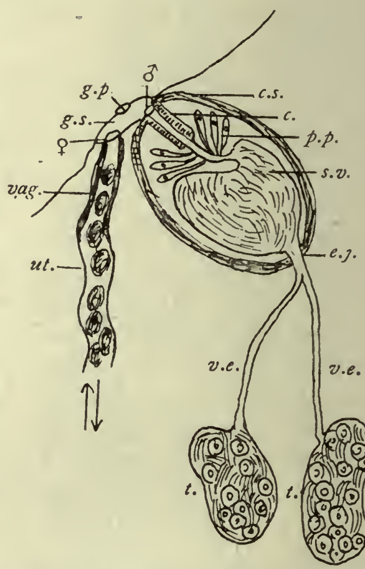


FIG. 127.—Diagram of male and part of female genitalia. *ut.*, uterus; *vag.*, vagina; ♀, opening of vagina; *g.s.*, genital sinus; *g.p.*, genital pore; ♂, opening of ejaculatory duct or vas deferens; *c.s.*, cirrus sac; *c.*, cirrus; *p.p.*, pars prostatica; *s.v.*, seminal vesicle; *e.j.*, ejaculatory duct or vas deferens; *v.e.*, vas efferens; *t.*, testis. (Stephens.)

Sexual Organs.—Nearly all the Trematodes are hermaphrodites, and only a few (*Schistosomidæ, Koellikeria*) are sexually differentiated. The sexual organs usually lie in the "central field" limited by the gut cæca; the vitellaria, on the other hand, are, as a rule, external to the gut cæca in the "lateral fields."

The male apparatus[1] is composed of two variously formed testes (fig. 127) (globular, oval, indented, lobed, or ramified), which may lie side by side or one behind the other; from each testicle a tube (vas efferens) originates; sooner or later, both tubes as a rule unite to form the ejaculatory duct or vas deferens, which is frequently

[1] The following description relates mainly to the *Distomata*.

enclosed in a muscular CIRRUS SAC, or more rarely passes directly into the genital pore. The cirrus, which is the thick muscular terminal portion of the vas deferens, can be everted and protruded from the cirrus sac and serves as an organ of copulation. The walls of the muscular portion of the tube (the cirrus) are attached to the walls of the cirrus sac, and hence when the sac contracts the cirrus cannot be protruded except by evagination of its lumen. Opening into the middle portion of the vas deferens, and as a rule enclosed in the cirrus sac, is found a mass of unicellular glands (prostate), the vesicula seminalis (which is likewise within, or may also be outside the sac) being the dilated first portion of the vas.

The female genitalia (fig. 126) consist of an ovary, usually situated in front of the testes, the form of which varies according to the species, the usually double vitellaria, the ducts and a number of auxiliary organs; the short oviduct directed towards the centre arises from the ovary, and is connected in the median line with the excretory duct of the vitelline glands. These grape-like glands possess longitudinal excretory ducts, which assume a transverse direction behind the ovary, unite together at the median line and form a single duct, often dilated into a vitelline receptacle, that unites with the oviduct. Near this point, moreover, there frequently opens a canal (Laurer's canal) which begins on the dorsal surface, and on the inner end of which a vesicle filled with sperm (receptaculum seminis) usually occurs (fig. 126). Moreover, there are also numerous radial unicellular glands (shell glands) at or beyond the point of junction of the oviduct, vitelline ducts and Laurer's canal. In this portion of the duct (oötype), which is usually dilated, the ovarian cells are fertilized, surrounded with yolk cells and shell material, and as ova with shells they pass into the uterus (a direct continuation of the oviduct), which, with its many convolutions, occupies a larger or smaller portion of the central field, and runs either direct to the genital pore or, forming convolutions, first runs posteriorly and then bends forward (descending and ascending limbs). In both cases the terminal part lies beside the cirrus pouch and discharges beside the male orifice either on the surface of the body or into a genital atrium. The terminal portion of the uterus, which is often of a particular structure, serves as a vagina (METRATERM).

The cirrus sac may include (1) the genital atrium (*i.e.*, the common sinus, into which the vas deferens and vagina may open), or (2) a variable extent of the vas from cirrus to seminal vesicle. Thus the latter may be outside the sac. In the absence of a sac, the genital sinus may be surrounded by a pseudo-sucker, as in *Heterophyes* (in some cases the ventral sucker itself, from its close proximity to the genital pore, serves as an accessory copulatory organ). In other cases copulatory organs are formed by hooks projecting into the lumen of the terminal portion of the vas.

The GENITAL PORE, which is the opening from the genital sinus on to the surface, is generally situated at or near to the median line on the ventral surface and in the anterior region of the body; in most of the *Distomata* it is in front of the ventral sucker, in other cases, *e.g.*, in the *Cryptocotylinæ*, it is behind.[1]

The spermatozoa do not differ essentially in their structure from those of other animals; the ovarian or egg cells are cells without integument and contain a large nucleus and a little protoplasm; the vitellaria also produce nucleated cells, in the plasm of which there are numerous yellow yolk granules; the yolk cells detach themselves, like the ovarian cells, from the ovarium, and pass into the oviduct to surround each ovarian cell in the oötype. They disintegrate sooner or later in the completely formed egg and are utilized as food by the developing embryo.

Development of the Trematodes.

(1) *Copulation.*—Observation has demonstrated that the one or two vaginæ occurring in the ectoparasitic Trematodes are utilized as female organs of copulation, and that the copulation is cross; it is also known that Laurer's canal, which was formerly generally regarded as the vagina, has only quite exceptionally, if at all, served the digenetic Trematodes as such—it appears to be homologous with the canalis vitello-intestinalis of the *Monogenea*[2]—but the terminal portion of the uterus, termed the metraterm, is used for copulation. Cross-copulation occurs as well as auto-copulation and auto-fecundation. The spermatozoa subsequently pass through the entire uterus, which is still quite short at the time the male organs are matured; the maturation of which, as usually is the case in hermaphrodites, precedes

[1] The typical position of the genitalia is subject to many deviations, which are of importance in the differentiation of the genera and families. The following are some few of these deviations: (1) The genital pore remains on the ventral surface, but is situated beside or behind the ventral sucker, or it becomes marginal, and is then found in front of or beside the oral sucker, or at a lateral edge, or, finally, in the centre of the posterior border; the ducts also correspondingly alter their direction. (2) The ovary usually lies in front of the testes, not rarely, however, behind them or between them. (3) The three genital glands mostly lie together close in front of, or behind, the centre of the body; they may be moved far back, and may incidentally become separated one from the other. (4) The vitellarium may be single, in which case it then may lie in the central field. (5) A few forms possess but one, others several or numerous testes. Amongst the ectoparasitic trematodes there are also species with but one testis; but they mostly have several. As a rule, their uterus is short, but the oötype well developed. Special canals (vagina), single or double, are used for copulation, not the uterus. The vitelline ducts also communicate with the intestine through the canalis vitello-intestinalis (fig. 123).

[2] *Monogenea:* Trematoda in which the anterior sucker, if present, is double. Development without an intermediate host.

that of the female organs. It is only later with the onset of egg formation that the uterus is fully developed. Copulation, however, takes place also in the case of fully grown forms with completely developed uteri.

(2) *Formation of the Ova.*—The ovarian cells arising from the ovary first become mature after their entry into the oötype by the formation of three polar bodies, fertilization then taking place. At the same time as the ovarian cell a number of yolk cells from the vitellarium and secretion, drop by drop, from the shell gland reach the oötype.[1] The shell is then formed during the generally active contractions of the oötype walls and then passes on into the uterus. In the uterus of the endoparasitic trematodes the eggs accumulate more and more, often in large quantities, while in ectoparasitic species generally only

FIG. 128.—Ovum of *Fasciola hepatica*, L., cut longitudinally. The lid has been lifted in the process. Within the egg are numerous yolk cells, and at the lid end there is the still unsegmented ovum (dark). 240/1.

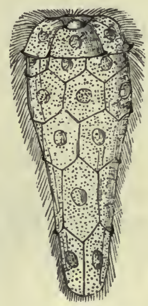


FIG. 129. — Miracidium of *Fasciola hepatica* that has just hatched from the egg, with a distinct cuticular ciliated epithelium. Magnified. (From Leuckart.)

one or some few eggs can be found. The completed ova are of various forms and sizes. They are mostly oval, at all events in the digenetic trematodes, and the yellowish or brown shell is provided with an opening at one pole which is closed by a watch-glass-shaped lid (operculum). Appendages (filaments) on the shell—at one or both poles—are uncommon, but are the rule in the ova of the *Monogenea* (ectoparasitic species).

(3) *Deposition of the Ova.*—Soon after their formation, the *Monogenea* (ectoparasitic trematodes) deposit round the place of

[1] [Recent work (*e.g.*, Goldschmidt, *Zool. Anzeiger*, xxxiv, p. 482) has shown that the older views regarding the formation of the egg must be modified. In certain species, at any rate, the shell material is formed by the yellow droplets of the yolk glands and not by the so-called shell gland (Mehli's gland) secretion, which is clear and watery. The function of this secretion accordingly still requires explanation; according to Looss it serves as a covering secretion for the egg-shell proper. It appears also that other granules, the yolk granules as distinct from the shell drop granules, are not always used up during the development of the embryo and hence do not function as yolk, so these also when they exist, and frequently they are wanting, must serve some other purpose, possibly that of imbibing water for the use of the embryo.—J. W. W. S.]

their attachment on the skin or the gills or other organs of their hosts, eggs which attach themselves by means of their filaments. The embryonic development thus takes place outside the parent. This also holds good for the eggs of many endoparasitic species, although as a rule in these the eggs are always retained for a longer time in the uterus. Moreover, they usually here undergo a part or a whole of their development, and are eventually deposited in those organs in which the adult forms are parasitic, but this is not always the case, as the egg, *e.g.*, of *F. hepatica* appears in bile (and fæces) quite unchanged. By the natural passages they eventually get out of the body, and in cases where such do not exist, as in the case of the blood-vessels, the eggs pass out by means of the kidneys.

(4) *The embryonic development*, after irregular segmentation of the ovum into a number of blastomeres, leads to the formation of a solid blastosphere or morula, which is surrounded by a cellular investing membrane (yolk envelope), while the principal mass of the cells forms the embryo, which uses for its nourishment the yolk cells, which have in the meantime disintegrated (*cf.* footnote, p. 223). Usually, after the ova have reached water the embryos hatch out, leaving the yolk envelope in the egg-shell ; in other cases, however, the embryos only hatch out after having been subjected to the influence of the intestinal juices, that is to say, in the intestine of an intermediate host which has ingested with its food the ova that have escaped from the primary host.

(5) *The post-embryonic development* of the Trematodes is accomplished in various ways ; the process is the most simple in the ectoparasitic species *(Monogenea)*, the young of which should certainly be regarded as larvæ, because they possess characteristics (cilia, simple gut, etc.) that are lacking in the adult worms, but which, nevertheless, pass into the adult state direct after a relatively simple metamorphosis. In the *Holostomata*,[1] a group found chiefly in the intestine of aquatic birds, and which rarely occur in other vertebrates, the ova develop in water. The young are ciliated all over, and, after having entered an intermediate host (leeches, molluscs, arthropods, amphibians, fishes) living in the water, they undergo a metamorphosis into a second larval stage ; they then encyst and await transmission into the final host, where they become adult Metastatic trematodes, *i.e.*, trematodes without asexually produced generations (p. 229).

In the remaining so-called digenetic trematodes (p. 230) one or two asexual generations interpose between the miracidium and terminal stage, so that quite a number of adult worms may originate from one egg. Usually the young, which are termed MIRACIDIA[2] (fig. 129),

[1] *Holostomata:* Prostomata with (in addition to the oral and ventral suckers) a third fixation apparatus, generally on a separate part of the body.

[2] [Also known as ciliated embryos.—F. V. T.]

hatch in water, where they move with the aid of their cilia. Sooner or later they penetrate into an intermediate host, which is always a snail or a mussel, and while certain of their organs disappear, they grow into a gutless germinal tube (SPOROCYST, fig. 131). These are simple elongated sacs with a central body cavity. They may or may not have excretory tubules. In these, according to the species, the larval stages (CERCARIÆ) that will ultimately become adult worms are produced, or another intermediate generation is first formed, *viz.*, that of the REDIÆ[1] (figs. 132, 133), which are always provided with an intestine, and these then give rise to cercariæ (figs. 130, 134). The cercariæ, as a rule, leave their host and move about in the water with the assistance of their rudder-like tails. After a little time, however, they usually again invade an aquatic animal (worms, molluscs, arthropods, fishes, amphibians), then they lose their tails and become

FIG. 130.—A group of cercariæ of Echinostoma sp. (from fresh water). 25/1.

encysted (fig. 135); here they wait until they attain, together with their host, the suitable terminal host, and in this new situation they establish themselves and reach maturity. Or, again, the cercariæ may themselves encyst in water or on foreign bodies (plants) and wait until they are taken up directly by the terminal host, *e.g.*, sheep.

Accordingly the following conditions are necessary for the completion of the entire development: (1) The terminal host in which the adult stage lives; (2) an intermediate host into which the miracidia penetrate and in which they become sporocysts; (3) a second intermediate host in which the cercariæ become encysted. In certain species, as in *Fasciola hepatica*, this second host is omitted, as the cercariæ spontaneously encyst on plants, or again (in other species) encystment may occur within the first intermediate host, when,

[1] [In *Fasciola hepatica* in the summer months the rediæ give rise to daughter rediæ, which then give rise to cercariæ.—J. W. W. S.]

in fact, the cercariæ (which in this case do not acquire an oar-like tail) do not swarm out of, but encyst themselves within their sporocysts. The development, moreover, may be further complicated by rediæ appearing in addition to the sporocysts, though this occurs in the first intermediate host and not in a second one.

Animals that harbour adult digenetic Trematodes thus become infected by ingesting encysted cercariæ, which either occur (1) in certain animals (second intermediate hosts) on which they feed, or (2) in water, or (3) on plants, or finally (4) in the first intermediate host; whereas animals harbouring encysted cercariæ have been directly infected by the corresponding tailed stage, and animals harbouring germinal tubes (sporocysts or rediæ) have been infected by the miracidia.

Thus certain species of ducks and geese become infected with *Echinostoma echinatum* by devouring certain water-snails (*Limnæus*,

FIG. 131.—Development of *Fasciola hepatica*, L. *a*, the miracidium in optical section showing cephalic lobe, X-shaped eye-spot resting on the cerebral ganglion, two germ balls; below each of these a flame cell, and still lower germ cells lying in a cavity (primitive body cavity). *b*, young sporocyst with two eye-spots, and germ balls; the cells lining the cavity are not shown. *c*, older sporocyst with a young redia. Magnified. (After Leuckart.)

Paludina) in which the encysted cercariæ occur. Oxen become infected with *Paramphistomum cervi* (= *Amphistomum conicum*) by swallowing with water, cysts of this species which occur at the bottom of puddles and pits. Sheep are infected with *Fasciola hepatica* by eating grass to which the encysted cercariæ of the liver-fluke are attached; our song-birds infect themselves or their young with *Urogonimus macrostomus* by tearing off pieces containing the corresponding sporocysts which are full of encysted cercariæ from snails (*Succinea amphibia*), which act as the first intermediate hosts, and eating, or offering their young these pieces.

(1) The MIRACIDIA of the digenetic Trematodes are comparatively highly organized, and the mode of their formation from the

segmentation cells of the ovum is only imperfectly known. They have a cuticular epithelium (fig. 129) entirely or partly covered with cilia, beneath this a dermo-muscular tube composed of circular and longitudinal muscles; also, a simple gut sac with an œsophagus, occasionally also with pharynx, salivary glands and boring spine, also a cerebral ganglion on which, in some species, there are eyes (fig. 131, *a*). As to the excretory organs, they are represented by two symmetrically placed terminal flame cells, with excretory vessels opening separately; there is a more or less ample (primary) body cavity between the parietes of the body and the gut; from the cellular parietal lining of this cavity single cells (germ cells) become free (fig. 131, *a*, *b*), and become rediæ or cercariæ.

[The germ cells of the miracidium and the germ balls of the sporocyst arise, according to some observers, by further division of undifferentiated blastomeres; according to others from the cells of the lining wall of its body cavity. It is from these free germ balls that the redia stage is developed.

[In the germ ball or morula appears an invagination, giving rise to the cup-shaped gastrula stage. This elongates and forms the REDIA (fig. 131, *c*).

[In the interior of the redia cells are budded off and develop into gastrulæ, as in the case of the sporocyst. These become a fresh generation of rediæ or give rise to the third stage (CERCARIA).]

FIG. 132.—Young redia of *Fasciola hepatica*, with pharynx and intestine, with a circular ridge anteriorly and a pair of processes posteriorly and masses of cells (germ balls) in the interior. Magnified. (From Leuckart.)

FIG. 133.—Older redia of *Distoma echinatum*, with rudimentary intestine *i.*; cercariæ, *c.*; germ balls, *b.*; and birth pore, *g.* Magnified.

(2) The SPOROCYSTS, on the contrary, which are produced direct from the miracidia, are very simple, as all the organs of the latter disappear, even to the muscles and excretory organs, during or after penetration into the intermediate host, whereas the budded and still budding cells of the wall of the (primary) body cavity continue to develop rapidly and form germ balls. The sporocysts when fully developed have the appearance of tubes or fusiform bodies with rounded edge; they are frequently of a yellow colour. Their length

rarely exceeds a few millimetres; in some species their size increases exceedingly through proliferation, and they then occupy a large portion of the body of the intermediate host.

FIG. 134.—Cercaria of *Fasciola hepatica*; the cutaneous glands at the side of the anterior body. Magnified. (After Leuckart.)

FIG. 135.—Encysted cercaria of *Fasciola hepatica*. Magnified. (After Leuckart.)

(3) The REDIÆ (figs. 132, 133), on the other hand, are more cylindrical and always have a simple intestine of varying length, provided with a pharynx; they likewise possess, situated near the circular ridge, a "birth pore" which serves for the exit of the cercariæ originating within them.

(4) The CERCARIÆ[1] are very different; typically they consist of the anterior body and the oar-like tail at the posterior end (fig. 134). The former, even to the genitalia, has the organization of the adult digenetic Trematodes, and thus allows the easy recognition of at least the characters of that large group to which the species in question belongs. On the other hand, however, there are also organs that are lacking in the adult form, such as, in many, the boring spine in the oral sucker, or the eyes situated on the cerebral ganglion; moreover, also, cutaneous glands (fig. 134), the secretion of which forms the cyst membrane. The oar-like tail may be long or short (stumpy-tailed cercaria) or entirely absent; its free end may be partly split (furcate cercaria), or split to its base (*bucephalus*); in various forms also the anterior end of the tail is hollow, and has enclosed within it the anterior body, which is otherwise free. The size also of the cercaria belonging to the different species is very diverse; in addition to forms swimming in the water that have the appearance of minute milky-white bodies, there are forms which measure as much as 6 mm. in length.

The encysted cercariæ (fig. 135) are globular or oval, and are surrounded by a homogeneous

[1] The cercaria is the characteristic larval stage of the Trematodes, and corresponds to a cysticercus or cysticercoid, though there is the important difference that the cercaria has an enteric cavity. According to some observers the enteron is represented by the frontal sucker of some Cestodes, and by the rostellum of the majority of others.

The sporocyst and redia are regarded as intercalated stages, *viz.*, as cercariæ exhibiting *pædogenesis*, *i.e.*, development of young by a parthenogenetic process from individuals (*i.e.*, cercariæ) not yet adult.

membrane, which may be striated or contain granules. The tail is always cast off when encystment occurs, and organs peculiar to the cercaria stage (boring papilla, eyes) almost entirely disappear. On the other hand, the genitalia appear or become more or less highly developed, in extreme cases to such an extent that they become functional, and after autocopulation the creatures produce ova within the cysts.

The cycle of development of the digenetic Trematodes has hitherto been generally explained as a typical ALTERNATION OF GENERATIONS, one sexual generation regularly alternating with one or two asexually reproducing generations. Recent authors, however, regard the cells in the sporocysts from which rediæ or eventually cercariæ arise as parthenogenetically developing ova, and the sporocysts as well as the rediæ as generations propagating parthenogenetically. In this case, however, it is an alternation of a sexual not with an asexual but with firstly a parthenogenetic generation (the sporocyst), the central cells of which are regarded as ova which develop parthenogenetically into the redia, and this the second parthenogenetic generation finally produces larvæ (cercariæ) capable of developing into the sexually mature form.

Other authors, again, regard the development of the Digenea as only a complicated metamorphosis (p. 283), which is distributed over several generations before it is concluded.

BIOLOGY.

Endoparasitic Trematodes, as fully developed organisms, occur in vertebrate animals only, with very few exceptions; they inhabit almost all the organs (with the exception of the nervous and osseous systems and the male genitalia), but by preference the intestine in all its extent from the oral cavity to the anus; and, further, certain species or groups inhabit only quite restricted parts of the intestine. Besides in the intestine other species live in the liver, or in the bile-ducts, or in the gall-bladder; other accessory organs of the intestine, such as the pancreas, bursa Fabricii (of birds), are only infected by a few species. Many inhabit the lungs, or the air sacs in fowls, a few the trachea. Trematodes have also been known to occur in the urinary bladder, the urethra and the kidneys of all classes of vertebrates; they are also present in the vascular system of a few tortoises, birds and mammals; in birds they even penetrate from the cloaca into the oviducts, and are occasionally found enclosed in the laid eggs; one species is known to occur in the cavum tympani and in the Eustachian tube of a mammal (Dugong), another in the frontal sinus of the polecat; several species infest the conjunctival sac under the membrana nictitans of birds, one species even lives in cysts in the skin of song-birds. In an analogous manner the ectoparasitic Trematodes are not entirely confined to the surface of the body or the trachea of the lower vertebrate animals; a few species appear exclusively in the urinary bladder, in the œsophagus, and in the case of sharks in an accessory gland of the rectum.

Trematodes live free and active within the organs attacked, though they may attach themselves by suction for a longer or shorter period; in other cases, however, they bore more or less deeply into the intestinal wall with their anterior end, or lie in cysts of the intestinal wall which only communicate with the lumen through a small opening; in those species living in the lungs of mammals the host likewise produces a cyst, which usually encloses two specimens; such association of a pair is also observed in other situations, and, though this is the rule in species sexually distinct, it is not entirely confined to these.

As regards the AGE attained by endoparasitic Trematodes, there are but few reliable records, and these differ considerably; the overwhelming majority of species certainly live about a year, or perhaps a little longer, but there are some whose term of life extends to several or many years.

Trematodes are but rarely found encysted in the higher vertebrate animals; the condition, however, is more frequent in amphibians, and especially in fishes, as well as in numerous invertebrate animals.

Classification of the Trematodes of Man.

The following classification, partly artificial, partly natural, embraces only the flukes found in man:—

Order. **Digenea,** v. Beneden, 1858.

Anterior sucker single and median, present. Eggs few. The (specialized) terminal portion of the uterus serves as a vagina. Development indirect, *i.e.*, an intermediate host is required.

Sub-order. **Prostomata,** Odhner, 1905.

Mouth surrounded by the anterior sucker.

Group. **Amphistomata,** Rudolphi, 1801, ep., Nitzsch, 1819.

Gut forked, two suckers, the posterior sucker (acetabulum) terminal or ventro-terminal behind the genitalia, or at most embraced by the vitellaria. Skin with no spines. Excretory bladder a simple sac opening dorsally near hind end. Testes in front of ovary. Genital pore, median in anterior third of body. Thick flukes, almost circular in cross section.

Family. **Paramphistomidæ**, Fischoeder, 1901.

Amphistomata: Body not divided into a conical anterior portion and disc-like caudal portion. Ventral pouch absent.

Sub-family. **Paramphistominæ**, Fisch., 1901.

Paramphistomidæ: Oral sucker without evaginations. Not in man.

Sub-family. **Cladorchiinæ**, Fisch., 1901.

Paramphistomidæ: Oral sucker with evaginations; testes, two, deeply cleft (fig. 137). Genera: *Watsonius*, *Cladorchis*, etc.

Family. **Gastrodisciidæ**, Stiles and Goldberger, 1910.

Amphistomata: With body divided into a conical cephalic and disc-like caudal portion (fig. 138). Posterior sucker ventro-terminal. Oral sucker with evaginations. Genera: *Gastrodiscus* and *Homalogaster*.

Group. **Distomata**, Retzius, 1782.

Gut forked, two suckers, the posterior sucker (acetabulum) ventral. It is always separated from the hind end by at least a part of the genitalia.

Family. **Fasciolidæ**, Railliet, 1895.

Large flat forms, genital pore *in front* of ventral sucker, the latter powerful. Vitellariæ of numerous follicles, united by branching vitellarian ducts, at the sides of the body meeting posteriorly and extending ventrally and dorsally. Cirrus and vagina without spines. No crown of strong spines around sucker. Testes much branched. Uterus not well developed. Excretory bladder much branched. Eggs large.

Sub-family. **Fasciolinæ**, Odhner, 1910.

Large or median forms, gut much branched. Body has a shoulder separating head from body. Receptaculum seminis absent. Ovary branched, ventral sucker in anterior part of body. Genus: *Fasciola*.

Sub-family. **Fasciolopsinæ**, Odhner, 1910.

Shoulder absent. Receptaculum seminis present. Ovary branched, gut takes a zig-zag course with kinks on it, ventral sucker in anterior part of body. Genus: *Fasciolopsis*.

Family. **Opisthorchiidæ**, Braun, 1901, emend. auctor.

Ovary in front of testes. Small to medium flukes, very transparent, tapering anteriorly. Vitellaria moderately developed not extending in front of sucker. Cirrus absent. Seminal vesicle a twisted tube free in parenchyma. Testes near hind end one behind the other, lobed or branched, but not dendritically. Excretory bladder **Y**-shaped, the two limbs short, the stem **S**-shaped passing between the testes. Receptaculum seminis well developed. Laurer's canal present. Uterine coils transverse, numerous. Eggs small.

Sub-family. **Opisthorchiinæ**, Looss, 1899, emend. auctor.

Opisthorchiidæ in which the excretory pore is terminal. Excretory bladder long, dorsal to testes. Uterine coils not overlapping gut forks. Genera : *Opisthorchis*, *Paropisthorchis*, *Clonorchis*, *Amphimerus*, etc.

Sub-family. **Metorchiinæ**, Lühe, 1909.

Opisthorchiidæ in which the excretory pore is ventral. Excretory bladder short, ventral to testes. Uterine coils partly overlapping gut forks and extend anteriorly beyond the sucker. Vitellaria compressed on the sides of the body. Genus : *Metorchis.*

Family. **Dicrocœliidæ**, Odhner, 1910.

Ovary *behind* testes. Testes behind the ventral sucker, between it and the ovary. Body thin and transparent. Cirrus sac encloses the pars prostatica and seminal vesicle. Skin smooth. Gut forks do not reach posterior end. Receptaculum seminis and Laurer's canal present. Vitellaria, moderate, lateral in mid-body slightly overlapping the gut. Uterus with an ascending and descending branch and numerous transverse coils extending to hind end. Eggs dark brown, 25 μ to 60 μ. Excretory bladder tubular in posterior third or half of body. Parasitic in bile-ducts of mammals and birds. Genus : *Dicrocœlium.*

Family. **Heterophyiidæ**, Odhner, 1914.

Ovary *in front* of testes. Genital pore *behind* or on a level with ventral sucker. Genital pore surrounded by a pseudo-sucker (*i.e.*, its muscle is not sharply separated from but blends with the body muscles). Cirrus sac absent, consequently vesicula seminalis and pars prostatica lie free. Vagina and ejaculatory duct unite into a common duct before opening. Small and very small forms. Body covered with scales. Genera : *Heterophyes*, *Metagonimus*, etc.

Family. **Troglotremidæ**, Odhner, 1914.

More or less flattened Distomes of compact form, 2 to 13 mm. long. Ventral surface flat or somewhat hollowed, dorsal surface *arched*. Skin completely covered with pointed spines. Musculature weakly developed also in the suckers in those forms that inhabit cysts. Gut with pharynx and a not very long œsophagus and cæca, which end more or less shortly before the hind end. Excretory bladder Y-shaped or tubular. Pars prostatica and seminal vesicle always distinct. Testes elongated, symmetrically placed in or behind the middle of the body. Ovary directly in front of the testes, right-sided, generally much lobed. Receptaculum seminis and Laurer's canal present. Vitellaria generally well developed, exclusively or for the most part confined to *the dorsal surface*, leaving only a median band unoccupied. Uterus either very long, coiling here and there, or shorter and more convoluted. Eggs in first case small 17 μ to 25 μ, in the second much larger 63 μ to 85 μ or even 120 μ (?) long. Parasitic in carnivora or birds, generally occurring in pairs in cyst-like cavities. Genera: *Paragonimus*, *Pholeter*, *Collyriclum*, *Troglotrema*.

Family. **Echinostomidæ**, Looss, 1902.

More or less elongated flukes, small or very large, much flattened anteriorly, less so posteriorly, or even round. Suckers near one another, the anterior small and weak, the posterior large and powerful directed obliquely backwards. Surrounding the oral sucker dorsally and laterally but not ventrally is a fold or "collar" bearing a row or rows of pointed spines which are continued round laterally on to the ventral corners, the number being constant for each species, the corner spines large or specialized, skin anteriorly scaled or spiny. Alimentary canal consists of a pharynx, epithelial "pseudo-œsophagus" and gut cæca reaching to posterior end. Testes behind one another in hind body. Ovary on right side or median directly in front of the testes. Vitellaria lateral, usually extending to the hind end and not beyond the ventral sucker anteriorly. Genital pore just in front of ventral sucker. Uterus in transverse loops. Genital sinus absent or present. Receptaculum seminis and Laurer's canal present. Eggs thin shelled and large, bright yellow, 65 μ *to* 120 μ *long. Excretory bladder* Y*-shaped. Parasitic in gut of vertebrates, especially birds.*

Sub-family. **Echinostominæ**, Looss, 1899.

Cirrus sac usually reaching to centre of ventral sucker, but not beyond. Cirrus long, usually without spines, coiled when retracted. Seminal vesicle tubular, twisted. On the head a ventral uniting ridge between the angles of the collar. Dorsal circlet of spines, single or double, not interrupted unless the collar itself is dorsally divided. Genera: Echinostoma, etc.

Sub-family. **Himasthlinæ**, Odhner, 1910.

Cirrus sac reaching far beyond ventral sucker. Cirrus armed with strong rose-thorn-shaped hooks. Vesicula seminalis tubular not coiled. Cervical collar not continued across ventral aspect. Spines on collar in one row. Body armed with fine needle-shaped spines.

Family. **Schistosomidæ**, Looss, 1899.

Sexes separate. Genital pore behind the ventral sucker. Ventral sucker elevated above the surface. Pharynx absent. Gut forks reunite to form a single stem. In ♂ four or more testicular follicles. In ♀ a single ovary, just in front of the union of the gut forks. Vitellaria on either side of the united gut stem.

THE TREMATODES OBSERVED IN MAN.

Family. **Paramphistomidæ,** Stiles and Goldberger, emend. 1910.

Sub-family. **Cladorchiinæ,** Fisch., 1901.

Genus. **Watsonius,** Stiles and Goldberger, 1910.

Cladorchinæ.—Body pyriform. Ventral pouch absent. Acetabulum ventral or (?) ventro-subterminal, very large, margins projecting, aperture small. Genital pore in front of bifurcation of gut, not surrounded by a sucker ; ductus hermaphroditicus apparently absent. Excretory pore at posterior end of excretory vesicle, behind Laurer's canal. Oral sucker with a pair of irregularly globular suctorial pouches ; œsophagus thickened distally ; cæca long, not wavy ; end in acetabular region.

Male Organs.—Testes two lobed, smaller than acetabulum ; longitudinally, nearly or quite coinciding ; transversely they abut or slightly overlap ; preovarial in equatorial and caudal thirds. Pars musculosa not largely developed ; cirrus pouch absent.

Female Organs.—Ovary and shell gland post-testicular. Vitellaria extend from gut fork to slightly beyond gut ending ; uterus intercæcal, partly post-testicular. Laurer's canal in front of excretory vesicle.

Type Species.—*Watsonius watsoni*, Conyngham, 1904.

Watsonius watsoni, Stiles and Goldberger, 1910.

Syn.: *Amphistomum watsoni*, Conyngham, 1904 ; *Cladorchis watsoni*, Shipley, 1905.

Body, 8 to 10 mm. long, by 4 to 5 mm. broad, by 4 mm. thick ; tapers anteriorly to 2·5 mm. Caudal extremity bluntly rounded, venter surrounded by an elevated ridge, surface with transverse ridges best defined ventrally. Genital pore median about one-quarter of body length from anterior end at level of suctorial pouches. Acetabulum 1 mm. in diameter, margin projecting, aperture small. Mouth in a groove with digitate papillæ. Oral sucker very large, one-fifth of length of body, with a pair of irregularly globular pouches. Œsophagus somewhat longer than sucker. Excretory pore at the level of the acetabular aperture. The vesicle extends from the plane of the transverse vitelline ducts to centre of acetabulum.

FIG. 136.—*Watsonius watsoni:* ventral view. 4/1. (After Shipley.)

Male Organs.—Testes deeply notched adjoining one another. Vesicula seminalis much coiled and dilated, pars musculosa not coiled. Pars prostatica (?) dilated, ejaculatory duct long and narrow, opening on a papilla ; genital atrium papillated.

Female Organs.—Ovary dorso-posterior of posterior testis. Shell gland dorsal to ovary. Vitellaria ventral and lateral to gut cæca extending from gut fork to equator of acetabulum. Uterus dorsal to testes, ductus hermaphroditicus absent. Laurer's canal opens in dorso-median line slightly behind anterior border of sucker.

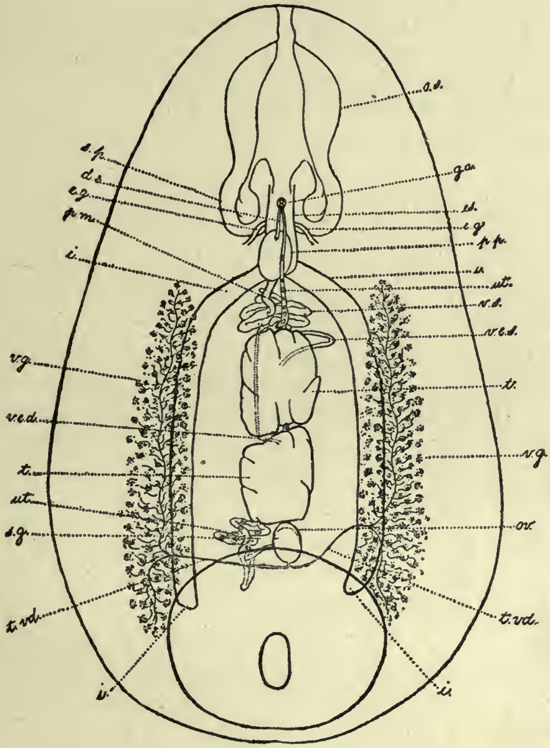


FIG. 137.—*Watsonius watsoni:* ventral projection composed from a series of transverse sections. *o.s.*, oral sucker; *s.p.*, suctorial pouch; *ga.*, genital atrium; *d.e.*, ejaculatory duct; *es.*, œsophagus; *e.g.*, œsophageal ganglion; *p.p.*, pars prostatica; *p.m.*, pars musculosa; *i.*, gut; *ut.*, uterus; *v.e.*, vas efferens; *v.e.s.*, left vas efferens; *v.e.d.*, right vas efferens; *v.g.*, vitellarium; *t.*, testes; *ov.*, ovary; *s.g.*, shell gland; *t.vd.*, transverse vitelline duct. (After Stiles and Goldberger.)

Eggs.—123 μ to 133 μ long by 75 μ to 80 μ broad.

Habitat.—Jejunum and duodenum of man, German West Africa. The parasite has only been found once in man. The patient, a negro from German West Africa, died at Zola, Northern Nigeria. The symptoms were persistent watery diarrhœa without blood or mucus. The parasites were also passed in the stools. It occurs also in monkeys.

Family. **Gastrodisciidæ.**

Genus. **Gastrodiscus,** Lkt., 1877.

Acetabulum small, caudal and ventral margin raised, aperture relatively large. Genital pore without sucker. Excretory pore post-vesicular, posterior to opening of Laurer's canal. Œsophagus with muscular thickening; cæca not wavy, long, end post-equatorial and post-testicular.

Male Genitalia.—Testes two, branched pre-ovarial.

Female genitalia.—Ovary and shell gland post-testicular. Vitellaria extracæcal; uterus intercæcal; Laurer's canal entirely prevesicular.

Type.—*Gastrodiscus ægyptiacus*, Cobbold, 1876.

Gastrodiscus hominis, Lewis and McConnell, 1876.[1]

Syn.: *Amphistomum hominis*, Lew. and McConn.

Body, reddish in the fresh, 5 to 8 mm. long; posteriorly, 3 to 4 mm. broad. The disc has incurved edges which are interrupted in front where it joins the anterior cylindrical portion and posteriorly behind the ventral sucker. The disc itself and ventral surface are covered with a number of (microscopic) papillæ. Pharynx provided with two diverticula or pouches. The bifurcation of the gut lies sometimes above, sometimes below the level of the genital pore. The gut cæca end about the level of the centre of the acetabulum.

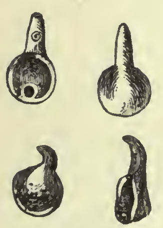


FIG. 138.—*Gastrodiscus hominis.* Slightly magnified. (After Leuckart.)

Genital Pore.—About the middle of the conical anterior portion. (It appears to be surrounded by a muscular sucker.) Leiper (1913) describes the ducts as discharging at the tip of a large fleshy papilla, the surface of which bears cuticular bosses.

Testes much lobed, the anterior is smaller than the posterior and lies at about the level where the anterior conical portion joins the disc. The posterior testis just in front of the anterior margin of the acetabulum separated from it by the ovary. The ovary, somewhat oval in shape or slightly constricted in the middle, lies slightly to the right of the median line. Dorsal to it lies the well-developed shell gland, Laurer's canal opening in front of the excretory bladder. The excretory bladder is a long sac with its opening at its posterior extremity about the level of the middle of the acetabulum. The

[1] Leiper places this species in a new genus *Gastrodiscoides*. Genus *Gastrodiscoides*, Leiper, 1913, distinguished from *Gastrodiscus* by: (1) large genital cone; (2) position of genital orifice; (3) disc without papillæ; (4) testes one behind the other.

vitellaria are restricted in extent. They do not extend forward beyond the anterior border of the posterior testis. They are best developed in the area between the acetabulum and the termination of the gut cæca.

The eggs are oval and measure 150 μ in length by 72 μ in breadth.

Habitat.—Cæcum and large intestine of man. Also in the pig (5 per cent.) in Annam.

Distribution.—This parasite has been recorded from Assam (not uncommon), British Guiana (Indian immigrants), and Cochin China.

Gastrodiscus ægyptiacus, Cobbold, 1876, and *G. secundus*, Looss, 1907, occur in the horse; *G. minor*, Leiper, 1913, in the pig in Nigeria and Uganda.

Family. **Fasciolidæ**, Raill., 1895.

Sub-family. **Fasciolinæ**, Odhner, 1910.

Genus. **Fasciola**, L., 1758.

The ventral sucker is situated at the level of the junction of the cone with the body, *viz.*, at the level of the "shoulder," and is large and powerful. The cuticle is covered with strong spines; the gut cæca run in the mid-line to the hind end, and are provided with numerous long lateral and fewer and shorter median branches. The ovary lies on one side in front of the transverse vitelline duct; the testes lie obliquely one behind the other. The uterus, in the shape of a rosette, lies in front of the genitalia. Laurer's canal is present; the vesicula seminalis lies in the cirrus pouch; the ova are large, not very numerous, and only develop after they have been deposited. Parasites of the biliary ducts of herbivorous animals.

Fasciola hepatica, L., 1758.

Syn.: *Distomum hepaticum*, Retz., 1786; *Fasciola humana*, Gmel., 1789; *Distomum caviæ*, Sons., 1890; *Cladocœlium hepaticum*, Stoss., 1892.

Length 20 to 30 mm., breadth 8 to 13 mm., cephalic cone 4 to 5 mm. in length and sharply differentiated from the body by a shoulder on each side. Spines in alternating transverse rows and extending on the ventral surface to the posterior border of the testes, and on the dorsal surface not quite so far. The spines are smaller on the cephalic cone than on the posterior part of the body, where they are discernible with the naked eye. The suckers are hemispherical, and near each other; the oral sucker is about 1 mm. and the ventral sucker about 1·6 mm. in diameter. The pharynx, which includes almost the entire œsophagus, measures 0·7 mm. in length and 0·4 mm. in breadth. The intestine bifurcates at the limit of the cephalic cone and the branches are even here furnished with diverticula directed outwardly. The ovary is ramified and situated in front of the transverse vitelline duct, usually on the right side; the shell gland lies near the ovary in the median line; posterior to the transverse vitelline ducts are the greatly ramified testes, which occupy the greater portion of the posterior part of the body, with the exception of the lateral and posterior border; the long vasa efferentia only unite as they enter the cirrus pouch. The vitellaria occupy the sides of the posterior part of the body, commencing at the level of the ventral sucker and uniting behind the testes. The ova are yellowish-brown, oval, operculated, 130 μ to 145 μ in length, 70 μ to 90 μ in breadth (average size 132 μ by 70 μ).

FIG. 139.—*Fasciola hepatica*, L. From a specimen that is not yet mature, showing the gut and its branches. 5/1.

The Liver Fluke inhabits the bile-ducts of numerous herbivorous mammals (sheep, ox, goat, horse, ass, rabbit,[1] guinea-pig, squirrel, beaver, deer, roe, antelope, camel, kangaroo, and others), and is distributed over the whole of Europe, though not to an equal extent. It is further known in North Africa, in North and South America, as well as in Australia; it is also found in Asia, as it has been reported from Japan, China, and Tonkin (Gaide, two cases in man). In some districts of Germany it is very frequent, and the slaughter-house statistics of various places show that it is of daily occurrence. *Fasciola magna* occurs in herbivora in America.

The liver fluke, however, is by no means a harmless parasite, for it produces in domestic animals, more especially in sheep, a disease of the liver that appears epidemically in certain years and districts, and commits great ravages amongst the flocks.

[The following records show the enormous loss caused in sheep by this parasite. In 1812, in the Midi, principally in the Departments of the Rhône, Herault, and Gard, the disease was rampant; 300,000 sheep perished in the Arles territory, and 90,000 in the Arrondissements of Nîmes and Montpellier. In 1829 and 1830, in the Department

[1] [There does not seem to be any direct evidence of either rabbits or hares normally being invaded by this fluke.—F. V. T.]

of the Meuse and near localities, not only sheep but oxen died in enormous numbers; for instance, in the Arrondissement of Verdun out of 50,000 sheep 20,000 died, and out of 20,000 cattle 2,200 died. In England, in 1830, 2,000,000 sheep were carried off; whilst in 1862 60 per cent. of the sheep died in Ireland; and in 1879 over 300,000 were lost in England; whilst as late as 1891 one owner in the same country lost over 10,000 sheep (*Live Stock Journal*, October 30, 1891).—F. V. T.]

The disease usually commences towards the end of summer with an enlargement of the liver, induced by the invasion of numerous young flukes; in the autumn and winter the animals suffer from the consequences of disordered biliary secretion; they become feverish, emaciated, and anæmic, and lose their appetite. In consequence of the consecutive atrophy of the liver, œdema and ascites set in, and many animals succumb to this "liver rot." On examination the liver is found to be shrunken, the bile-ducts are enormously dilated and in parts saccular and full of flukes. Should the animals survive this stage, spontaneous recovery ensues in consequence of the flukes commencing to leave the liver in the

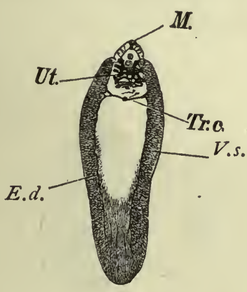


FIG. 140.—*Fasciola hepatica.* *M.*, mouth; *Ut.*, uterine rosette; *Tr.c.*, transverse vitelline ducts uniting to form a vitelline receptacle in the mid-line; *E.d.*, longitudinal vitelline ducts; *V.s.*, vitellaria. The clear space in the centre represents the position of the ramifying testes and part of the gut. Natural size. (Mull. fluid, alcohol, creosote, Canada balsam.)

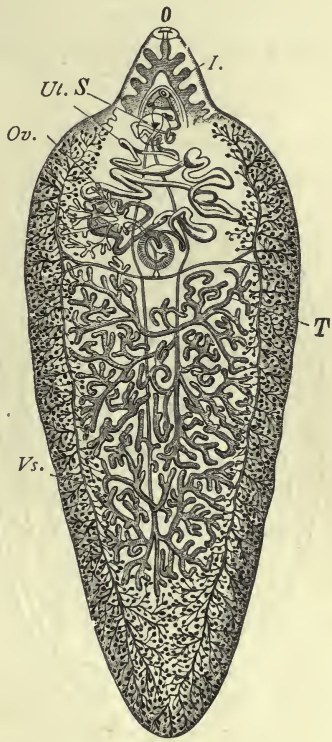


FIG. 141.—*Fasciola hepatica*, L. *I.*, intestine; *Vs.*, vitellaria; *Ov.*, ovary; *O.*, oral aperture; *Ut.*, uterus; *S.*, ventral sucker; *T.*, testes. In front of the testes are seen the transverse vitelline ducts uniting to form the pyriform vitelline receptacle. Immediately in front of this the spherical shell gland. The two vasa efferentia can also be seen running up in the mid-line. The branches of the gut are only shown in the cephalic cone. (After Claus.)

spring, but the liver remains changed and its sale is prohibited[1] when the changes are extensive.[2]

[The following stages may be noticed in sheep suffering from fascioliasis. Gerlach recognized four stages, based on the varied relations that the flukes contract with the liver of their host. These periods are sometimes very marked, but at others, owing to subsequent infections, the features become merged and so obliterated. But when a single infestation occurs they are very marked.

[The first period is called the PERIOD OF IMMIGRATION. This occurs at the fall of the year and generally passes unperceived, as the young flukes do little harm to the liver. It varies from four to thirteen weeks. Gerlach has remarked upon cases of death from apoplexy at this period.

[The second period is the PERIOD OF ANÆMIA. This occurs in November and December. The sheep at first fatten rapidly, but later the mucous membranes become pale and of a yellowish hue, and the sheep become sluggish and cease to feed. The fæces are normal, but may contain fluke ova.

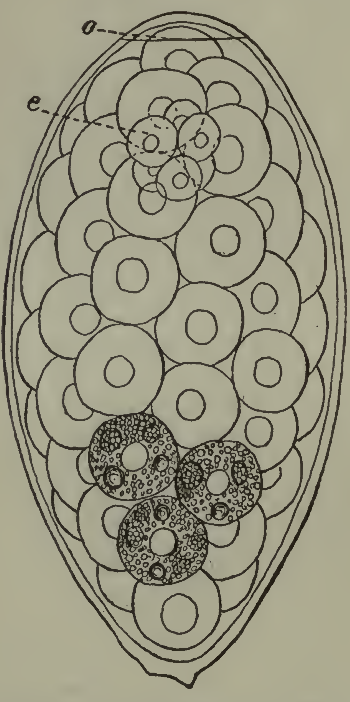


FIG. 142.—*Fasciola hepatica:* egg from liver of sheep. *o*, operculum, *e*, segmenting ovum. The rest of the space is occupied by yolk cells, the granules in three only being shown. ×680. (After Thomas.)

FIG. 143.—*Limnæus truncatulus*, Müll., the intermediate host of *Fasciola hepatica*. *a.*, natural size; *b.*, magnified. (From Leuckart.)

[The third period is the PERIOD OF WASTING. This corresponds with the beginning of January—about three months after the

[1] [This is not the case in Great Britain; fluky sheep are sent to market, there being no danger to man from eating the flesh.—F. V. T.]

[2] As an example, this occurred in Berlin in the case of 19,034 oxen, 15,542 sheep, 1,704 pigs, and 160 calves in the period of 1883-1893; during which time 719,157 oxen, 1,519,003 sheep, 2,258,110 pigs, and 567,964 calves were slaughtered. As a matter of fact, however, the number of infected beasts was really larger.

entry of the larvæ. Emaciation now becomes very marked, the skin and mucous membranes blanched, temperature variable and marked by an irregular curve; respiration laboured and quick; appetite regular; abortion frequently occurs in pregnant ewes; pressure on the back causes the animals to fall; local œdemas occur, the most perceptible in the submaxillary space, extending below the larynx and over the cheeks and parotids (called "bourse," "boule" in France; "watery poke" or "cockered" in England). Death usually occurs at this period, but a fourth stage may occur.

[The fourth period is the PERIOD OF MIGRATION OF THE FLUKES. This is a period of convalescence and recovery, generally in May and June.—F. V. T.]

Oxen suffer less in general, but even in these animals "stray" hepatic flukes are occasionally found in the lungs, enclosed in thick-walled cysts.

Pathological Anatomy.—The bile-ducts are conspicuous on the surface of the liver. They are thickened and much dilated and in parts saccular, and considerable atrophy of the liver cells accompanies the condition. Histologically there is immense proliferation of the epithelium of the bile-ducts leading to "adenomata."

The LIFE-HISTORY of the liver fluke was discovered by R. Leuckart and P. Thomas. According to these investigators the elongated miracidium (fig. 131, *a*) ciliated all over develops from the eggs a few weeks after the latter (fig. 142) have reached the water, and after it has become free the embryo penetrates and becomes a sporocyst (fig. 131, *b*) in a water-snail (*Limnæus truncatulus*, Müll. = *L. minutus*, Drap.) that is common in fresh water, and can live in the smallest collection of water as well as in fields that have been flooded. The sporocyst first of all produces rediæ, which remain in the same host (and under certain circumstances, *e.g.* in summer, these develop a second generation of rediæ), and these finally form cercariæ (fig. 134). The latter become encysted on blades of grass and are taken up by the respective hosts with their food; this takes place towards the end of summer, while the sheep feeding on the pasture land in the spring spread the eggs of the fluke, and sometimes the fluke itself, by passing them with their fæces.

In districts where *Limnæus truncatulus* is absent, analogous species act as the intermediary hosts, of which one example according to Lutz is *Limnæus oahuensis* in the Sandwich Islands.

[The host in Europe is *Limnæus truncatulus*. This snail extends from Siberia to Sicily and Algeria, and according to Captain Hutton is a native of Afghanistan. It also occurs in

Thibet, Amoor, Morocco, Tunis, Canary Islands and the Faroe Islands. It deposits its eggs or spawn upon the mud around ponds, ditches and streams. The eggs are laid in batches of thirty to a hundred, each snail laying as many as 1,500 eggs ; they are united into strips of a gelatinous substance. In about two weeks young snails appear. It is amphibious, being more frequently met with out of the water than in it. It occurs in elevated spots as well as in low-lying districts. Moquin-Tandon found it at 4,000 feet in the Pyrenees. In the allied species, *L. peregra*, the fluke will develop up to a certain stage, but never completes all its varied phases.

[In South America the host is probably *Limnæus viator*, Orb., and in North America *Limnæus humilis*, Say.—F. V. T.]

In human beings as well as in some of the mammals quoted above, the liver fluke is only a casual parasite, and hitherto only twenty-eight cases have been observed in man ; the infection was mostly a mild one and there were no symptoms, or only very trifling ones ; a few isolated cases were only discovered *post mortem*. Occasionally, however, even when the infection was inconsiderable, severe symptoms were set up, which in isolated cases led to death. The symptoms (enlargement and painfulness of the liver, icterus) merely pointed to a disease of the liver.

Diagnosis can only be established by finding eggs in the fæces. Care should be taken not to confuse them with those of *Dibothriocephalus latus.*

Halzoun.

In North Lebanon, the liver fluke is, according to A. Khouri, a frequent parasite of man, not in the liver, however, but in the pharynx. The occurrence in this unusual site is effected by the eating of raw infected livers, especially those of goats (*Capra hircus*). The flukes thus taken in do not all reach the stomach, where they would be soon killed, but some of them attach themselves to the pharyngeal mucosa and to the adjoining parts, and there cause inflammation and swelling, which lead to dyspnœa, dysphagia, dysphonia and congestion of the head, sometimes even to still more severe symptoms, and even death. The affection termed "Halzoun" lasts some hours or several days, and after vomiting recovery sets in. In other cases man becomes infected in the usual way by ingesting cysts attached to grass or the underside of leaves of plants (*e.g.*, Rumex sp.), where they

FIG. 144.—Young *Fasciola hepatica*, soon after entry into the liver. The intestinal cæca have lateral diverticula. Magnified. (From Leuckart.)

are overlooked from their scanty size (0·2 to 0·3 mm.).

As the liver fluke feeds on blood it is possible that it also reaches, particularly when young, the circulatory system, and cases have been known in which it has been carried by the blood into organs far from its original situation. Such cases also have been repeatedly observed in men. Probably the parasite described by Treutler, 1793, as *Hexathyridium venarum*, which protruded from the ruptured anterior tibial vein of a man, was a young liver fluke. A few adult specimens were found by Duval in the portal and other veins *post mortem* at Rennes (1842) in a man, aged 49, and a similar statement is reported by Vital from Constantine (1874). Giesker, in 1850, found two hepatic flukes in a swelling on the sole of the foot of a woman. Penn Harris states that he observed six specimens in Liverpool in a spontaneously ruptured abscess of the occiput of a two months old infant. Another case which, like the previous

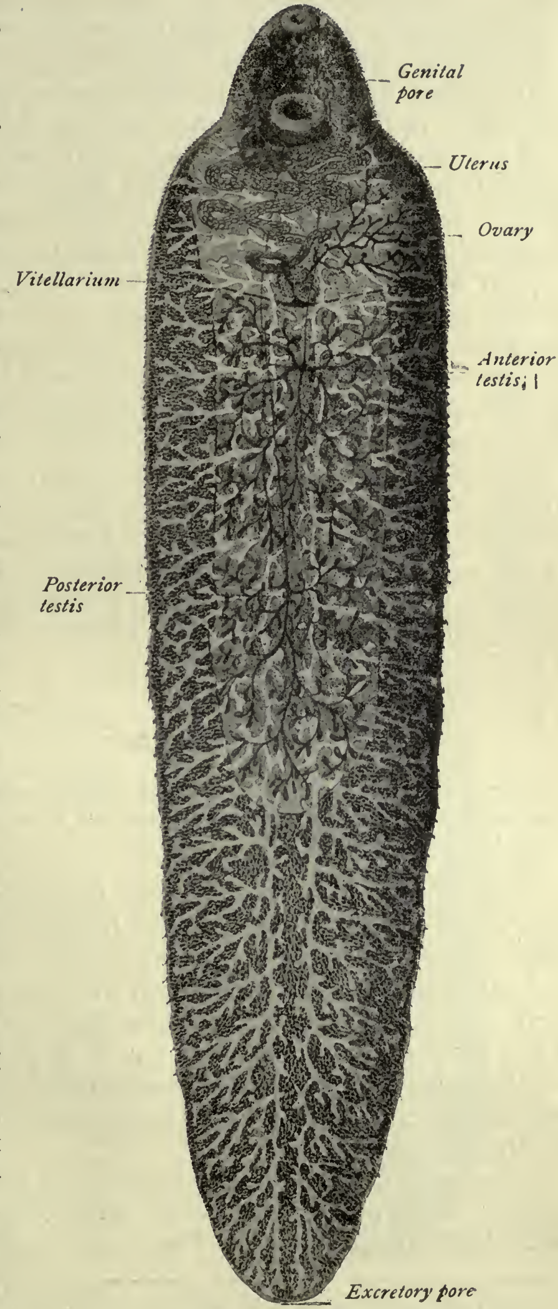


FIG. 145.—*Fasciola gigantica*. × 6½.
(After Looss.)

one, is reported by Lankester,[1] relates to a sailor who suffered from an abscess behind the ear, and from which a liver fluke was expelled. Finally, Dionis de Carrières reports the case of a man, aged 35, in whose right hypochondriac region a tumour the size of a pigeon's egg had formed, and from which a young liver fluke was extracted.

From such records it is not impossible that *Distomum oculi humani*, Ammon, 1833, as well as *Monostomum lentis*, v. Nordm., 1832, may have been very young hepatic flukes that had strayed. Ammon found four specimens (length 0·5 to 1 mm.) of his species (named *Distomum ophthalmobium* by Diesing in 1850) between the opaque lens and the capsule of a five months old child in Dresden, and von Nordmann discovered his *Monostomum lentis* to the number of eight specimens (only 0·3 mm. in length) in the opaque lens of an old woman. Minute white bodies which Greef found in the cortex of the lens of a fisherman, aged 55, removed on account of cataract, were with some reserve regarded as Trematode larvæ. The fact that Ammon found that the intestinal cæca of the worm discovered by him had no lateral branches does not negative the above opinion, as in the liver fluke the intestinal cæca are originally unbranched, and according to Lutz they only develop lateral ramifications later, between the twelfth and twenty-second day of infection (fig. 144).

Fasciola gigantica, Cobbold, 1856.

Syn.: *Distomum giganteum*, Diesing, 1858; *Fasciola gigantea*, Cobbold, 1858; *Cladocœlium giganteum*, Stoss., 1892; *Fasciola hepatica* var. *angusta*, Raill., 1895; *Fasciola hepatica* var. *ægyptiaca*, Looss, 1896.

This species is closely allied to *Fasciola hepatica*, but is distinguished by its elongated body, short cephalic cone, almost parallel sides, larger ventral sucker, which is also closer to the oral sucker, and by its larger eggs. Length up to 75 mm., width up to 12 mm. Oral sucker 1 to 1·2 mm., ventral sucker up to 1·7 mm. in diameter. Eggs 150 μ to 190 μ long by 75 μ to 90 μ broad.

Habitat.—Bile-ducts of *Camelopardalis giraffa, Bos taurus, Bos indicus, Bos bubalis, Ovis aries* and *Capra hircus*.

Distribution.—Africa.

This species has once been observed in man by Gouvea, in Rio de Janeiro, in a French naval officer who became ill with fever, cough and slight blood-spitting. The lungs were normal except for a

[1] In the English translation of Küchenmeister's work on Parasitology (London, 1857). The specimen is preserved in the Hunterian Museum, London, and is an adult liver fluke, measuring 18 mm. in length and 7 mm. in breadth.

sharply circumscribed spot at the base of the left lung. Twenty days later during a fit of coughing the patient spat up a fluke 25 mm. long, characterized by its slender aspect and by the size of its ventral sucker, and its close proximity to the oral sucker. Considering the fact that Gouvea's patient had spent many weeks in July of the same year in Dakar (Senegambia), where according to Railliet *Fasciola gigantica* is common in slaughtered animals, and considering also the characters of the fluke, Railliet rightly assumes that one had to do with the African giant fluke and that the patient had infected himself in Dakar.

Sub-family. **Fasciolopsinæ**, Odhner, 1910.

Genus. **Fasciolopsis**, Looss, 1898.

Ventral sucker large, and elongated posteriorly into a sac. Cirrus pouch long and cylindrical, its greatest length being occupied by the sinuous tubular seminal vesicle, on which exists a peculiar cæcal appendage. Laurer's canal present.

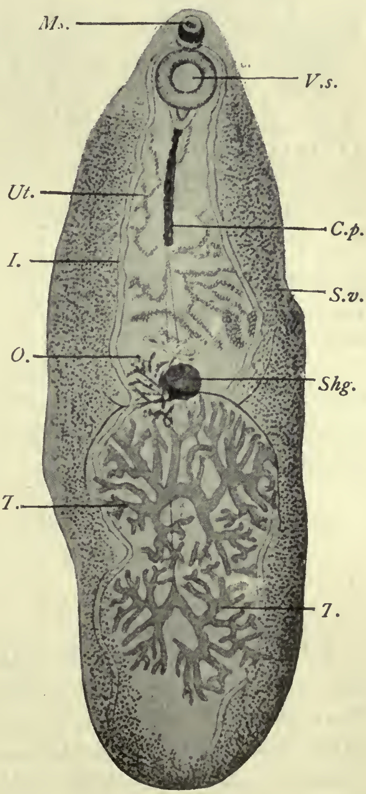


FIG. 146.—*Fasciolopsis buski*, Lank. *V.s.*, ventral sucker; *C.p.*, cirrus pouch; *I.*, intestinal fork; *S.v.*, vitellaria; *T.*, testes; *O.*, ovary; *Ms.*, sucker; *Shg.*, shell gland; *Ut.*, uterus. Magnified. (After Odhner.)

Fasciolopsis buski, Lank., 1857.

Syn.: *Distomum buski*, Lank., 1857; *Dist. crassum*, Cobbold, 1860, *nec* v. Sieb., 1836.

The length of the body varies; it may measure 24 to 37 or even attain 70 mm.; the breadth is from 5·5 to 12 to 14 mm. In the pig the fresh parasites measure, smallest, 12 to 8 mm.; largest, 35 to 16 mm. (Mathis and Léger). Skin without spines, but according to Heanly always present in man and pig specimens. The oral sucker measures 0·5 mm. in diameter; the ventral sucker is three to four times as large; the pharynx is globular, 0·7 mm. in diameter; the prepharynx is provided with a sphincter; the intestinal cæca extend to the posterior border with two characteristic curves, one at the anterior border of the anterior testis, the other between the two testes. The genital pore is at the anterior border of the ventral sucker; the cylindrical cirrus pouch extends from behind the ventral sucker to half-way to the shell gland. The seminal vesicle extends forwards within the cirrus pouch as a convoluted tube. From its anterior portion is given off the cæcal appendage, which has itself short lateral diverticula. It runs backwards, ending blindly about 0·5 mm. from the posterior end of the cirrus sac. The seminal vesicle is continued as the pars prostatica (?) 0·5 mm. long, and this by the very short ejaculatory duct (13 μ), and finally by the fairly long cirrus, which is beset with very fine spines except at either extremity. The ovary and shell gland are situated at about the middle of the body with the testes behind them, and the uterus in front. The vitellaria extend from the ventral sucker to the posterior border. The eggs measure 120 μ to 130 μ in length and 77 μ to 80 μ in breadth, and resemble those of Echinochasma sp. in dogs. The larval stages are said to occur in shrimps.

FIG. 147. — *Fasciolopsis rathouisi*, Poir.: the mouth at the top, and under it the genital pore and ventral sucker, behind which again is the uterus. The vitellaria are at the sides, and posteriorly in the central field the ramified testes; the ovary is in front of the right testis. (After Claus.)

Habitat.—Intestine of pig and man.

Distribution.—In man: India, Siam, China, Assam, Sumatra. It is common in Cochin China (16 out of 133 Annamites, Noc.), in Tonkin very rare. Dr. J. Bell has sent me [J. W. W. S.] human specimens from Hong Kong. In pigs: very common in South China (Heanly). Common in pigs in Hong Kong. Sixteen out of 248 pigs (*i.e.*, 6 per cent.) infected in Hanoi.

Fasciolopsis rathouisi, Ward, 1903.

Syn.: *Distomum rathouisi*, Poirier, 1887.

Fifteen to 19 mm. long by 8·5 to 10·5 mm. broad by about 3 mm. thick. Skin with spines (Leiper). Bluntly oval or elliptical with short cephalic cone which is absent in *Fasciolopsis buski*. Oral sucker subterminal, 0·25 to 0·29 mm. broad by 0·2 mm. in antero-posterior diameter. Distant from ventral sucker by about twice its diameter. Ventral sucker 1·32 to 1·38 mm. broad by 0·68 to 0·7 mm. in antero-posterior diameter. Œsophagus extremely short. Cirrus sac not conspicuous and straight as in *Fasciolopsis buski*, but is convoluted. Testes one behind the other (according to Poirier they lie beside one another), more compactly branched, broader and denser than in *Fasciolopsis buski.* Ovary on right side, small, coarsely branched. Uterus in broad, closely grouped coils, packed with ova anterior to ovary. Vitellarian acini more numerous and somewhat differently distributed. Eggs 150 μ by 80 μ, thin shelled. [H. B. Ward, who has examined this species, and from whose account the above is mainly taken, considers that it is a good species, although the differences between it and *Fasciolopsis buski* are slight, while Odhner, who examined the original species, is of the opposite opinion.—J. W. W. S.] The parasite appears to cause diarrhœa, wasting and occasionally jaundice.

Habitat.—Intestine of man.

Distribution.—China, common in some parts (Goddard).

Fasciolopsis goddardi, Ward, 1910.

Twenty-one to 22 mm. long, 9 mm. broad. Skin with spines (Leiper). Uterus very closely coiled, most striking character is the large size of the vitelline acini. Imperfectly known.

Distribution.—China (Shanghai).

Fasciolopsis fülleborni, Rodenwaldt, 1909.

The fully extended fluke is tongue-shaped, 50 by 14 mm.; two contracted specimens measured 40 by 15 mm. and 30 by 16 mm. respectively. Skin without spines, with according to Leiper cephalic cone not clearly defined. Oral sucker circular, 0·75 mm. in diameter, slightly larger than that of *Fasciolopsis buski.* Ventral sucker 2·6 mm. in diameter (that of *Fasciolopsis buski* 1·6 to 2 mm.). Length 2·9 mm. (as in *Fasciolopsis rathouisi*), the excess of length over breadth being due to the posterior elongated sac-like prolongation of the sucker. Prepharyngeal sphincter present. Pharynx 0·7 mm. in diameter. Œsophagus practically absent. Gut cæca similar to those of *Fasciolopsis buski.*

Testes—regularly branched, separated by an incurving of the cæca, the anterior occupying a smaller area than the posterior.

Ovary—very small, as in *Fasciolopsis buski*, on the right side.

Shell Gland—almond-shaped, 2·3 by 1·2 mm. In *Fasciolopsis buski* it is round and smaller, 1 to 1·5 mm. in diameter.

Vitellaria—similar in distribution to those of *Fasciolopsis buski*, but the acini are strikingly small.

Cirrus Sac—is the most characteristic feature of this species. It is a powerfully built, convoluted sac standing out clearly on the body.

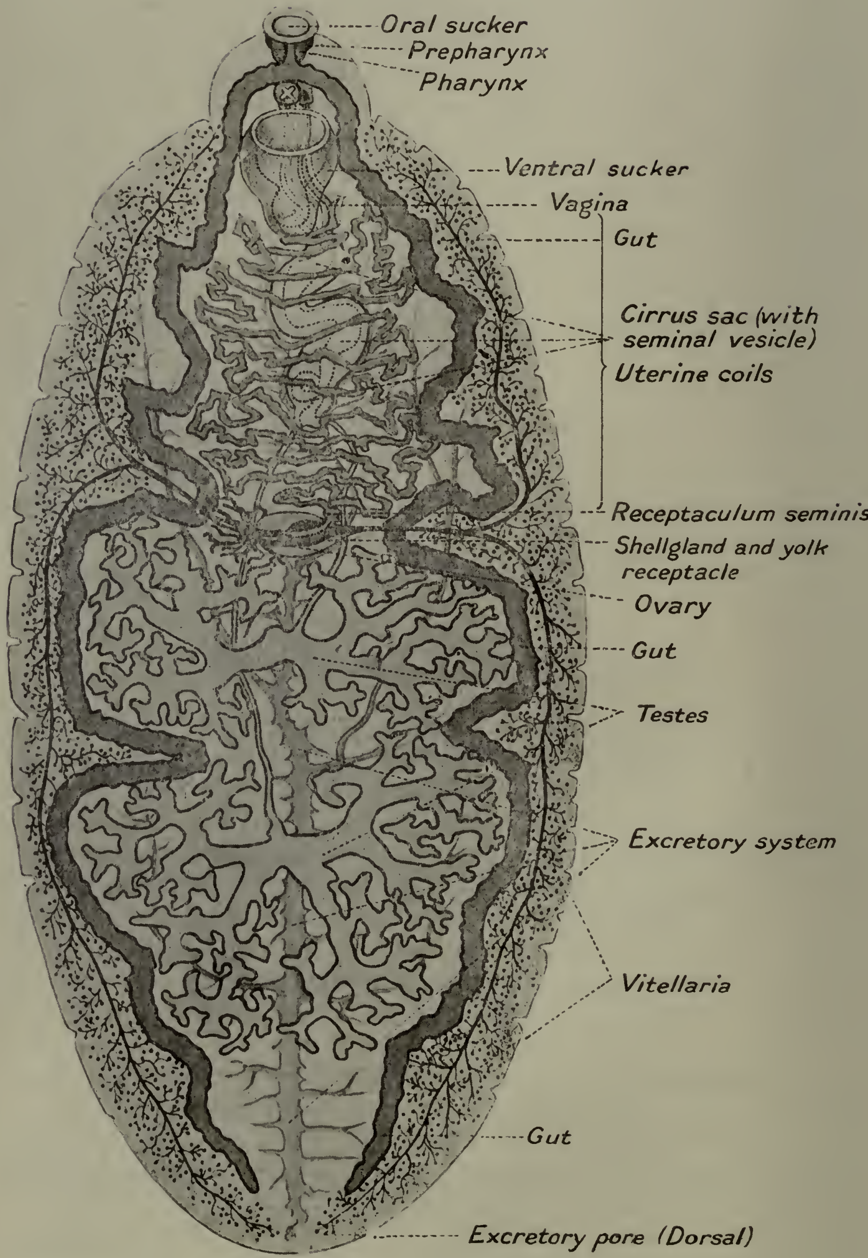


FIG. 148.—*Fasciolopsis fülleborni*, ventral aspect. (After Fülleborn.)

It is not a uniform, straight cylinder 0·25 to 0·33 mm. in diameter, as in *Fasciolopsis buski*, but even in fully extended flukes is typically convoluted. It is 1 mm. thick in the middle, but in other parts varies much from this. The posterior end of the cirrus sac is at two-thirds or more of the distance from ventral sucker to shell gland. In the case of *Fasciolopsis buski* the posterior end of the sac only extends half-way.

Seminal Vesicle—has a peculiar convoluted, saccular and angular course, but the cæcal appendage characteristic of the genus appears to be absent!

Excretory System.—The main stem gives off very regular transverse branches which are well seen posteriorly.

Eggs.—100 μ by 73 μ. Thin shelled.

Habitat.—Intestine. Mahommedan from Calcutta.

[It is evident that a re-examination of fresh material is required before the validity of all these species can be accepted.—J. W. W. S.]

Family. **Troglotremidæ**, Odhner, 1914.

Genus. **Paragonimus**, Braun, 1899.

Body egg-shaped or somewhat elongated, generally more broadly rounded in front than behind. Covered all over with spear-shaped spines *arranged in groups.* Gut cæca winding with dilatations or constrictions in parts. Ventral sucker in or in front of the middle of the body. Excretory bladder cylindrical, very long and broad, reaching in front to the bifurcation of the gut. The lateral excretory canals join the bladder only a little in front of the excretory pore. Genital pore median just behind the ventral sucker. Genital sinus duct-like. Cirrus sac absent. Male terminal organs very small. Ejaculatory duct present. Testes and ovary deeply lobed, the testes in or just behind the middle, the ovary somewhat laterally placed just *behind* the ventral sucker. Uterus forms a coil behind the ventral sucker. Eggs rather large, thin shelled, the ovarian cell still unsegmented on deposition. Receptaculum seminis, small.

Parasitic in the lungs of mammals, enclosed in cyst-like cavities, generally in pairs.

Type Species.—P. westermanii in the tiger.

Paragonimus ringeri, Cobb., 1880.

Syn.: *Distoma ringeri*, Cobb., 1880; *Distoma pulmonale*, Baelz, 1883; *Distoma pulmonis*, Suga, 1883.

The body is of a faint reddish-brown colour and plump oval shape. The ventral surface a little flattened; 7·5 to 12 mm. in length, 4 to 6 mm. in breadth, and 3·5 to 5 mm. thick (in man). The oral sucker (0·75 mm.) is subterminal; the ventral sucker (0·8 mm.) somewhat in front of the middle of the body. Pharynx spherical, 0·3 mm. in diameter, or 0·4 by 0·3 mm.; œsophagus, 0·02 mm.; intestinal cæca convoluted, asymmetrical, the first part having the same structure as the œsophagus. The cuticle is covered with spines in groups; the excretory pore opens at the posterior end rather on the ventral surface, the excretory ducts open into the elongated bladder at the hind end near the pore. Genital pore behind the ventral sucker and median. Genital sinus 0·2 mm. long with thick wall, ejaculatory duct 0·13 mm., pars prostatica 0·2 mm., seminal vesicle duct-like of irregular outline. Behind the sucker the ovary on the left, and the closely packed uterine coil on the right (though amphitypy of these two organs is common); the two irregularly lobed testes lie side by side posteriorly. Vitellaria extensive, leaving only a median dorsal and ventral space

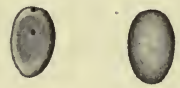


FIG. 149.—*Paragonimus ringeri*, Cobb.: to the right, dorsal aspect; to the left, ventral aspect. Natural size. (After Katsurada.)

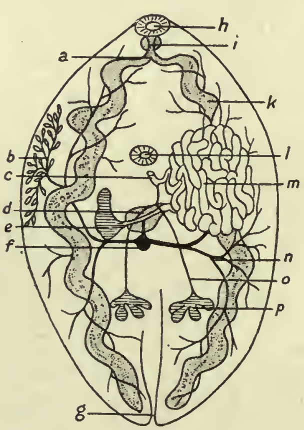


FIG. 150.—*Paragonimus ringeri*, Cobb.: diagram of the internal organs. *a*, œsophagus; *b*, vitellaria (a portion only shown); *c*, common genital duct; *d*, shell gland with oviduct, Laurer's canal and vitelline duct; *e*, ovary; *f*, vitelline receptacle; *g*, excretory pore; *h*, oral sucker; *i*, pharynx; *k*, gut; *l*, ventral sucker; *m*, uterine coils; *n*, vitellarian ducts; *o*, vas efferens; *p*, testis. (After Kubo.)

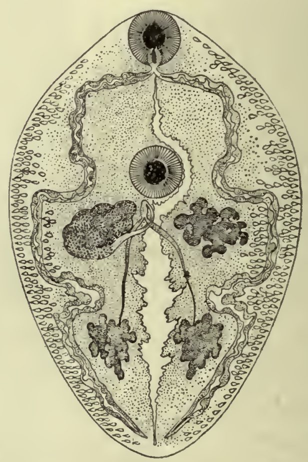


FIG. 150A.—*Paragonimus westermanii*, Kerb.: seen from the ventral surface. Mouth, pharynx, intestinal cæca, at the sides of which the vitellaria are observed. The genital pore is behind the ventral sucker, and next to it, on the left, the ovary; on the right, the uterus; the two testes posteriorly; the excretory vessel in the middle. 10/1. (After Leuckart.)

free. Seminal receptacle probably absent; Laurer's canal present. The eggs are oval, brownish-yellow, fairly thin shelled, and measure on an average 81·2 μ by 49·2 μ.

The following species are also known:—*P. westermanii*, Kerb., 1878, in the tiger, and *P. kellicotti*, Ward, 1908, in the pig, dog, and cat (N. America). Ward and Hirsch give the following differences between the spines of the three forms :—

	P. ringeri.	*P. westermanii.*	*P. kellicotti.*
Shape	Chisel-shaped, moderately heavy.	Lancet-shaped, very slender.	Chisel-shaped, heavy.
Distribution ...	Circular rows, in groups.	Circular rows, in groups.	Circular rows, singly.

Two other species, *P. rudis*, Diesing, 1850, in a Brazilian otter (*Lutra brasiliensis*), and *P. compactus*, Cobbold, 1859, in the Indian ichneumon, are but little known.

Habitat.—Lungs, pleuræ, and especially the bronchi of man and dog. The alleged occurrence (of eggs) in other organs may be due to confusion with those of *Schistosoma japonicum.*

Distribution.—China, Korea, and especially in Japan, where, according to Katsurada, there are no districts that are entirely free from pulmonary flukes. The *mountainous* provinces of Okayama, Kumamoto, Nagano and Tokushima are the principal centres.

Pathology. — The number present in the lung varies from two to twenty, about. Usually one cyst contains one worm, but in the dog each cyst contains two. The cysts admit the tip of the finger, and have a fibrous wall 1 mm. thick. They originate partly from dilatation of bronchi and bronchioles. Others arise from the inflammatory reaction of lung tissue into which the worms have wandered. The worms and their eggs cause bronchitis and peribronchitis, catarrhal, hæmorrhagic, or purulent, and areas of consolidation. Areas containing eggs in their centre resembling tubercle nodules are not uncommon, and extensive cirrhosis of the lung may be found. As a result of these changes, emphysema and bronchiectasis also occur.

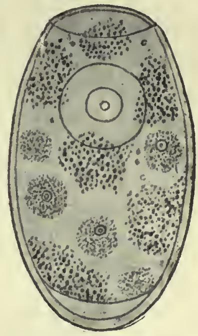


FIG. 151.—Egg of *Paragonimus ringeri*, Cobb., from the sputum. Showing the ovarian cell and vitelline cells and granules. 1,000/1. (After Katsurada.)

As to the development, only the following details are known: that the eggs, which before segmentation of the ovum reach the open in the sputum and through being swallowed also in the fæces, develop in water into a miracidium ciliated all over, which hatches and swims about freely. According to Manson this takes place in four to six weeks.

Sub-family. **Opisthorchiinæ**, Looss, 1899.

Genus. **Opisthorchis**, R. Blanch., 1845.

Opisthorchiinæ with lobed testes. Laurer's canal present. Parasitic in the bile-ducts of mammals and birds.

Opisthorchis felineus, Riv., 1885.

Syn.: *Distoma conus*, Gurlt, 1831 (*nec* Creplin, 1825); *Distoma lanceolatum*, v. Sieb., 1836, v. Tright, 1889 (*nec* Mehlis, 1825 = *Fasciolo lanceolata*, Rud., 1803); *Distoma sibiricum*, Winogr., 1892; *Distoma tenuicolle*, Mühl., 1896.

This parasite is yellowish-red in the fresh condition, and almost transparent. The body is flat, with a conical neck at the level of the ventral sucker marked by a shallow constriction; this, however, is only noticeable in fresh and somewhat contracted specimens. Posteriorly to the ventral sucker the lateral borders run fairly parallel; the posterior end is either pointed or rounded off. The length and breadth vary according to the contraction, being usually 8 to 11 mm. by 1·5 to 2 mm. The suckers are about one-fifth to one-sixth of the length of the body distant from each other, and of about equal size (0·23 to 0·25 mm.). The œsophagus is hardly any longer than the pharynx, which lies close behind the oral sucker; the intestinal cæca reach almost to the posterior border and are often filled with blood. The excretory pore is at the posterior extremity, and the excretory bladder forks in front of the anterior testis. The testes in the posterior fourth of the body lie obliquely one behind the other; the anterior one has four lobes, the posterior one five lobes; the ovary is in the median line transversely, simple or slightly lobed; behind it lies the large pear- or retort-shaped receptaculum seminis and Laurer's canal. The uterus is in the median field. The vitellaria occupy the fairly broad lateral areas, in about the central third of the body, beginning behind the ventral sucker and terminating at about the level of the ovary; the acini are small and arranged in groups of seven to eight, separated by interstices. The genital pore is close in front of the ventral sucker. The eggs are oval with sharply defined operculum at the pointed pole, 30 μ by 11 μ.

This species, which is frequently confused with others, inhabits the gall-bladder and bile-ducts of the domestic cat especially; but is also found in the dog, in the fox, and in the glutton (*Gulo borealis*). It has been observed in France, Holland, North Germany (being particularly frequent in East Prussia), in Russia, Scandinavia, Siberia, Japan, Tonkin, Hungary, and Italy. The North American form (from cats and *Canis latrans*) is a distinct species (*Opisthorchis pseudofelineus*).

In man this species was first found by Winogradoff in Tomsk (nine cases), then by Kholodkowsky in a peasant from the neighbourhood of Petrograd who had travelled a great deal in Siberia, and finally by Askanazy in five persons who were natives of the East Prussian district of Heydekrug. In Tomsk, *Opisthorchis felineus* is the most frequent parasite of man that comes under observation at *post mortem* (6·45 per cent.), whereas *Tænia saginata* has only been found in 3·2 per cent., Echinococcus in 2·4 per cent., *Ascaris lumbricoides* in 1·6 per cent., and *Oxyuris vermicularis* in 0·8 per cent. of the autopsies. In the district of Heydekrug, however, the species in question is also frequent, as in a few years five cases came to our knowledge (of which three were diagnosed by the discovery of the eggs in the fæces).

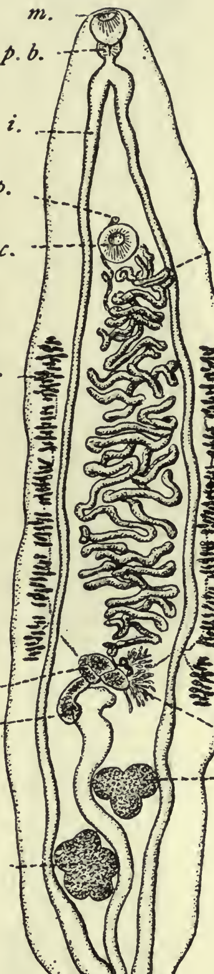
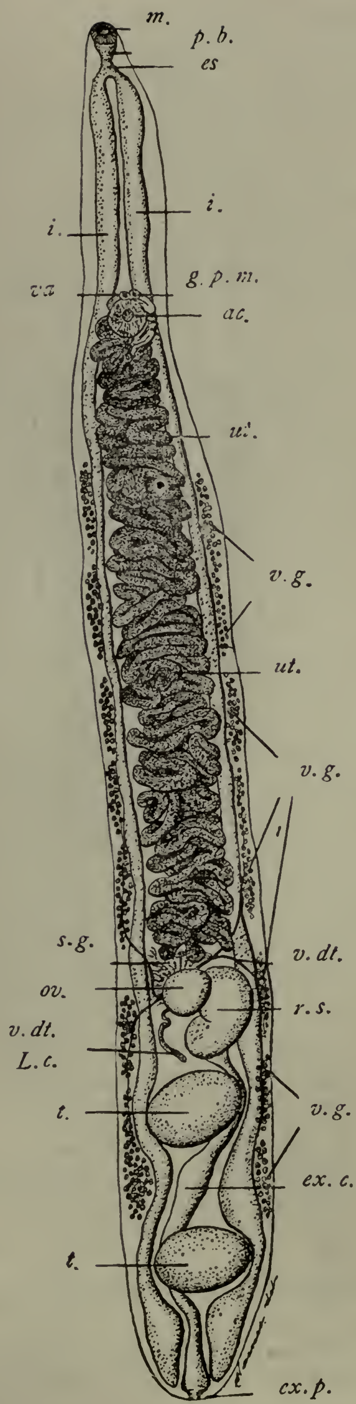


FIG. 153.— *Opisthorchis felineus*: from the cat. *m.*, mouth; *p.b.*, pharynx; *i.*, gut; *g.p.*, genital pore; *ac.*, ventral sucker; *ut.*, uterus; *v.g.*, vitellarium; *ov.*, ovary; *s.g.*, shell gland; *r.s.*, receptaculum seminis; *t.* testes; *ex. p.*, excretory pore. (After Stiles and Hassall.)

In none of Winogradoff's nine cases had the death of the patient been caused direct by the parasites, yet more or less extensive changes in the liver were found in all of them; such as dilatation of the bile-ducts with inflammation and thickening of their walls, and foci of inflammation or atrophy in the liver substance; icterus was present five times and atrophy of the liver an equal number of times; ascites was observed three times, and in two cases, probably of recent date, the organ was enlarged. The number of parasites found fluctuated between a few and several hundreds.

FIG. 152.— Egg of *Opisthorchis felineus*, Riv. 830/1.

In two of Askanazy's cases, which he examined more closely, carcinoma which had developed at the places most invaded by flukes was found at the *post-mortem*, so that perhaps there may be grounds for the connection which the author seeks to establish between cancer of the liver and the changes induced by the parasites; these changes consist of numerous and even ramified



proliferations of the epithelium of the biliary duct into the connective tissue, which is likewise proliferated. The number of worms found in one case amounted to over 100; in a second case, in which the parasites had also invaded the pancreatic duct, their number was even larger.

Winogradoff as well as Askanazy found isolated flukes in the intestine also.

Unfortunately, nothing much is known of the history of the development of *Opisthorchis felineus;* we only know that when deposited the eggs already contain a ciliated miracidium, which, however, according to my experience, does not hatch out in water, but only after the entry of the eggs into the intestine of young *Limnæus stagnalis;* no further development, however, occurs. Winogradoff states that he has seen the miracidia hatch after the eggs had been kept in water for a month at 37° C.; and has even observed free miracidia in the bile of man and of a dog respectively. Although the whole post-embryonal development of the cat fluke remains yet to be investigated, Askanazy by a series of experiments on cats and dogs has discovered the mode of infection. The intermediate hosts are fish, and mainly the ide, in this country called Tapar (*Idus melanotus*, H. and Kr.), and of subsidiary importance the

FIG. 154.—*Opisthorchis pseudofelineus:* from the bile-duct of the cat (Iowa). *m.*, oral sucker; *p.b.*, pharyngeal bulb; *es.*, œsophagus; *i.*, intestine; *va.*, vagina; *g.p.m.*, male orifice; *ac.*, ventral sucker; *ut.*, uterus; *v.g.*, vitellarium; *s.g.*, shell gland; *v.dt.*, vitelline duct; *ov.*, ovary; *r.s.*, receptaculum seminis; *L.c.*, Laurer's canal; *t.*, testis; *ex.c.*, excretory bladder; *ex.p.*, excretory pore. (After Stiles.)

roach (*Leuciscus rutilus*). Both species of fish as well as others are readily eaten raw by man on the Courland lagoon (Baltic). It is, moreover, significant that those persons whom Askanazy found infected with the cat fluke were also infected with *Dibothriocephalus latus*, the intermediate host of which is also fish (Lota sp., Esox sp., Perca sp.).

In one of his nine cases Winogradoff also saw a small fluke covered all over with spines, which he conjectured to be the young stage of *Opisthorchis felineus*; as, however, according to my experience, this species, even in smaller specimens, is always without spines, the above hypothesis cannot be accepted. It is much more probable that one of the other species that also invade the liver of cats may accidentally be introduced into man; we know, in fact, that *Metorchis albidus*, Braun, and *Metorchis truncatus*, Rud., are both covered with spines. As, however, the spines of the first-named species are rather apt to fall off, and also as it possesses a different shape (spatula-shaped), it may be assumed that probably Winogradoff had found *Metorchis truncatus*, Rud., 1819, in his patient.

Genus. **Paropisthorchis**, Stephens, 1912.

Structure as in Opisthorchis, except that the ventral sucker and genital pore occur on the apex of a process or pedicle projecting from the anterior portion of the body. This process is about ½ mm. long, and is retractile.

Paropisthorchis caninus, Barker, 1912.

Syn.: *Distoma conjunctum*, Lewis and Cunningham, 1872; *Opisthorchis noverca*, M. Braun, 1903 (*pro parte*); *Opisthorchis caninus*, Barker, 1912 (?).

Length varies from 2·75 to 5·75 mm. in preserved specimens, average 3·6 to 5·2 mm. Body uniformly spinose, though as a rule spines are not present on the pedicle. Body slightly concavo-convex, the concavity being ventral. Oral sucker 0·28 mm. Pharynx 0·224 by 0·184 mm. Œsophagus 0·04 mm. Ventral sucker 0·176 mm. in diameter. Pedicle about ½ mm. long, may be completely retracted.

Genital Pore—opens on the apex of the pedicle in front of the ventral sucker. Its exact position varies with the state of contraction of the parts. In certain cases it actually opens within the cuticular border of the sucker, in other cases it opens externally to the sucker and anterior to it. The opening is covered with scales. The vas deferens and uterus run alongside one another until they merge near the apex of the pedicle into a common sinus.

Vitellaria—consist of eight acini on each side, extending from slightly behind the base of the pedicle to the anterior border of the ovary, or as far back as a line separating the posterior border of the ovary from the anterior border of the anterior testis.

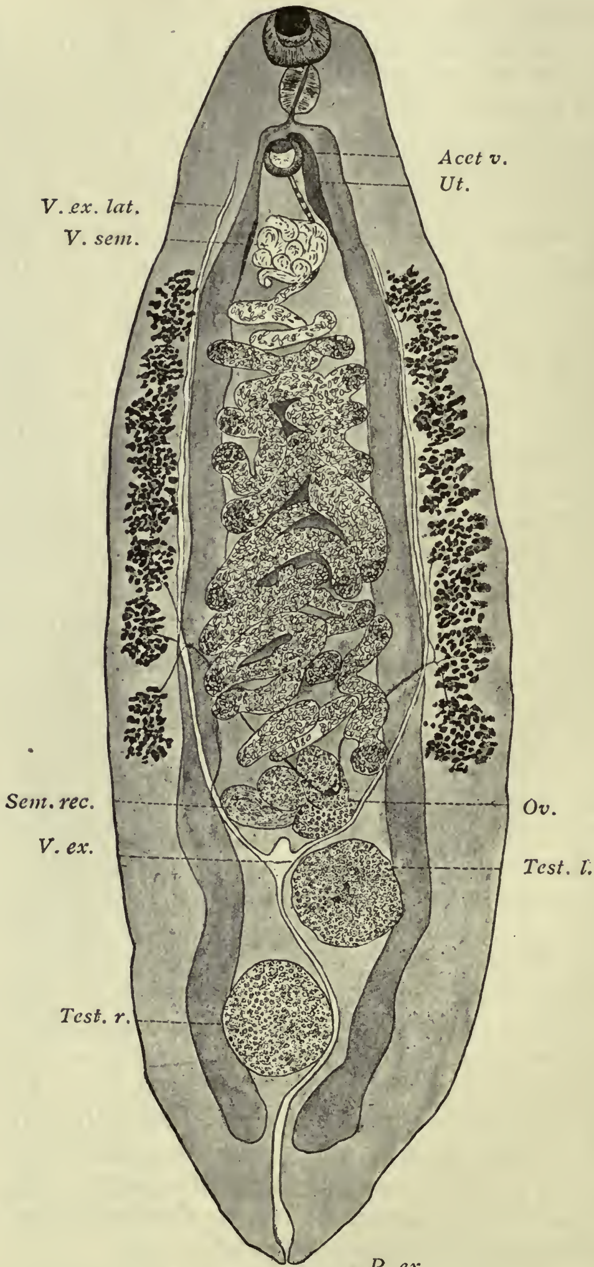


FIG. 155.—*Paropisthorchis caninus:* from the bile-ducts of the pariah dog, India. *Acet. v.*, ventral sucker; *Ut.*, uterus; *V. ex. lat.*, longitudinal excretory duct; *V. sem.*, seminal vesicle; *Sem. rec.*, seminal receptacle; *Ov.*, ovary; *V. ex.*, excretory bladder; *Test. l.*, left testis; *Test. r.*, right testis; *P. ex.*, excretory pore. × 40. (After Stephens.)

Testes.—Anterior testis 0·496 by 0·44 mm.; posterior testis 0·52 by 0·48 mm., usually ovoid, though both may be regularly lobed. The anterior testis is usually on the left side.

Ovary—multilobular, the lobes 6 to 8 being irregular in size and shape.

Shell Gland—extensive and diffuse, occupying an area which approximately corresponds with the loop of the transverse vitelline ducts.

Seminal Receptacle—globular, to the right of and dorsal to the posterior lobe of the ovary.

Laurer's Canal—generally runs from the end of the receptacle with a single curve medially and backwards.

Uterine Coils—form loosely packed transverse coils terminating slightly in front of the level of the first vitelline acini. From here the uterus passes forwards into the pedicle to the left and ventral to the seminal vesicle.

Seminal Vesicle—commences about the level of the first vitelline acini. The coils displace the uterus ventrally and to the left. In the pedicle the vesicle diminishes in extent and lies in its dorsal (anterior) side.

Habitat.—Liver of pariah dogs, India. In North-Western Provinces about 40 per cent. are infected. This fluke appears to be different from *Amphimerus* (*Opisthorchis*) *noverca* in man, as the latter has not the pedicle on the summit of which lie the sucker and common genital pore.

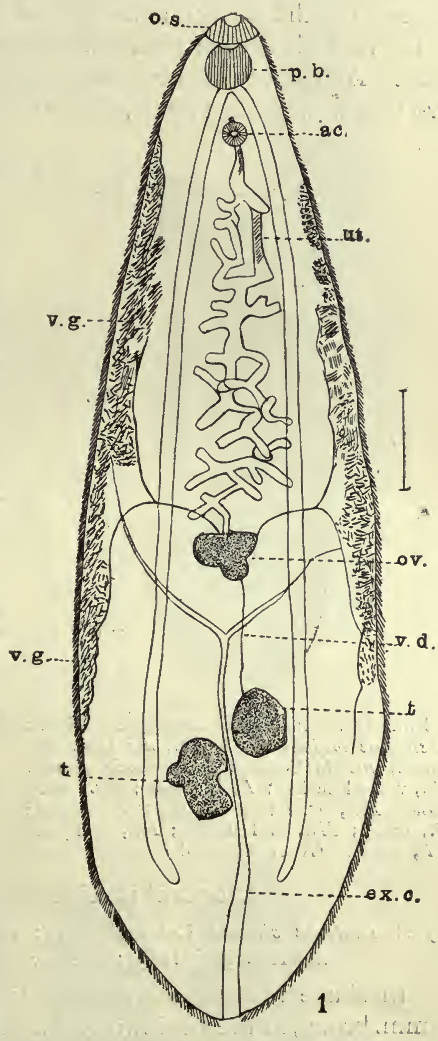


FIG. 156.—*Amphimerus noverca*, Braun. o.s., oral sucker; p.b., pharynx; ac., ventral sucker; ut., uterus; v.g., vitellarium; ov., ovary; v.d., vas efferens; ex.c., excretory canal; t., testis. (After McConnell.)

Genus. **Amphimerus**, Barker, 1912 (?).

Structure as in Opisthorchis, except that the vitellaria are separated into two portions, an ant-ovarial and a post-ovarial.

Amphimerus noverca, Barker, 1912 (?).

Syn.: *Distomum conjunctum*, McConnell, 1876 (*nec* Cobbold, 1859); *Opisthorchis noverca*, M. Braun, 1903 *pro parte*.

At the autopsy of two Mahommedans who died in Calcutta, McConnell found a large number of Distomata in the thickened and dilated bile-ducts. The worms were lancet-shaped, covered with spines, and measured 9·5 to 12·7 mm. in length and 2·5 mm. in breadth. The two suckers lie very close to one another, the anterior one being larger than the ventral; the genital pore opens immediately in front of the ventral sucker; pharynx spherical; intestinal cæca extending far back. At the commencement of the posterior third of the body the two testes, somewhat apart, the anterior one roundish, the posterior one distinctly lobed. The transverse and slightly lobed ovary in front of the bifurcation of the Y-shaped excretory bladder, whence the uterus, in convolutions barely spreading beyond the central field, extends to the pore; the vitellaria in the lateral areas commence behind the ventral sucker and extend to the testes. Cirrus pouch absent. Eggs oval, 34 μ by 21 μ.

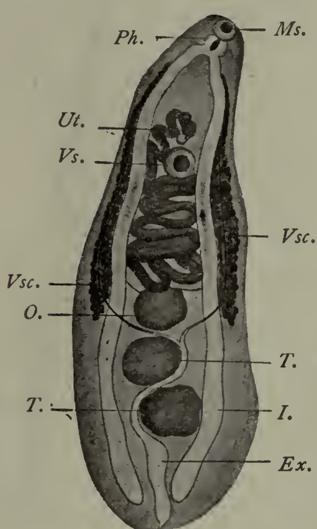


FIG. 157.—*Metorchis conjunctus*,[1] (Syn.: *Distomum conjunctum*, Cobb., *nec* Lew. and Cunn., *nec* McConn.): from *Canis fulvus*. *Vs.*, ventral sucker; *I.*, intestine; *Vsc.*, vitellaria; *Ex.*, excretory bladder; *T.*, testes; *O.*, ovary; *Ms.*, oral sucker; *Ph.*, pharynx; *Ut.*, uterus. (After Cobbold.)

Genus. Clonorchis, Looss, 1907.

Structure as in Opisthorchis, distinguished, however, by the branched testes situated one behind the other, the branches of which ventrally encroach upon the gut forks; dorsal to the testes the S-shaped excretory bladder, the main branches of which, arising at the level of the bifurcation of the gut, open into the bladder below its anterior end. Parasitic in the bile-ducts of mammals and man.

Clonorchis sinensis, Cobbold, 1875.

Syn.: *Distoma sinense*, Cobbold, 1875; *Distoma spathulatum*, R. Leuckart, 1876 (*nec* Rudolphi, 1819); *Distoma hepatis innocuum*, Baelz, 1883.

In shape resembles *Opisthorchis felineus*, 13 to 19 mm. long, 3 to 4 mm. broad, at the beginning of sexual maturity 12 to 13 mm. long, 2·5 to 3 mm. broad. Oral sucker 0·58 to 0·62 mm., ventral sucker 0·45 to

[1] This species from *Canis fulvus* was for long thought to be the same as that here described as *Amphimerus noverca*. It probably does not belong to the genus Metorchis.

0·49 mm. in transverse diameter. In the parenchyma numerous yellowish or brownish granules, especially behind the oral sucker and at the posterior end. Testicular branches very long, in the anterior testis often four, in the posterior testis five branches. Ovary generally with three large lobes and a smaller lobe. Vitellaria not always symmetrical, generally extending laterally from the ventral sucker to the ovary, interrupted in parts.

Eggs 26 μ to 30 μ by 15 μ to 17 μ. Average 29 μ by 16 μ.

This (?) species was discovered in 1874 by McConnell, in Calcutta, in the bile-ducts of a Chinaman who died shortly after being admitted into hospital.

Habitat.—Bile-ducts of man, dog and cat.

Distribution.—Especially in China, apparently rare in Japan.

FIG. 158.—*Clonorchis sinensis.* *C.L.*, Laurer's canal; *Dst.*, vitellaria; *Ex.*, excretory bladder; *H.*, testes; *K.*, ovary; *R.s.*, receptaculum seminis; *Vd.*, terminal section of vas deferens. Magnified 4½ times. (After Looss.)

Clonorchis endemicus, Baelz, 1883.

Syn.: *Distoma sinense* s. *spathulatum p.p.*; *Distoma hepatis endemicum* s. *perniciosum*, Baelz, 1883; *Distoma japonicum*, R. Blanchard, 1886.

Very similar to the previous species and consequently generally confused with it. Length between 6 and 13 mm., width varying between 1·8 and 2·6 mm. Oral sucker 0·37 to 0·5 mm., usually 0·43 to 0·45 mm. in transverse diameter; ventral sucker 0·33 to 0·45 mm., usually 0·37 to 0·40 mm. No pigment in parenchyma; anterior testis with four, posterior testis with five branches. Vitellaria continuous, ova 26 μ by 13 μ to 16 μ.

Habitat.—Bile-ducts of man, dog, cat and pig.

FIG. 159.—Ova of *Clonorchis sinensis.* The knobs on the ends of the eggs are not shown. 900/1. (After Looss.)

Distribution.—This species occurs very frequently in man, in certain districts of Japan, especially in the province of Okayama, Central Japan, in particular localities of which above 60 per cent. of the population are infected. The worms are sometimes found in enormous numbers in the liver (upwards of 4,000), also in the pancreas and rarely in the duodenum. It is common in Tonkin and Indo-China. Léger in Tonkin found 50 per cent. of people apparently in normal health infected, so that probably symptoms only arise when the infection is intense. [The exact distribution of these two species is, however, not precisely defined at present, as commonly no distinction is made between them.—J. W. W. S.]

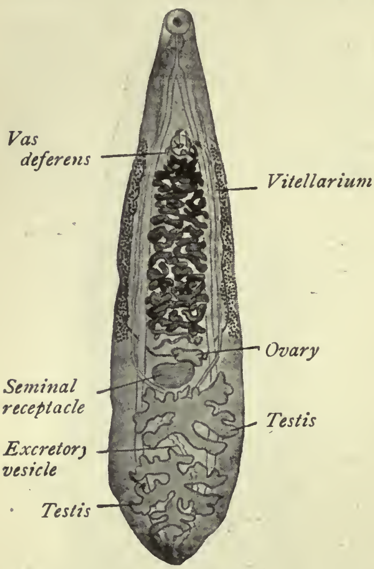


FIG. 160.—*Clonorchis endemicus.* × 6 about. (After Looss.)

Verdun and Bruyant deny, in opposition to Looss, the possibility of being able to distinguish within the genus Clonorchis the two species described, but they admit the justification for the new genus. They also report the occurrence of *Opisthorchis felineus* in man in Tonkin (*Compt. Rend. Soc. de Biol.*, lxii, 1907).

Pathology.—Both species of Clonorchis give rise to grave symptoms. The liver is generally enlarged, though when the infection has lasted some time it begins to contract. The surface of the organ is studded with white vesicles, and on cutting into it one sees numerous cavities with thickened walls (distended bile-ducts) filled with a brownish fluid containing innumerable eggs, which cause its colour. Microscopically, the epithelium of the bile-ducts is either (1) entirely destroyed, or (2) actively proliferates, forming an adenomatous outgrowth. Occasionally this proliferation is not limited by the wall of the bile-duct but penetrates it and leads to a growth of numerous new ducts, forming a

FIG. 161.—*Clonorchis endemicus:* eggs. The knobs on the eggs are not shown. × 900. (After Looss.)

malignant biliary adenoma. The bile-ducts have their connective tissue wall greatly sclerosed. These fuse with one another, forming areas of sclerosis devoid of liver tissue. As a result of these changes the liver cells atrophy and undergo fatty pigmentary and granular degeneration. Besides these changes, due probably to the toxic action of the flukes, mechanical obstruction due to the actual plugging of the ducts by the flukes causes retention of bile and icterus, and through pressure on veins, ascites and hypertrophy of the spleen.

To what extent blood or bile respectively forms the food of the flukes is uncertain.

Life-history.—(Kobayashi, 1911, *Mitteilungen aus dem kaiserlichen Institut für Infektions-Krankheiten zu Tokio*, pp. 58-62.)

It results from the work of Kobayashi in Japan that fresh-water fish form the *second* intermediate host for *Clonorchis endemicus.* He fed cats with encysted flukes (cercariæ) from various fish and easily succeeded in infecting them, *e.g.* a kitten, proved to be uninfected by repeated examination of its fæces, was fed on infected fish ; a month later innumerable flukes were found in the bile-ducts, gall-bladder, pancreas and even in the duodenum. The fish infected were *Leucogobis güntheri, Pseudorasbora parva,* and to a less extent *Acheclognathus lanceolata, Acheclognathus limbata, Paracheclognathus rhombea, Pseudoperilampus typus, Abbottina psegma, Biwia zezera* and *Sarcocheilichthys variegatus.* The cysts occur throughout the muscles and subcutaneous tissue of the fish. Length 0·13 mm., breadth 0·1 mm. The cercaria lies folded in the cyst, length 0·5 mm. breadth 0·1 mm. It tapers posteriorly. Skin at first covered with fine spines, disappearing as they grow older. Body dotted with fine pigment.

The *first* intermediate host is still unknown.

Sub-family. **Metorchiinæ,** Lühe, 1909.

Genus. **Metorchis,** Looss, 1899, emend. auctor.

Hind end rounded. Gut forks reach extreme end. Testes only slightly lobed, filling the hind end.

Metorchis truncatus, Rud., 1819.

This species, which attains a length of 2 mm., is slender and conical, the anterior end is pointed and the posterior truncated, and provided with a muscular tuberosity that resembles a terminal sucker ; for this reason the discoverer of the species (Rudolphi) classed it with the Amphistomes. The cuticle in the young, as well as in the adult specimens, is entirely and closely covered with spines. Suckers about equal in size (0·134 to 0·172 mm.) ; the ventral sucker lies somewhat in front of the middle of the body. The pharynx is small (0·09 mm.), the œsophagus minute, the intestinal cæca reach to the posterior extremity. Between them, and in front of their blind ends, lie the two elliptical testes, one generally a little in front of the other. In front of them, either in the median line or somewhat laterally, the spheroidal ovary is situated; in front, again, is the uterus, the coils of which usually extend beyond the median field. The vitellaria are at the sides of the central third of the body, thus commencing in front of the ventral sucker; cirrus pouch absent; the genital pore is close in front of the acetabulum. The excretory pore is terminal (?). Eggs 29 μ by 11 μ.

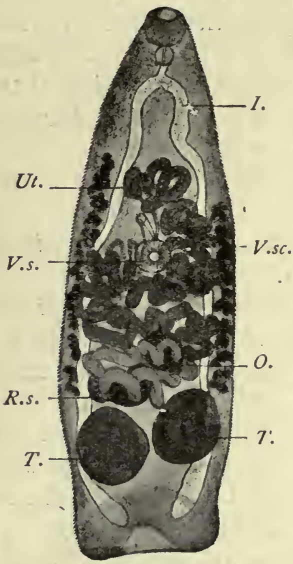


FIG. 162.—*Metorchis truncatus*, Rud.: from the biliary ducts of the domestic cat. *V.s.*, ventral sucker; *I.*, gut; *V.sc.*, vitellaria; *T.*, testes; *O.*, ovary; *R.s.*, receptaculum seminis; *Ut.*, uterus. 25/1.

Metorchis truncatus lives in the bile-ducts of the seal, cat, dog, fox, and glutton (*Gulo borealis*). The source of infection is unknown, although one would suspect fish. Askanazy did not succeed in getting this fluke in his feeding experiments, but another species, *Metorchis albidus*, not uncommon in cats by feeding them on roach (*Leuciscus rutilus*).

Family. **Heterophyiidæ**, Odhner, 1914.

Genus. **Heterophyes**, Cobbold, 1866.

Syn.: *Cotylogonimus*, Lühe, 1899; *Cœnogonimus*, Looss, 1899.

No crown of spines on head. Body divided into a narrow, movable, anterior part (neck), and a broader, less movable, posterior portion, which contains the genitalia. The suckers separated from one another by a space equal to half the length of the body or more; the pharynx is close behind the oral sucker; the œsophagus is long; the intestinal cæca extend to the posterior border; the genital pore is placed laterally, and behind the ventral sucker. Genital sucker provided with a circlet of chitinous rodlets, shaped like stags' horns. The testes are at the posterior end, the ovary in a median position in front of them. Laurer's canal with receptaculum seminis present; the small vitellaria are at the sides of the posterior part of the body. Parasitic in the intestine of mammals and birds.

Heterophyes heterophyes, v. Sieb., 1852.

Syn.: *Distomum heterophyes*, v. Siebold, 1852; *Heterophyes ægyptica*, Cobbold, 1866; *Mesogonimus heterophyes*, Railliet, 1890; *Cœnogonimus heterophyes*, Looss 1900; *Cotylogonimus heterophyes*, Braun, 1901.

Length up to 2 mm., breadth 0·4 mm.; the neck not sharply defined; in life it stretches to double the length of the hind body. The scales are rectangular, 5 μ to 6 μ by 4 μ, their posterior margin serrate with seven to nine teeth. Cuticular glands are numerous on the ventral surface, especially in the fore part of the body, and partly discharge at the anterior border of the oral sucker. The oral sucker is 0·09 mm., the ventral sucker 0·23 mm. in diameter; the pharynx measures 0·05 to 0·07 mm. in length; the œsophagus is about three times as long; posteriorly the intestinal cæca are directed one towards the other and terminate beside the excretory bladder. Close in front of the posterior ends of the intestinal branches are the two elliptical testes, which are not exactly on the same level. In the middle in front of them is the receptaculum seminis, and in front of the latter lies the spherical or elliptical ovary. The two vasa efferentia unite to form the vas deferens, which after a short course passes over into the angularly bent seminal vesicle; after the entry of the prostatic glands it becomes united with the metraterm (vagina), and the common duct opens into the genital sucker. The latter is somewhat smaller than the ventral sucker, lateral to and close (0·15 mm.) behind it, and bears a not entirely closed ring of from seventy-five to eighty chitinous rods (20 μ in length). The vitellaria on either side consist of about fourteen acini. The uterus is spread almost throughout the entire posterior part of the body. The eggs have thick shells with a knob resembling that of Clonorchis eggs but not so prominent, and measure 30 μ by 17 μ; they contain a completely ciliated miracidium with a rudimentary intestinal sac.

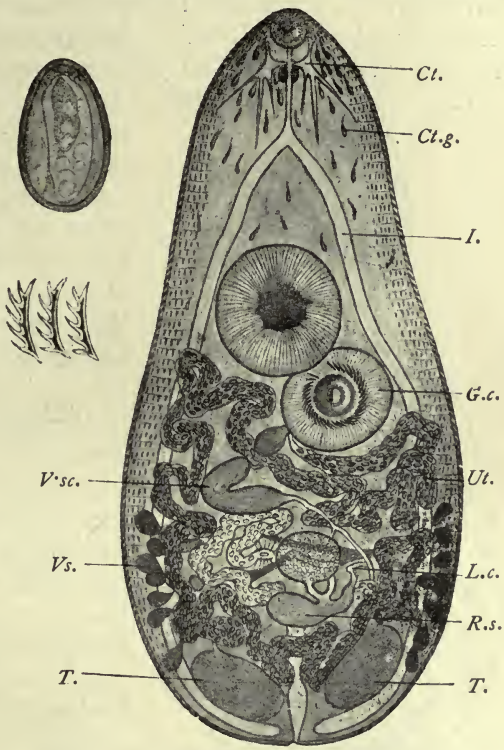


FIG. 163. — *Heterophyes heterophyes*, v. Sieb. *C.*, cerebral ganglion; *I.*, intestinal cæca; *Ct.g.*, cuticular glands; *V.sc.*, vitellaria; *Ut.*, genital sucker; *T.*, testes—the excretory bladder between them; *L.c.*, Laurer's canal; *R.s.*, receptaculum seminis, with the ovary in front of it; *G.c.*, ventral sucker; *Vs.*, vesicula seminalis, 53/1. On the left side above, an egg, 700/1, is depicted, and below it three chitinous rodlets from the genital sucker. 700/1. (After Looss.)

This species was discovered in 1851 by Bilharz in the intestine of a boy who died in Cairo; a second case was only found in 1891 and published by R. Blanchard, so that it appeared as if the species were very scarce. According to Looss, this is, however, not the case, but the species easily escapes notice on account of its small size. Looss found it in Alexandria twice in nine autopsies, and once in Cairo, and has recently stated that in man "it is not at all uncommon to meet with the parasite in cadavers, and the eggs of the worm in the stools of the patients." Leiper records one case from Japan and one from China. The parasites occupy the middle third of the small intestine, and even when present in large numbers appear to be harmless.

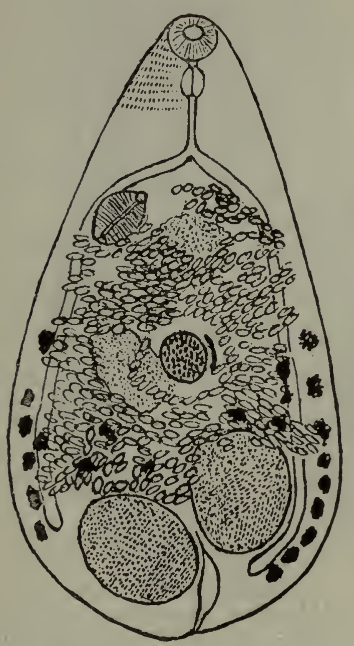


FIG. 164.—*Metagonimus yokogawai*, Katsurada, 1913: the spines are only shown over a small part of the skin. (After Leiper.)

This small species, according to Looss, frequently occurs in Egyptian dogs, less so in cats, and has also been found in the fox, as well as once in *Milvus parasiticus*; Janson also reports this species from the intestine of the dog in Japan.

Metagonimus, Katsurada, 1913; Yokogawa, Leiper, 1913.

Resembles in general structure Heterophyes. In the arrangement of its ventral genital suckers resembles but differs from that of Tocotrema,[1] Looss. The ventral and genital suckers lie laterally and on the right.

Metagonimus yokogawai. Katsurada, 1913.

Syn.: *Yokogawa yokogawai*, Leiper, 1913.

One to 1·5 mm. long, seldom 2·5 mm., and 0·4 to 0·7 mm. broad; elliptical in shape. The body is thickly covered with nail-shaped spines about 10 μ long. Oral sucker 77 μ to 85 μ in diameter. Ventral sucker characteristic and peculiar 0·12 to 0·14 mm. by 0·08 to 1 mm. It is a sac-like organ placed deeply in the body, but does not open as in other flukes on the ventral surface. Testes elliptical, not quite symmetrically placed at the hind end of the body. Vesicula seminalis retort-shaped, situated transversely, internal to the ventral sucker. Pars prostatica present.

[1] In the genus Tocotrema the common genital duct opens into the ventral sucker.

Ejaculatory duct opens with the uterus into a genital sinus, which, together with the internal opening of the ventral sucker, opens into a pit at the front of the ventral sucker. The opening of the genital sinus and that of the ventral sucker are furnished with a complex muscular apparatus. Ovary spherical, 0·12 to 0·13 mm. in diameter, lies in the middle of the hind body. Receptaculum seminis and Laurer's canal present. Vitellaria in the hind half of the body, consisting of about ten acini on each side. Shell gland to the left of the ovary. Uterus forms three to four transverse coils. Eggs elliptical, double contoured, yellowish-brown in colour. There is no shoulder below the operculum as in the eggs of *Cl. sinensis*. At the rounder end there is a thickening or knob different from the spine-like or hook-like process seen in *Cl. sinensis*. Dimensions 28 μ by 16 μ.

Habitat. — Mainly in upper or middle portion of jejunum, rarely in cæcum. They penetrate deep into the mucosa, but not into the submucosa, and *post mortem* appear as a number of small brown points. They frequently occur in the solitary glands, which they destroy. They cause chronic catarrh of the gut. Parasitic in man and mammals.

Geographical Distribution.—Japan.

Life-history.—The cercarial stage occurs in a trout (*Plecoglossus altivelis*) and seldom in Crassius sp. and Cyprinus sp. Infection takes place through the eating of the fish raw. Seven to sixteen days later eggs appear in the fæces (of dog).

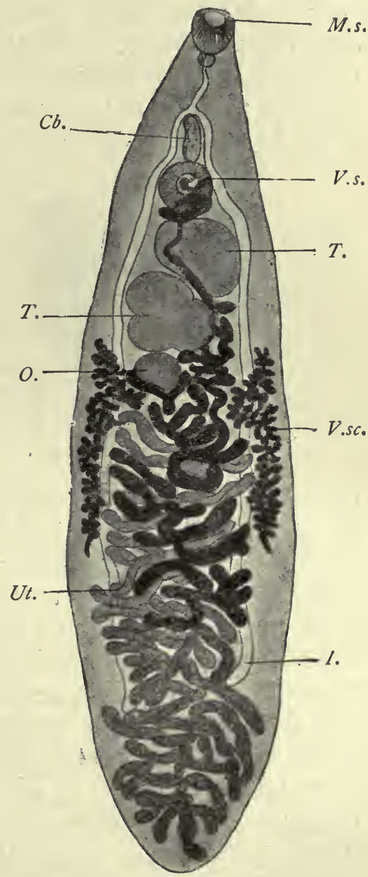


FIG. 165. —*Dicrocœlium dendriticum*, Rud. *V.s.*, ventral sucker; *Cb.*, cirrus pouch; *I.*, intestinal cæca; *V.sc.*, vitellaria; *T.*, testicles; *O.*, ovary; *M.s.*, oral sucker; *Ut.*, uterus. 15/1.

Family. **Dicrocœliidæ**, Odhner, 1910.

Genus. **Dicrocœlium**, Dujardin.

Dicrocœliidæ, with leaf-shaped bodies, pointed posteriorly and anteriorly. Greatest width behind the mid-line. Vitellaria double. The testes smooth or indented, lying symmetrically or obliquely beside or behind the ventral sucker. The ovary approaches the median line behind one testis. Parasitic in the liver and gall-bladder (rarely in the intestine) of members of all classes of vertebrate animals—by preference in birds and mammals.

Dicrocœlium dendriticum, Rud., 1819.

Syn.: *Dicrocœlium lanceatum*, Stil. and Hass., 1896; *Fasciola lanceolata*, Rud., 1803 (*nec* Schrank, 1790); *Distomum lanceolatum*, Mehlis, 1825; *Dicrocœlium lanceolatum*, Dujardin, 1845.

Body lancet-shaped, narrowing especially at the anterior extremity; length 8 to 10 mm., breadth 1·5 to 2·5 mm., the greatest breadth usually behind the middle of the body. Suckers distant from each other by about one-fifth the length of the body; oral sucker about 0·5 mm., ventral sucker about 0·6 mm. Pharynx globular, adjoining the oral sucker; œsophagus 0·6 mm. in length; intestinal cæca reach to four-fifths of the body length. Genital pore at the level of the bifurcation of the intestine; cirrus pouch small and slender. The large, slightly lobed testes lie obliquely one behind the other behind the ventral sucker;

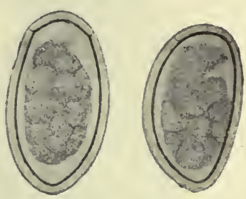


FIG. 166.—Eggs of *Dicrocœlium dendriticum*, Rud. To the left seen flat, to right lying on one side. 600/1.

FIG. 167. — Miracidia of *Dicrocœlium dendriticum*. *a*, from the dorsum; *b*, from the side. (After Leuckart.)

the ovary, which is considerably smaller, is placed behind the posterior one; the vitellaria, commencing at the level of the posterior testis, terminate far before the cæca. The uterus, situated behind the ovary, extends throughout the posterior end, not confined to the central field, but overlapping the lateral fields with its transverse coils; at the posterior edge of the body it turns back again and winds forwards to the ovary in transverse loops, then between the testes, and finally, dorsal to the ventral sucker, terminates in the genital pore. The thick-shelled eggs when young are yellowish, when older dark brown. They measure 38 μ to 45 μ by 22 μ to 30 μ. They contain an oval or roundish miracidium, only the anterior part of which is ciliated, and which possesses a rudimentary intestinal sac with a boring spine. The miracidia do not hatch out in water spontaneously, but, according to Leuckart, in the intestines of slugs (*Limax*, *Arion*), but they do not develop either in these (slugs) or in water-snails.

The lancet fluke inhabits the biliary duct of herbivorous and omnivorous mammals (sheep, ox, goat, ass, horse, deer, hare, rabbit, pig), and is often found associated with the liver fluke; it is not, however, so common nor so widely disseminated, nevertheless, it has been met with outside of Europe, namely, in Algeria, Egypt, Siberia, Turkestan, and North and South America.

In man it is still more uncommon than the liver fluke, and has hitherto only been observed seven times (Germany, Bohemia, Italy, France, and Egypt); it may, however, have occurred more frequently, and have been overlooked, as in slight infections it produces no special symptoms.

The intermediate host is still unknown. Leuckart for some time held the opinion that small species of *Planorbis* from fresh water, which contain encysted Distomata, were to blame, and he supported his views by a feeding experiment which seemingly yielded positive results; this, however, is not definitely proved. Piana's statement that small land snails are the intermediate hosts has also not been proved.

Family. **Echinostomidæ**, Looss, 1902.

Sub-family. **Echinostominæ**, Looss, 1899.

Genus. **Echinostoma**, Rud. 1809; Dietz, 1910.

Fore-body not bulging. Greatest width at or behind the ventral sucker. Oral sucker not atrophied. Collar kidney-shaped with a double dorsally unbroken row of spines, terminating in four to five angle spines. The border spines of the aboral series not larger than the oral. Skin spined or smooth. Body elongated. Uterus long with numerous transverse coils. Ventral sucker in the anterior quarter of body. Cirrus sac small, almost completely in front of the ventral sucker. Testes round or oval, smooth incurved or lobed, in the hinder half of body. Ovary median or lateral in front of testes. Vitellaria from hinder margin of ventral sucker to end of body. Eggs oval, 84 μ to 126 μ by 48 μ to 82 μ.

The spines placed most ventrally, or those placed most medially on ventral surface, are from differences of position or form termed "angle" spines, the rest "border" spines.

Type.—Echinostoma echinatum, Rud.

Echinostoma ilocanum, Garrison, 1908.

Length 4 to 5 mm., breadth 1 to 1·35 mm., thickness 0·5 to 0·6 mm. The circum-oral disc 0·3 mm. broad, separated by a shallow groove from the body. Crown of forty-nine spines and five to six angle spines on each side continuous with an irregularly alternating series of fourteen spines on the dorsum. Largest spines are 34 μ long, 8 μ thick at the base. The remainder of the dorsal spines are 24 μ by 6 μ. Skin thickly covered with scales on the margins of the body as far back as the level of the hind testis. Oral sucker, 0·18 mm.; ventral sucker, 0·4 to 0·46 mm. Its anterior border about 0·07 mm. from the anterior end. Pharynx 0·17 mm. long, 0·11 mm. broad. Testes about mid-line of the body, much lobed; the lobes of the anterior testis run transversely, while the axis of the posterior testis is longitudinal, as often occurs in the *Echinostomidæ*. Cirrus sac reaches to the centre of the ventral sucker. Ovary transversely oval in front of the testes. Vitellaria commence about half-way between the ventral sucker and ovary and extend to the posterior end. Eggs numerous, 92 μ to 114 μ by 53 μ to 82 μ.

Average.—99·5 μ by 56 μ.

Habitat.—Gut of man (Filipinos), Philippine Islands.

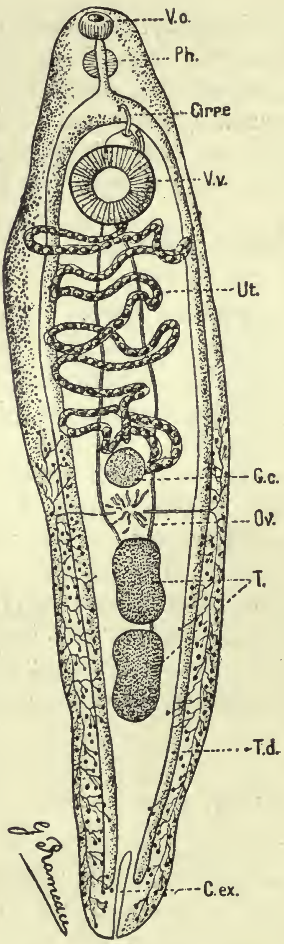


FIG. 168.—*Echinostoma ilocanum*. *Vo.*, oral sucker; *Ph.*, pharynx; *Cirre*, cirrus; *V.v.*, ventral sucker; *Ut.*, uterus; *G.c.*, ovary; *Ov.*, shell gland; *T.*, testes; *T.d.*, vitellarium; *C.ex.*, excretory vesicle. (After Brumpt.)

Echinostoma malayanum, Leiper, 1911.

Twelve millimetres long, 3 mm. broad, 1·3 mm. thick. Ends bluntly rounded. At the anterior end a ventral furrow on either side, one-third the width of the body, marking off the circum-oral collar. Along its edge is a row of forty-three spines extending across the middle line dorsally but not ventrally. The spines vary in size from 0·07 mm. in length (ventrally) to 0·05 to 0·016 mm. (dorsally). Cuticular spines also exist on the ventral side as far back as posterior end of body, but dorsally limited to a triangular area ending in front of the ventral sucker. Oral sucker 0·07 mm. thick, occupying the middle

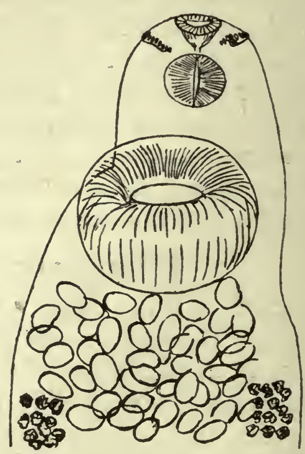


FIG. 169. — *Echinostoma ilocanum*, Garrison, 1908: head end showing collar of spines, ventral view. (After Leiper.)

third of the circum-oral disc; pharynx 0·25 mm. in diameter; œsophagus 0·04 mm. long; gut cæca simple, extending to end of body; ventral sucker 0·9 mm. long by 0·75 mm. broad by 0·7 mm. deep; wall about 0·25 mm. thick. The sucker is inclined at an angle of 40° to the ventral surface. Testes lobed, one behind the other, behind the ventral sucker. Cirrus pouch well developed, reaching to the posterior edge of the sucker. Genital pore in the angle between neck and anterior lip of ventral sucker. Ovary smooth, 0·3 mm. in diameter, 0·85 mm. behind ventral sucker. Vitellaria very numerous, extending from posterior margin of sucker to posterior end of body, where they intermingle. Eggs few in number, brown and large.

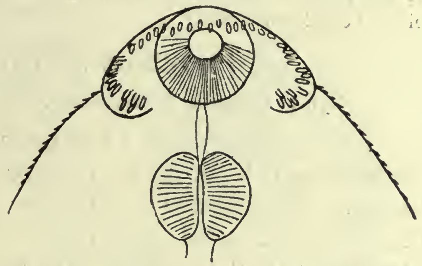


FIG. 170.—*Echinostoma malayanum*, Leiper, 1912: anterior end showing collar of spines, ventral view. (After Leiper.)

Habitat.—Gut of man (Tamils), Malay States.

Sub-family. **Himasthlinæ**, Odhner, 1910.

Genus. **Artyfechinostomum**, Clayton-Lane, 1915.

Crown of thirty-nine spines, continuous over dorsum. Two corner spines long. Vitellaria extend from posterior margin of sucker to posterior end of fluke. Eggs without filament. [Although the possession of strong rose-thorn hooks is given by Odhner as a sub-family characteristic, yet in this genus assigned to this sub-family they have not been seen.—J. W. W. S.]

Artyfechinostomum sufrartyfex, Clayton-Lane, 1915.

Spirit specimens: 9 by 2·5 by 0·8 mm. thick. Ventral sucker conspicuous, 1 mm. in diameter. Cirrus sac 2 mm. long. Testes lobed, about 1·5 mm. in diameter. Posterior border of posterior testes 1 mm. from posterior end. Vitellaria meet posteriorly behind the posterior testis.

Family. **Schistosomidæ**, Looss, 1899.

Genus. **Schistosoma**, Weinl, 1858.

Syn.: *Gynæcophorus*, Dies., 1858; *Bilharzia*, Cobb., 1859; *Thecosoma*, Moq. Tandon, 1860.

The males have bodies that widen out considerably behind the ventral sucker, the lateral parts of which in-roll ventrally, forming the almost completely closed canalis gynæcophorus, within which the female is enclosed. There is no cirrus pouch. The male has five or six testes, the females are filiform; the uterus is long.

There is no Laurer's canal. The ova almost equally attenuated at either extremity; they have a small terminal spine, and are not provided with a lid. They contain a miracidium, ciliated on all sides, which is characterized by the possession of two large glandular cells, which discharge anteriorly beside the gastric sac. They live in the vascular system of mammals. (An allied genus [Bilharziella] lives in the blood-vessels of birds.)

Schistosoma hæmatobium, Bilharz, 1852.

Syn.: *Distoma hæmatobium*, Bilh.; *Distoma capense*, Harley, 1864.

The Male is whitish, 12 to 14 mm. in length, but is already mature when 4 mm. long. The anterior end is 0·6 mm. or a little over in length. The suckers are near each other, the oral sucker is infundibular, and the dorsal lip is longer than the ventral one. The ventral sucker is a little larger, 0·28 mm., and is pedunculated. A little behind the ventral sucker the body broadens to a width of 1 mm., decreasing, however, in thickness; the lateral edges in-roll ventrally, so that the posterior part of the body appears almost cylindrical, 0·4 to 0·5 mm. in diameter; the posterior extremity is somewhat more attenuated. The dorsal surface of the posterior part of the body is covered with spinous papillæ. There are delicate spines on the suckers, and larger ones invest the entire internal surface of the gynæcophoric canal, as well as a longitudinal zone at the edge of that side of the external surface that is covered by the other side rolling over it. The œsophagus is beset with numerous glandular cells (fig. 173), and presents two dilatations; the intestinal bifurcation is close in front of the ventral sucker, the two branches uniting sooner or later behind the testes into a median trunk, which may again divide at short intervals. The excretory pore is at the posterior end, but placed somewhat dorsally; the genital pore is at the beginning of the gynæcophoric canal, thus

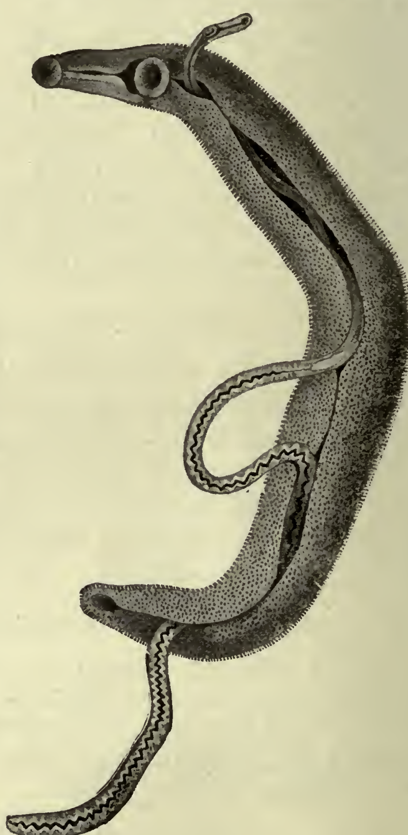


FIG. 171.—*Schistosoma hæmatobium*, Bil.: male carrying the female in the canalis gynæcophorus. 12/1. (After Looss.)

behind the ventral sucker; into it opens the vas deferens which, posteriorly, broadens into the seminal vesicle and then continues as the vasa efferentia of the four or five testes (fig. 173).

The Female—filiform, about 20 mm. in length, pointed at each end, and measuring 0·25 mm. in diameter in the middle. Their colour varies according to the condition of the contents of the intestine. (Posteriorly they are dark brown or blackish.) The cuticle is smooth except in the sucker, where there are very delicate spines, and at the posterior end, where there are other larger spines. The oral sucker is a little larger than the pedunculated ventral sucker (0·07 and 0·059 mm. respectively). The anterior part of the body, 0·2 to 0·3 mm. in length; the œsophagus is as in the male. The intestinal bifurcation is in front of the ventral sucker, the two branches uniting behind the ovary and the trunk running in a zigzag manner to the posterior border. There are indications of diverticula at the flexures. The ovary is median. In young females it is of an elongated oval shape; in older females the posterior end becomes club-shaped, whereas the anterior end becomes attenuated; the oviduct originates at the posterior end, but immediately turns forwards and joins the parallel vitelline duct in front of the ovary (fig. 174), where the shell gland cells open; the common canal becomes dilated to form the oötype, and then proceeds as the uterus, with only slight convolutions, along the central field to the genital pore, which lies in the middle line immediately behind the ventral sucker. The single vitellarium starts behind the ovary and extends to the posterior end. The acini are situated at the sides of the excretory duct, which runs a median course. The eggs are compact spindles, much dilated in the middle; they have no lid, and are provided with a terminal spine (rudimentary filament) at the posterior end, measuring 120 μ to 150 μ in length and 40 μ to 60 μ in breadth, but vary in size and shape (fig. 175).

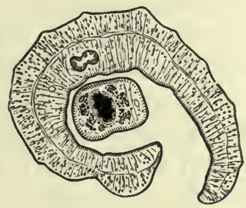


FIG. 172. — Transverse section through a pair of *Schistosoma hæmatobium* in copulâ. In the male the point of reunion of the intestinal forks has been cut across. (After Leuckart.)

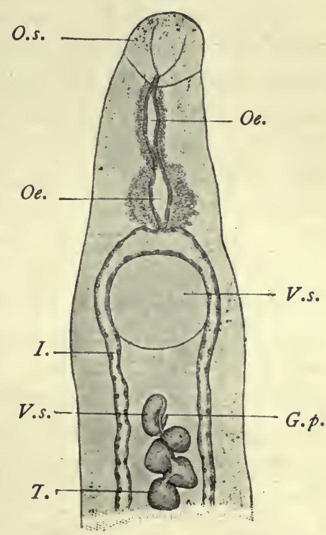


FIG. 173.—Anterior end of the male *Schistosoma hæmatobium*, Bilh. *V.s.*, ventral sucker; *I.*, gut cæca; *G.p.*, genital pore; *T.*, testes; *O.s.*, oral sucker; *Oe.*, œsophagus with glandular cells; *V.s.*, vesicula seminalis. 40/1. (After Looss.)

Distribution.—In order to understand the distribution of the worms and eggs in the body, it may be well to recall the blood supply of the abdominal and pelvic organs. It is generally assumed that the early life (? cercarial stage) of the worms occurs in the liver, and that the young worms travel from here, where they are invariably found, to their various sites along the portal vein and its tributaries and so *against* the blood stream. The tributaries of the portal vein are :—

(1) *Superior mesenteric,* the tributaries of which are : (*a*) the veins of the small intestine ; (*b*) ileo-colic ; (*c*) right colic ; (*d*) middle colic ; (*e*) right gastro-epiploic ; and (*f*) inferior pancreatic. By these paths infection of the small intestine, ascending and transverse colon and pancreas would occur.

(2) *Splenic.* (Ova have been recorded by Symmers in the spleen.)

(3) *Inferior mesenteric,* the tributaries of which are (*a*) superior hæmorrhoidal veins from the upper part of the hæmorrhoidal plexus ; (*b*) sigmoid veins from sigmoid flexure and lower portion of *descending* colon ; (*c*) left colic vein draining descending colon.

The superior hæmorrhoidal veins form a rich plexus in the rectum, and below this level in the upper and middle parts of the anal canal. The plexus forms two networks, an internal plexus in the submucosa and an external on the outer surface. The *internal* plexus opens at the anal orifice into : (*a*) branches of the inferior hæmorrhoidal vein (from the pudic) ; (*b*) the external plexus. The *external* plexus gives off : (*a*) inferior hæmorrhoidal opening into internal pudic (of *internal iliac* vein) ; (*b*) mid-hæmorrhoidal into *internal iliac* or its branches ; and (*c*) superior hæmorrhoidal opening into inferior mesenteric. The external plexus further communicates with the vesico-prostatic plexus. The vesico-prostatic (vaginal) plexus opens into the *vesical veins,* which drain into the interior iliac vein. This plexus also receives afferents from the pudendal plexus, the chief tributary of which is the dorsal vein of the penis. The pudendal plexus also receives branches from the inferior pudic and the anterior surface of the bladder.

There is thus a communication between the portal vein and the vena cava by means of these plexuses, *viz.,* through the inferior and middle hæmorrhoidals, and by the inferior hæmorrhoidals to the bladder and thence by the vesical veins or the pudic to the caval system (interior iliac).

It is thus by the inferior mesenteric and its tributaries that the worms reach the descending colon, rectum, anal canal, and eventually the bladder, and in some cases the caval system.

Before considering what is actually found *post mortem* in these veins and the organs drained by them, we may further recall the fact that the calibre of "medium" veins is 4 to 8 mm., "small" veins less than 40 μ in diameter and capillaries 8 μ to 20 μ. Further, the maximum diameter of the male worm is 1 mm., that of the female 280 μ and eggs *in utero* 80 μ to 90 μ long by 30 μ to 40 μ.

Liver and Portal Vein.—Here worms are most easily found *post mortem*. Often only males are found and these of the same size, and if females occur only a few worms are found in copulâ. The worms are frequently not full size and the males may contain no free spermatozoa in their testes, and as regards the females some may be fertilized, others not, as shown by the presence or absence of spermatozoa in the seminal receptacle or uterus. In either case they may contain eggs—*lateral-spined*—usually one, less often two, but there may be as many as five or six. These eggs may also show some abnormality, which takes the form of: (1) abnormal contents, *viz.*, disintegrating yolk cells with or without an ovarian cell; (2) abnormal shape but with normal contents and probably represented by the collapsed and empty egg-shells which are found in the tissues.

As to the interpretation of these facts, Looss believes that these lateral-spined eggs are products of young females whose egg-laying is not at first properly regulated. The shape that the eggs take, *viz.*, with a lateral spine, is determined by an excess of material—ovarian and yolk cells—being present in the oötype. The shape of eggs depends upon the position they have in the oötype during their formation. In young females an excess of cells—yolk cells especially—accumulates, distending not only the dorsal wall but a portion also of the short duct joining the oötype to the uterus. The result of this is that the axis of the oötype and egg is almost transverse to the body, and the posterior funnel-shaped portion of the oötype, instead of being terminal, has now a lateral or rather a ventral position, so that the spine which occupies this portion, instead of being terminal, is now lateral. It is noteworthy that these lateral-spined eggs are thicker, owing to the excess of material present, and not uncommonly have a curved anterior border, due to a projection of the anterior end into the anterior opening of the oötype.

As these eggs are being laid by females in the portal vein they are carried back to the liver by the blood stream. The liver is one of the commonest sites for these eggs; also terminal-spined eggs may be found here for the same reason.

Hæmorrhoidal Veins.—Mature worms, generally in copulâ, are usually found here, though young not fully grown females may also occur. The tissues of the rectal wall (or colon) show, as a rule, large quantities of lateral-spined eggs, though less often only terminal-spined eggs may be found.

Vesico-prostatic Plexus.—Worms in copulâ are found in the veins of the submucosa in the bladder, and the eggs in the mucosa, and those voided are usually terminal-spined, though lateral-spined eggs are not so rare as generally thought. The problem next arises as to how the eggs get to the lumen of the gut or bladder.

The female worm is 280 μ in diameter. Veins in the submucosa of the rectum less than 178 μ in diameter are not affected with endophlebitis. It is probable that the female even by stretching could not penetrate much beyond this. Eggs are probably then laid in the submucosa as near the muscularis mucosa as possible. Now if the eggs are laid in a vein of larger calibre than the worm fills, the eggs would be carried back to the inferior mesenteric vein, so that presumably the worm must succeed in blocking the vein already narrowed by endophlebitis, so that by the stasis which ensues the eggs may escape from the veins. How this occurs is not exactly known ; it is not necessarily due to the spine, as the same escape into the tissues occurs in spineless eggs, such as those of *Schistosoma japonicum*. The eggs, then, pass as foreign bodies through the tissues. Another hypothesis is that the worms leave the veins in order to lay their eggs, but the evidence is against this.

Caval System.—Occasionally worms that have passed through the vesical plexus may be found in the iliac vein, inferior vena cava, and even the lungs. If the worms are young they contain a lateral-spined egg ; if adult, numerous (50 to 100) terminal-spined eggs.

Lungs.—When the liver is strongly infected with (terminal-spined) eggs it is possible that by passive movements some may pass into the intralobular veins, and thence by the inferior vena cava to the lungs.

Gall-bladder.—Similarly terminal-spined eggs pass into the bile-capillaries and gall-bladder (where they may be abundant), and so into the fæces.

Detection of Eggs.—Occasionally eggs may be found in various other parts of the body. They are best detected by macerating pieces of the tissue in question in about ¼ per cent. hydrochloric acid at 50 to 60° C. (Looss).

Pathological changes :—

Rectum.—These have been studied thoroughly by Letulle in the case of an apparently pure infection of the rectum.[1] They take the form of a chronic diffuse inflammation, which may result in—(1) ulceration, or (2) hyperplasia of the mucosa, producing adenomata.

Ulcerative Form.—The *mucosa* is transformed into a mass of vascular connective tissue. The connective tissue spaces next become invaded by numerous mononuclear cells. The tissue itself

[1] It is noteworthy that in this almost classical case no worms were found in any of the sections. It is further noteworthy that the eggs in the rectum showed great irregularity of form. Eggs with a spine at each end were not uncommon ; exceptionally eggs with two polar spines and one lateral.

undergoes diffuse sclerosis, becoming hard and fibroid. Eventually ulcerative necrosis sets in. During these changes the Lieberkühn glands are destroyed. The process does not extend to the submucosa, in this respect differing from that in chronic dysentery.

Hyperplastic Form.—The Lieberkühn glands of the mucosa at first hypertrophy ; then there is an actual hyperplasia resulting in adenomata. The interstitial tissue of the glands is also greatly hypertrophied, giving rise to very vascular granulations. These growths are often hollow and contain worms. Many eggs are found in the mucosa on their way to the lumen of the gut.

The *muscularis mucosa* is thickened up to twice or even ten times the normal. Its vessels are dilated ($36\,\mu$ to $80\,\mu$), but they do not allow of the passage of worms.

The *submucosa* is profoundly changed ; rigid and hard instead of supple. It is here that the greatest number of eggs occur. A remarkable condition of endophlebitis exists in the veins of the submucosa, not only in the smaller ones but also in the larger ones ($370\,\mu$ by $270\,\mu$). This endophlebitis results in a more or less complete occlusion of the vessels of the lumen.

The *muscular coats* are free from change, also their veins.

The *Serous Coats.*—The veins about $1{,}900\,\mu$ also show endophlebitis. Besides the rectum, in extreme cases even the transverse colon, the cæcum and small intestine may be affected.

Bladder.—In the early stages the mucosa is deep red and swollen like velvet, or there may be localized patches of hyperæmia or extravasation. The subsequent changes take two chief forms :—

(1) *Sandy Patches.*—The mucosa ooks as if it were impregnated with a fine brownish or yellowish powder (myriads of ova). This is accompanied by a gradual hypertrophy and new formation of connective tissue, so that dry, hard or plate-like patches with this sandy appearance arise ; the thickening eventually affects all the coats of the bladder. In the older patches many of the eggs are calcified. These patches sooner or later break down, ulcerate and necrose. Phosphatic deposits are abundant and stone is common. These patches are not found in the rectum.

(2) *Papillomata.*—Where the inflammatory change produced by the eggs gives rise to hypertrophy and hyperplasia of the mucosa, papillomata result, the axis of which is formed by connective tissue of the submucosa. These are most variable in shape and form and bleed readily, and sometimes contain cavities of extravasated blood.

As in the rectum, it is in the submucosa that eggs are most abundant, and worms in copulâ occur in the veins of this layer, but endophlebitis is not as general as described in the rectum. Malignant disease of the bladder is not an uncommon sequela of bilharziasis.

Besides the bladder, the ureters and kidneys may in advanced cases be involved. The prostate and vesiculæ seminales are commonly diseased. Eggs have been recorded in the semen. The urethra is frequently attacked; the vagina in the female.

Eggs also occur in the lymphatic glands of the gut.

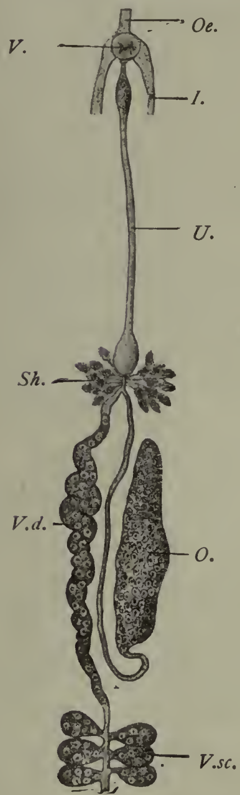


FIG. 174. — *Schistosoma hæmatobium*, Bilh.: genitalia of the female. *V.s.*, ventral sucker; *I.*, gut cæca; *V.d.*, vitelline duct; *V.sc.*, vitellarium; *O.*, ovary; *Oe.*, œsophagus; *Sh.*, shell gland; *U.*, uterus. Magnified. (After Leuckart.)

Geographical Distribution. — East Africa: Nile Valley, Red Sea Coast, Zanzibar, Portuguese East Africa, Delagoa Bay, Natal, Port Elizabeth.

South Africa: Cape Colony, Orange Free State, Transvaal, Mauritius, Bourbon, Madagascar.

West Africa: Angola, Cameroons, Gold Coast, Gambia, Senegal, Sierra Leone, Lagos, Nigeria.

North Africa: Tripoli, Tunis, Algeria, parts of the Sahara.

Central Africa: Sudan, various portions. Uganda, Nyasaland.

It occurs with varying frequency in these regions. It is probably more widely spread than this list implies, as undoubtedly many cases are seen which are not recorded.

Isolated cases have been recorded from Arabia, India,[1] Greece, Cyprus.

The means by which infection is brought about are still uncertain; we only know that the miracidia (fig. 175) enclosed in the discharged eggs do not hatch if the eggs remain in the urine, but after cooling perish. As soon, however, as the urine is diluted with water the shell swells, generally bursting lengthways, and releases the miracidium from its investing membrane, so that it can swim about with the aid of its cilia. In its structure it differs but little from the miracidium of *Fasciola hepatica*, as, for instance, in the lack of eyes; the two large gland cells situated on either side of the intestinal sac are also present in the miracidia of *Fasciola hepatica*.

Sarcode Globules.—This is a term applied to certain globules which at times appear in the miracidium and are later ejected. Some authors

[1] In a case from Madras, recorded by Stephens and Christophers, the eggs were long and spindle-shaped, quite unlike the eggs of *Schistosoma hæmatobium*.

consider them as indicative that the miracidium has developed into a sporocyst, but Looss considers them to be degeneration products.

The Bilharzia mission, under R. T. Leiper, sent to Egypt by the War Office early in 1915, reports that cercariæ of bilharzia type were recognized in four of the commonest fresh-water molluscs around Cairo.

With material obtained from naturally infected *Planorbis boissyi* acute bilharziosis was experimentally produced in rats, mice, and monkeys. Infection takes place experimentally through the skin and also through the mucous membrane of the mouth and œsophagus. The miracidium, after entering the mollusc, develops into a sporocyst. This gives rise not to rediæ, but to secondary sporocysts, which, in

Schistosoma hæmatobium, Bilharz, 1852.

Male, four or five large testes. Gut forks unite late, so that the single gut stem is short. Female, ovary in posterior half of body. Uterus very long, voluminous, with many terminal-spined eggs, some lying in pairs. Vitellaria in posterior fourth of body. Cercariæ in *Bullinus contortus* and *Bullinus dybowski* (syn. : *Physa alexandrina*) in Egypt.

Schistosoma mansoni, Sambon, 1907.

Male, eight small testes. Gut forks unite early, so that the single gut stem is very long. Females, ovary in anterior half of body. Uterus very short ; usually only one lateral-spined egg at a time *in utero*. Vitellaria occupy posterior two-thirds of body. Cercariæ in *Planorbis boissyi* in Egypt.

The above morphological descriptions are founded on worms of each species, derived from experimentally infected mice (Leiper, R. T., *Brit. Med. Journ.*, March 18, 1916, p. 411).

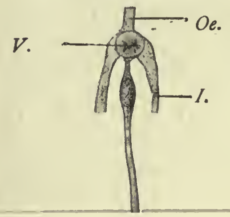
To Binder : face p. 276

Syn.: *S. cattoi*, Blanchard, 1905.

Male.—Eight to 19 mm., but extreme limits are 5 to 22·5 mm. Consists of a short fore-body, separated by the ventral sucker from the hind-body. The ventral sucker is stalked and somewhat larger than

Besides the bladder, the ureters and kidneys may in advanced cases be involved. The prostate and vesiculæ seminales are commonly diseased. Eggs have been recorded in the semen. The urethra is frequently attacked; the vagina in the female.

Eggs also occur in the lymphatic glands of the gut.



Geographical Distribution.—East Africa: Nile Valley, Red Sea Coast, Zanzibar, Portuguese East Africa, Delagoa Bay, Natal, Port Elizabeth.

South Africa: Cape Colony, Orange Free State, Transvaal, Mauritius, Bourbon, Madagascar.

Sarcode Globules.—This is a term applied to certain globules which at times appear in the miracidium and are later ejected. Some authors

[1] In a case from Madras, recorded by Stephens and Christophers, the eggs were long and spindle-shaped, quite unlike the eggs of *Schistosoma hæmatobium*.

consider them as indicative that the miracidium has developed into a sporocyst, but Looss considers them to be degeneration products.

The Bilharzia mission, under R. T. Leiper, sent to Egypt by the War Office early in 1915, reports that cercariæ of bilharzia type were recognized in four of the commonest fresh-water molluscs around Cairo.

With material obtained from naturally infected *Planorbis boissyi* acute bilharziosis was experimentally produced in rats, mice, and monkeys. Infection takes place experimentally through the skin and also through the mucous membrane of the mouth and œsophagus. The miracidium, after entering the mollusc, develops into a sporocyst. This gives rise not to rediæ, but to secondary sporocysts, which, in turn, produce cercariæ. These, like the adult worm, differ from other distomes in lacking a muscular pharynx.

Schistosoma mansoni, Sambon, 1907.

According to Manson, Sambon and others, the eggs with lateral spines belong to a species different from *Schistosoma hæmatobium*. Infections with this species only are said to occur in the Congo, Southern States of North America, West Indies (Guadeloupe) and Brazil (Bahia). The following characters, according to Flu, differentiate this species : (1) In the male the transition from the anterior portion of the worm to the lateral fields (the infolded portions which form the gynæcophoric canal) is not a gradual one as in *Schistosoma hæmatobium*, but in this case the lateral fields rise suddenly, almost at right angles to the anterior portion. (2) The ovaries have a well-marked convoluted course as in no other schistosome. (3) The oötype is symmetrical in reference to the long axis of the body, its duct being lateral on the ventral side (Looss' explanation of this we have already given). (4) The worms live exclusively in portal vein and tract. (As lateral-spined eggs occur also in the bladder, this is not exactly true.)

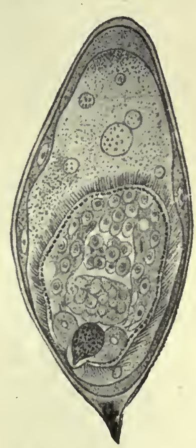


FIG. 175. — Ovum of *Schistosoma hæmatobium*, Bilh., with miracidium, which has turned its anterior end towards the posterior end of the egg. 275/1. (After Looss.

Schistosoma japonicum, Katsurada, 1904.

Syn.: *S. cattoi*, Blanchard, 1905.

Male.—Eight to 19 mm., but extreme limits are 5 to 22·5 mm. Consists of a short fore-body, separated by the ventral sucker from the hind-body. The ventral sucker is stalked and somewhat larger than the oral sucker. Both suckers are larger than the corresponding ones in *S. hæmatobium*. Body usually smooth, but in the fresh state numerous fairly evident spines along the margin of the canal. Œsophagus: two bulbs. The junction of the gut forks more posterior than in *S. hæmatobium*, the median united gut stem occupying a quarter to one-fifth to one-sixth of the body length. An excretory canal runs along each side of the body, opening into the dorsal excretory pore. Testes irregularly elliptical, six to eight in number, in the anterior part of hind-body. The vasa efferentia unite into a common vas deferens which opens directly behind the ventral sucker. The seminal vesicle lies just behind this.

FIG. 176.—*Schistosoma japonicum*: anterior end with testes; posterior end with point of union of cæca. Length of worm about 10 mm. (After Katsurada.)

Female.—Up to 26 mm., generally thinner than the male. Surface smooth. Suckers armed with fine spines. Ventral sucker larger than oral. Body thicker behind the region of the ovary. The gut forks unite immediately behind the ovary. The united gut much thicker than in *S. hæmatobium*. Ovary elliptical, almost in the mid-body, its hinder portion dilated. The oviduct arises from its posterior end and then runs sinuously forward, where it is joined by the vitellarian duct; the vitellarium well developed, extending from behind the ovary almost but not quite to the posterior end as in *S. hæmatobium*. Shell gland ducts enter at the junction point of oviduct and vitelline duct. The canal here forms an oötype and then proceeds as the uterus to open directly behind the ventral sucker. The uterus occupies almost half the hind-body. In *S. hæmatobium* this is not so. The uterine canal is cleft-like, *i.e.*, its dorso-ventral diameter is much greater than its lateral diameter. The number of eggs varies from about 50 to 300 from observations made in various hosts.

Eggs.—*In utero* assume various shapes, as they are soft; the lumen of the uterus is narrow. Outside they are oval, faint yellow, double contoured. In fæces the eggs measure $83{\cdot}5\,\mu$ by $62{\cdot}5\,\mu$ (man); $85\,\mu$ by $61{\cdot}5\,\mu$ (cattle); $98{\cdot}2\,\mu$ by $73{\cdot}8\,\mu$ (dog). The eggs have either small lateral spines or thickenings, and Looss at the opposite side has described cap-like thickenings. The eggs in the tissues undergo various deformities, and may contain a miracidium, as also the eggs in fæces do; or the contents may consist of granular matter or amorphous masses or they may be calcified. Lymphocytes and giant cells may also invade the eggs.

FIG. 177.—*Schistosoma japonicum*, male and female in copulâ. × 60. (After Katsurada.)

Mode of Infection.—The miracidia hatch in water in as little as fifteen minutes, but the majority in one to three hours. They will live in water for about twenty-four hours. In water they undergo a transformation into "larvæ," which then penetrate the skin, as has been shown by

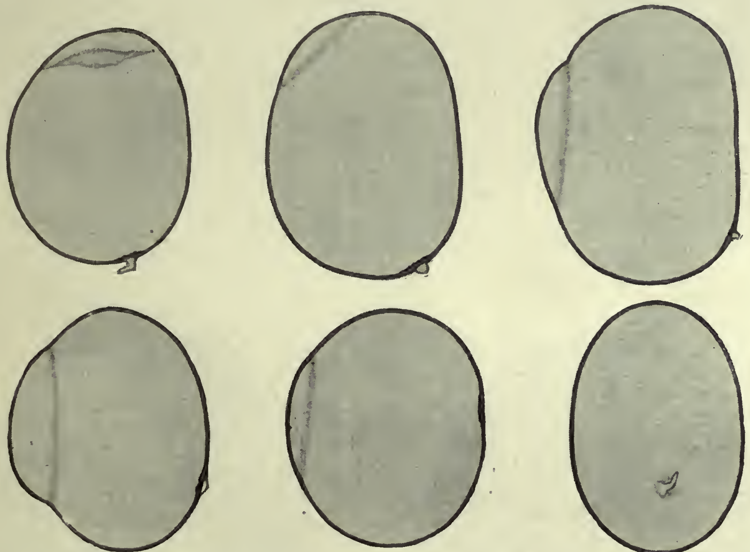


FIG. 178.—*Schistosoma japonicum*: eggs from human liver, showing "spines" and "hoods" at opposite pole. (After Looss.)

Japanese writers to hold good for man, cattle, dog and cat. The penetration of the skin is attended with an eruption on the legs, "Kabure." The exact route by which the worms reach the portal vein is uncertain. Infection in Japan takes place from spring to autumn, especially May to July, when the soil is contaminated with manure of cattle infected with *S. japonicum*. They also appear to develop in molluscs. Leiper and Atkinson found cercariæ (in sporocysts) in the liver of a mollusc, *Katayama nosophora*. They infected mice by immersing them in water containing liver emulsion and so free cercariæ, thus confirming the similar results of Miyairi and Suzuki.

Habitat.—The worm occurs in Japan, China, and the Philippines. The normal host is man and mammals. Cattle, dog and cat are often found naturally infected. Mice can also be experimentally infected. Their seat of election is the portal vein and its branches, especially the mesenteric veins. They either swim free in the blood or remain fixed by their suckers to the intima of the vessels. They have also been found in the vena cava and right heart of a cat, but not so far in the vesical plexus.

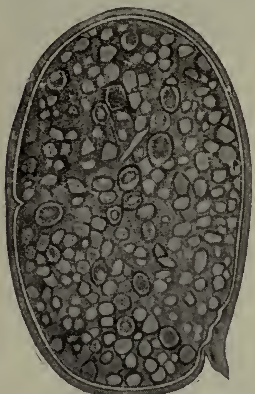


FIG. 179.—*Schistosoma japonicum*: from dog. Uterine egg. × c. 800. (After Katsurada.)

Eggs are found in the submucosa and mucosa of the gut, especially the colon, and at times in the serosa and subserosa of the small intestine, where they give rise to new growths. Occasionally eggs are found in the brain. The life of the worms is at least two years.

Pathogenic Effects.—Anæmia through loss of blood due to worms; enlarged spleen, toxic in origin (?); phlebitis, thrombosis, due to portal stasis; the eggs, however, cause the greatest mischief. They are carried by the circulation to various

FIG. 180.—*Schistosoma japonicum*: from dog. × c. 800. (After Katsurada.)

FIG. 181.—*Schistosoma japonicum*: from dog. Egg from fæces. × c. 800. (After Katsurada.)

organs where they produce inflammation, granulation tissue, and later connective tissue.

Liver.—The eggs reaching this organ give rise to granulomata and hence enlarged liver, and later, when connective tissue is formed, to contraction. The surface is rough and irregularly granular, "parasitic embolic cirrhosis" of Yamagiwa.

FIG. 182.—*Schistosoma japonicum :* section through the gut of a Chinaman showing eggs. × 58. (After Catto.)

Gut.—The eggs in the mucosa and submucosa cause catarrh and destruction of tissue or new growth. In the small intestine the eggs are mainly in the serosa and subserosa, where they give rise to polypoid or branched growths.

Spleen.—Enlarged, at first due to toxin (?) and later due to portal stasis. Eggs in the spleen are uncommon.

Ascites also arises from the portal stasis, and is generally present in advanced cases.

Eggs may be found in many other situations: glands (numerous), mesentery, stomach, pancreas, kidney, etc. The bladder remains free.

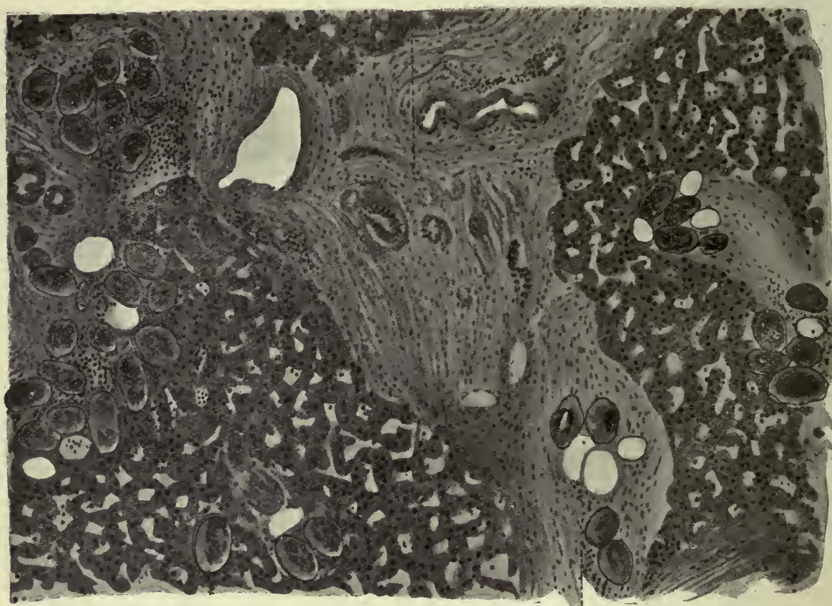


FIG. 183.—*Schistosoma japonicum*: liver showing eggs in the intra- and interlobular connective tissue. × c. 80. (After Katsurada.)

Class III. **CESTODA**, Rud., 1808.

Tapeworms have been known from ancient times—at all events, the large species inhabiting the intestines of man—and there has never been a doubt as to their animal nature. The large cysticerci of the domestic animals (occasionally of man also) have been known for an equally long period, but they were generally regarded as growths, or "hydatids," until almost simultaneously Redi in Italy, and Hartmann and Wepfer in Germany, concluded from their movements and organization that they were of animal nature. From that time the cysticerci have been included amongst the other intestinal worms, and Zeder (1800) established a special class (*Cystici*, Rud., 1808) for the bladder worms. Things remained in this condition until the middle of the last century, when Küchenmeister, by means of successful feeding experiments, demonstrated that the cysticerci were definite stages of development of certain tapeworms. Before Küchenmeister, E. Blanchard, van Beneden, and v. Siebold had held the same opinion in regard to other asexual Cestodes.

Since the most remote period another question has again and again occupied the attention of naturalists, the question of the morphological nature—that of the INDIVIDUALITY OF THE TAPEWORM. The ancients, who were well acquainted with the proglottids (*Vermes cucurbitani*) that are frequently evacuated, were of the opinion that the tapeworm originated through the union of these separate proglottids, and this view was maintained until the end of the seventeenth century. In 1683 Tyson discovered the head with the double circlet of hooks in a large tapeworm of the dog; Redi (1684) was also acquainted with the head and the suckers of several Tæniæ. Andry (1700) found the head of *Tænia saginata*, and Bonnet (1777) and Gleichen-Rusworm (1779) found the head of *Dibothriocephalus latus*. Consequently most authors, on the ground of this discovery, considered the tapeworm as a single animal, that maintains its hold in the intestine by means of the head, and likewise feeds itself through it. The fact was recognized that there were longitudinal canals running through the entire length of the worm, and it was thought that these originated in the suckers, and that the entire apparatus was an intestine. As, moreover, the segments form at the neck, and are cast off from the opposite extremity, the tapeworm was also compared with the polyps, which were formerly regarded as independent beings.

Steenstrup, in his celebrated work on the alternation of generations (1841), was the first to give another explanation. This has been elaborated still further by van Beneden, v. Siebold and Leuckart, and until a few years ago all authorities adopted his views. According to this view, the tapeworm is composed of numerous individuals, something like a polyp colony, and, in addition to the proglottids—the sexual individuals which are usually present in large numbers—there is ONE individual of different structure, the *scolex*, which not only fastens the entire colony to the intestine, but actually produces this colony from itself, and therefore is present earlier than the proglottids. The scolex is a "nurse," which, though itself produced by sexual means, increases asexually like a *Scyphistoma* polyp; the tapeworm chain has therefore been termed a *strobila*. Consequently the development of the tapeworms was explained by an alternation of generations. In support of this opinion it was demonstrated not only that the adult sexual creatures, the proglottids, can separate from the colony and live independently for a time, but that in certain Tæniæ, and especially in many Cestodes of the shark, the proglottids detach themselves long before they have attained their ultimate size, and thus separated continue to develop, grow and finally multiply; the scolex also exhibits a certain independence in so far as, though not, as a rule, capable of a free life, yet it in some cases lives as a free being, partly on the surface of the body of marine fishes and partly in the sea. With the more intimate knowledge of the development of the cysticerci, the independent nature of the scolex was recognized. It is formed by a budding of the bladder that has developed from the oncosphere, in some cases (Cœnurus) in large numbers, in other cases (Echinococcus) only after the parent cyst has developed several daughter cysts. Released from its mother cyst and placed in suitable conditions, it goes on living, and gives rise at its posterior end by budding to the strobila, the proglottids of which eventually become sexual individuals.

In order to make this clearer we will briefly summarize what takes place in the jelly-fishes.

By *metamorphosis* is meant a developmental change in the *same* individual, while alternation of generations, or *metagenesis*, implies a stage in which *reproduction* of individuals takes place by a process of budding or fission. This *asexual* reproductive stage *alternates* with the *sexual* mode of reproduction. Thus in the development of the Scyphozoa (jelly-fishes) we have:—

(1) The fertilized egg cell divides regularly and forms a *morula*.

(2) By accumulation of fluid in the interior this becomes a closed sac with a wall formed of a single layer of cells, forming the *blastosphere* or *blastula*.

(3) One end of the sac is invaginated, forming a *gastrula*.

(4) The gastrula pore or mouth closes, forming again a sac, the walls of which have two layers, forming a *planula*.

(5) This becomes fixed to a rock, an invagination forms at one end, a depression —the stomodæum—communicating with the enteric cavity. Tentacles grow out and we have a *Scyphozoön polype*, *Scyphistoma* or *Scyphula*. It is to this stage that Steenstrup gave the name "nurse" ("wet-nurse"), because it nourished or produced asexually the succeeding forms.

(6) *Asexual reproduction* by transverse fission occurs in this, forming a pile of saucer- or pine-cone-like animals which before this time had been considered to be a distinct animal, which was called *strobila* from its resemblance to a pine-cone. This is the alternate generation.

(7) The individuals of the strobila become free and are called *Ephyrulæ*.

(8) These develop finally into adult sexual jelly-fish, *Scyphozoa*, so that comparing a tapeworm with this we have (*a*) egg, (*b*) scolex (= Scyphula or "nurse"), (*c*) asexual reproduction of the tapeworm chain (= strobila), (*d*) development of the individuals of the chain (proglottids) into sexual adults.

Van Beneden's terminology for these stages is the following: Ciliated embryo = protoscolex; scyphistoma = deutoscolex (or scolex); free Ephyrula = proglottis. According to this view, as is the case in many endoparasitic Trematodes, asexual reproduction by budding occurs at two stages of the whole cycle of development, *viz.* (1) in the formation of the scolex by budding from the bladder ("nurse"), (2) in the formation of the strobila by budding from the scolex ("nurse").

But in cysticercal larval forms it appears that the scolex does not arise in this way but is simply a part of the proscolex (hexacanth embryo), becoming invaginated into it for protection, so that there is no asexual gemmation here. It has been questioned also whether the strobila also arises by gemmation. If it does, the tapeworm is a *colony* of zoöids produced by budding from the asexual scolex; if it is not produced in this way, then the tapeworm is to be regarded as an *individual* in which growth is accompanied by segmentation. Against the "colony" view are the facts that the muscular, nervous, and excretory systems are continuous throughout the worm, and that some tapeworms, such as *Ligula*, are unsegmented.

Finally, if the tapeworm is an individual the question arises which is the head end. As new segments are formed at the neck, and as this point in annelids is the antepenultimate segment, the scolex must be the last or posterior segment. The caudal vesicle or bladder of larval forms is consequently anterior. According to this view, in tapeworms as among many endoparasitic flukes, an *asexual* multiplication occurs at two points of the whole cycle of development, which is as follows: (1) egg, (2) oncosphere or hexacanth embryo, (3) bladder (cysticercus or hydatid), (4) (after digestion of the bladder) by budding, the scolex, (5) by budding from the scolex the sexual proglottids, (6) the egg; (4) and (5) being the two asexual stages.

Anatomy of the Cestoda.

If we except the tapeworms with only one proglottis, the Cestoidea Monozoa, Lang = *Cestodaria*, Monticelli, we can always distinguish in the Cestodes, in the narrower sense, one scolex or head and a large or small number of segments (proglottids). The scolex serves the entire tapeworm for fastening it to the internal surface of the intestinal wall, and therefore carries at its end various organs which assist in this function, and which are as follows: (1) SUCTORIAL ORGANS, *i.e.*, the four suckers (acetabula), which are placed crosswise at the circumference of the thickened end of the scolex; further, the double or quadruple groove-like suckers (bothridia), which are diversely shaped in the various genera and families.[1] (2) FIXATION ORGANS (hooklets)[2] that likewise occur in varying numbers and different positions; they may be in the suckers, or outside them on the apex of the scolex; for instance, in many of the *Tæniidæ* they appear in a circle around a single protractile organ, the rostellum, or the latter may be rudimentary, and is then replaced by a terminal sucker. (3) PROBOSCIS. One family of the Cestodes, the *Rhynchobothriidæ*, carries four proboscides, moved by their own muscular apparatus, on the scolex, and they are beset with the most diverse hooks. (4) TENTACLE-LIKE formations are only known in one genus (Polypocephalus).

The thickened part of the scolex that carries the suckers is usually called the head; the following flat (unsegmented) part connecting it with the proglottids is called the neck, and is sometimes quite small. In a few cases the entire scolex (or head) disappears, and its function is then undertaken by the contiguous portion of the chain of proglottids, which is transformed into a variously shaped PSEUDO-SCOLEX.

The proglottids are joined to the scolex in a longitudinal row, and are arranged according to age in such a manner that the oldest proglottis is farthest from the scolex, and the youngest nearest to it.

The number of segments varies, according to the species, from only a few to several thousands; they are either quadrangular or rectangular; in the latter case their longitudinal axis falls either longitudinal or transverse to that of the entire chain, according as the segments are longer than broad or broader than long. When the number of segments is very large, the youngest ones are, as a rule, transversely oblong, the middle ones are squarish, and the mature ones longitudinally oblong. The posterior border of the segments, as a rule, carries a longitudinal groove for the reception of the shorter anterior border of the following proglottis. The two lateral borders of the segment are rectilinear, but converge more or less towards the front, or they are bent outwards. In most of the Cestodes the segments, just as the neck, are very flat; in rare cases their

---

[1] They may remain simple, and are then not separated from the remaining muscles of the scolex; or they project as roundish or elongated structures over the scolex, hollow on their free surface, and often divided into numerous areas by muscular transverse ribs. They may also carry accessory suckers on their surface.

[2] The various parts of a hooklet are thus named from the point backwards: (1) blade or prong, (2) guard or ventral or posterior root, (3) handle or dorsal or anterior root.

transverse diameter is equal to their dorso-ventral diameter. As a rule the segments, singly or several united together, detach themselves from the posterior end, in many cases only after complete maturity is attained, and in others much earlier; they then continue to live near their parent colony, to still call it by that name, in the same intestine and continue their development. Even when evacuated from the intestine the proglottids under favourable circumstances can continue to live and creep about, until sooner or later they perish.

The first proglottis formed, and which in a complete tapeworm [*i.e.*, sexually complete] is the most posterior, is as a rule smaller and of different shape, it also frequently remains sterile, as likewise happens in the next (younger) segments in a few species; otherwise, however, sooner or later the generative organs develop in all the segments, mostly singly, sometimes in pairs; in the latter case they may be quite distinct from each other or possess some parts in common. The term "mature" is used for a proglottid that has the sexual organs fully developed, while "gravid" is used for one containing eggs. Most of the species combine male and female genitalia in the same segment, only a few are sexually distinct (Diœcocestus). In the hermaphrodite species one male and one female sexual orifice are always present, and, in addition, there may be a second female orifice, the uterine opening; as a rule, however, this is lacking, and in one sub-family, the *Acoleinæ*, to which also the genus Diœcocestus belongs, the other sexual orifice, the opening of the vagina, is also absent. The position of these orifices varies; the cirrus and vagina usually open into a common atrium on one lateral border or on a surface of the segments; the orifice of the uterus may be on the same surface or on the opposite one.

The surface on which the uterus opens is termed the VENTRAL SURFACE; if this orifice is absent, one must depend on the ovary, which almost always approaches one of the two surfaces; this surface is then called the ventral.

The length of the Cestodes—independently of their age—depends on the number and size of the segments, as well as on their contraction; the smallest species (*Davainea proglottina*) is 0·5 to 1·0 mm. in length; the largest may attain a length of 10 m., and even more.

The entire superficial surface of the tapeworms is covered with a fairly resistant and elastic layer, which exhibits several indistinctly limited layers and which is usually called a cuticle, which also covers the suckers, and is reflected inwardly at the sexual orifices. In some species fine hairs appear, either on the entire body or only in the region of the neck, on the external surface. In the cuticle there can be recognized, besides the pores, which no doubt are concerned with nutrition, spaces in which lie the ends of sensory cells. Close under the cuticle lies the external layer of the parenchyma (basal membrane), and below this the circular and longitudinal muscles forming the dermo-muscular coat. The matrix cells of the cuticle occur as in the Trematodes, only on the inner side of the peripheral muscles in the external zone of the parenchyma; they are fusiform cells, forming one or two layers, but are not arranged in the manner of epithelial cells (fig. 184, *Sc. c.*). They have fine branching processes which run between the dermal muscles, pass through the basal membrane and penetrate the internal surface of the cuticle with small pistil-like enlargements, expanding on the internal surface of the cuticle into a thin plasma layer.

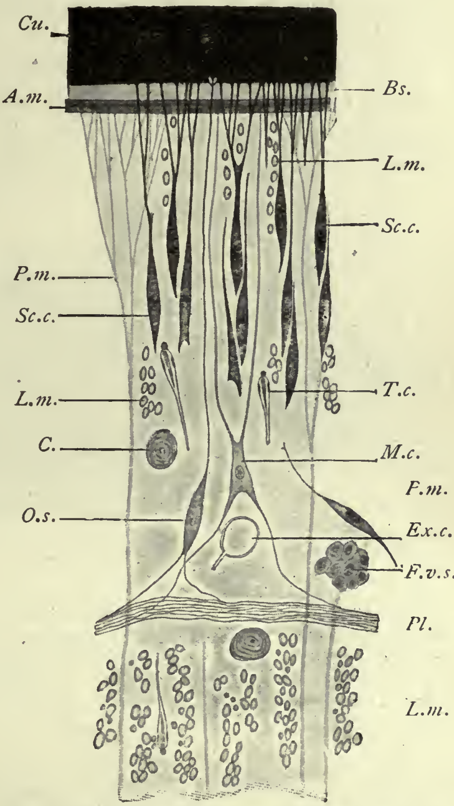


FIG. 184.— Schematic representation of a small part of a transverse section of *Ligula* sp. *Bs.*, basal membrane; *Cu.*, cuticle; at its base are the end-plates of the subcuticular (epithelial) cells; in the centre a cuticular sense organ, *O.s.*; *F.v.s.*, vitelline follicle; *Exc.*, excretory vessel; *C.*, calcareous corpuscle; *L.m.*, longitudinal muscles; *M.c.* myoblast; *P.m.*, parenchymatous or dorso-ventral muscles; *Pl.*, plexus of nerve fibres; *A.m.*, circular muscles; *Sc.c.*, subcuticular or matrix cell; *T.c.*, terminal flame cell. 500/1. (After Blochmann.)

In addition to the above mentioned, there are other cuticular formations occurring on the cuticle of some Cestodes, such as immobile hairs and variously formed hooks, such as are seen principally on the scolex. Their development is only roughly known in a few species; they are usually already present in the larval stage, and of the same arrangement and shape as in the fully developed tapeworms; a matter of importance, because by these structures larvæ can be recognized as being those of a certain species of tapeworm.

The CUTICULAR GLANDS in Cestodes are scarce.

The PARENCHYMA forms the chief tissue of the entire body, and in all essentials its structure is similar to that of the Trematodes.

The same doubt exists here also as to the nature of the parenchyma. Recent authors consider that it consists of highly branched cells, the processes of which ramify in all directions. These cells lie in a non-cellular matrix containing fluid vacuoles. This matrix spreads in between and so breaks the continuity of the epidermal cells.

In the parenchyma of almost all the Cestodes there are found in adult specimens, as well as in larvæ, light-refracting concentrically striated structures, of a spherical or broad elliptical shape, which, on account of their containing carbonate of lime, are termed CALCAREOUS CORPUSCLES (fig. 184, *C.*). Their size, between 3 μ and 30 μ, varies according to the species; their frequency and distribution in the parenchyma also varies, but they are chiefly found in the cortical layer.

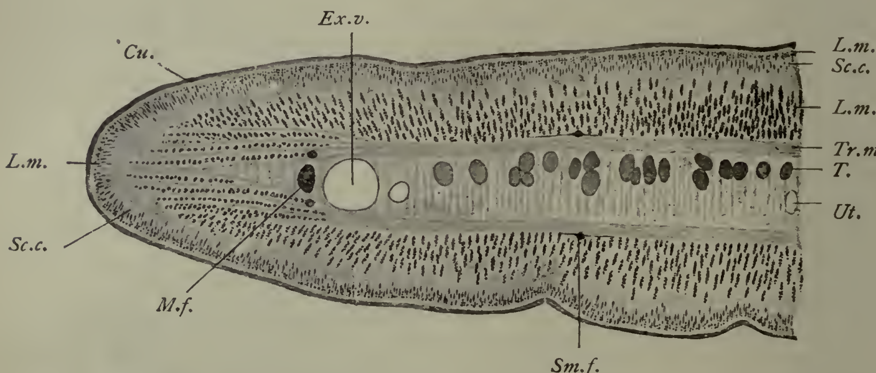


FIG. 185.—Half of a transverse section through a proglottis of *Tænia crassicollis*. *Cu.*, cuticle; *Ex.v.*, external excretory vessel, to the right of which there is the smaller internal one; *T.*, testicular vesicles; *L.m.* longitudinal muscles (outer and inner); *M.f.*, lateral nerve with the two accessory nerves; *Sc.c.*, subcuticular matrix cells; *Sm.f.*, submedian nerve; *Tr.m.*, transverse muscles; *Ut.*, the uterus, and the middle of the entire transverse section. 44/1.

They are the product of certain parenchymatous cells, in the interior of which they lie like a fat globule in a fat cell, but according to others they are *intercellular* in origin.

The MUSCULAR SYSTEM of the proglottids is composed of—(1) the subcuticular muscles (figs. 184 and 185), as a rule consisting of a single layer of annular muscles; (2) longitudinal muscles; (3) dorso-ventral fibres extending singly from one surface to the other, and at both ends expanding in a brush-like manner, and inserted into the basal membrane, consisting of an outer, more numerous, and an inner, less numerous but more powerful layer (the number of bundles in this layer being in certain cases of specific importance); (4) transverse fibres, the elements of which penetrate to the borders of the segments, thus passing through the longitudinal muscles and reaching the cuticle. In the region of the septa the transverse and dorso-ventral muscles form a kind of plate.

The mass of parenchyma bounded by the transverse muscles is termed the MEDULLARY layer, while the mass lying outside them is termed the CORTICAL LAYER.

It was known long ago that the myoblasts adhere to the dorso-ventral fibres as thickenings, but it is only recently that large star-shaped cells (fig. 184), separated from but connected with them by processes, have been recognized as the myoblasts of other fibres (Bochmann, Zernecke).

Within the scolex the direction and course of the muscular layers change.

The SUCKERS are parts of the musculature, locally transformed, with a powerful development of the dorso-ventral muscles, now become radial fibres.

The ROSTELLUM of the armed Tæniæ, like the proboscis of the *Rhynchobothriidæ*, also belongs to the same category of organs.

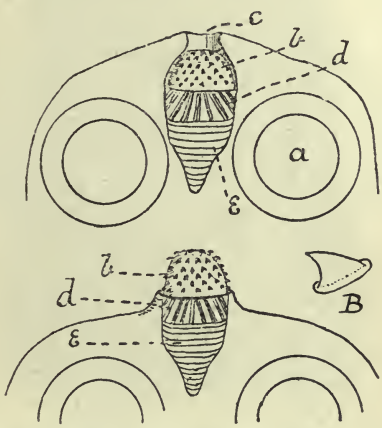


FIG. 186.—*Dipylidium caninum:* from the cat. In the upper figure the rostellum is retracted, in the lower protruded. *a*, sucker; *b*, hooks of rostellum; *B*, enlarged hook; *c*, apical aperture on scolex; *d*, longitudinal muscles; *e*, circular muscles. (After Benham.)

In the simplest form, the rostellum, or top of the head (as in *Dipylidium caninum*), appears as a hollow oval sac, the anterior part of which, projecting beyond the upper surface of the head, carries several rows of hooks (fig. 186). The entire internal space of the sac is occupied by an elastic, slightly fibrous mass, while the anterior half of the surface of the rostellum is covered by longitudinal fibres and the posterior half by circular fibres. On contraction of the latter the entire mass is protruded through the apical aperture, the surface of the rostellum becomes more arched, and the position of the hooks is, in consequence, altered. The rostellum of the large-hooked *Tæniidæ*, which inhabit the intestine of man and beasts of prey, is of a far more complicated structure, for, in addition to the somewhat lens-shaped rostellum carrying the hooks on its outer surface, there are secondary muscles grouped in a cup-like manner (fig. 187). Every change in the curvature of the surface of the rostellum induces an alteration in the position of the hooks. In the hookless *Tæniidæ* the muscular system of the rostellum is altered in a very different manner; in a few forms a typical sucker appears in its place.

The NERVOUS SYSTEM commences in the scolex and runs through the neck and the entire series of proglottids. Within the proglottids it consists of a number of longitudinal nerve fibres of which those at each lateral border are usually the largest. In the Tæniæ the lateral nerves are accompanied both dorsally and ventrally by a thinner nerve (accessory nerve) (fig. 185); on each surface, moreover, between the lateral nerve and the median plane, there are two somewhat stronger bundles (sub-median), so that there is a total of ten longitudinal nerve bundles. They lie externally to the transverse muscle plates, and the lateral and accessory bundles lie externally to the principal excretory vessels, and are everywhere connected by numerous anastomoses and secondary anastomoses; one typical ring commissure is usually found at the posterior border of the segments. In the *Bothriocephalidæ* the distribution of the nerve bundles is different (for instance, two lie in the medullary layer), or they are split up into a larger number of branches. In the scolex the nerve bundles are connected in a very remarkable manner by commissures with that which is generally termed the central part of the entire nervous system. There occurs normally a commissure between the two lateral nerves; at the same level, the dorsal and ventral median nerves are also connected at each surface as well with each other as with the lateral nerves, so that a hexagonal or octagonal figure is formed. The so-called apical nerves pass from this commissural system anteriorly, embrace the secondary muscular system of the rostellum semicircularly, and form an annular commissure (rostellar ring) at the inner part of the rostellum.

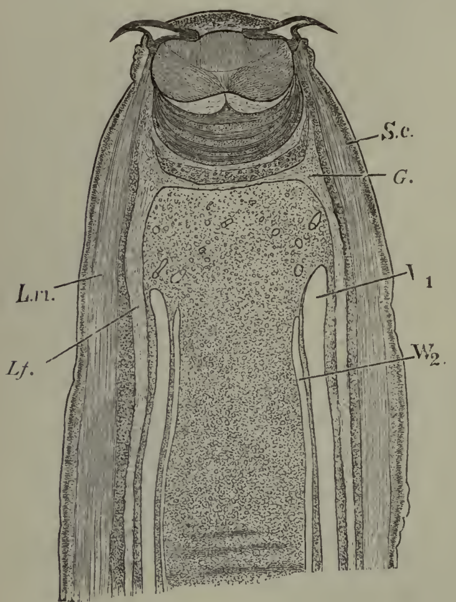


FIG. 187.—Longitudinal section of the head and neck of *Tænia crassicollis*, showing the lens-shaped muscular rostellum, with two hooks lying in the concentric cup-like mass of muscles. *L.m.*, longitudinal muscles of the neck; *Lf.*, left lateral nerve; *G.*, ganglion; *S.c.*, subcuticular layer; W_1, external, W_2, internal excretory vessel. 30/1.

The peripheral nerves arise from the nerve bundles as well as from the commissures situated in the scolex; some go direct to the muscles, while others form a close plexus of nerves external to the inner longitudinal muscles, which plexus likewise sends out fibres to the muscles, but principally to numerous fusiform sense organs (fig. 184, *Pl.*); they lie internal to the subcuticular cells and, piercing the cuticle with their peripheral processes, end as projecting "receptor" hairs. Higher organs of sense are not known.

The EXCRETORY APPARATUS of the Cestodes is similar to that of other flat worms. The terminal (flame) cells, which hardly differ in appearance from those of the Trematodes, are distributed throughout the parenchyma, but are more common in the cortical than in the medullary layer (fig. 184, *T.c.*). Before opening into a collecting tube, the capillaries run straight, tortuously, or in convolutions, anastomosing frequently with one another or forming a *rete mirabile*. The collecting tubes, which have their own epithelial and cuticular wall, and which also appear to be provided with muscular fibres, occur typically as four canals passing through the entire length of the worm (fig. 189); they lie side by side, two (a wider thin-walled ventral, and a narrower thick-walled dorsal one) in either lateral field; in the head the two vessels on each side unite by means of a loop, at the posterior extremity they open into a short pyriform or fusiform terminal bladder which discharges in the middle of the posterior edge of the original terminal proglottis.

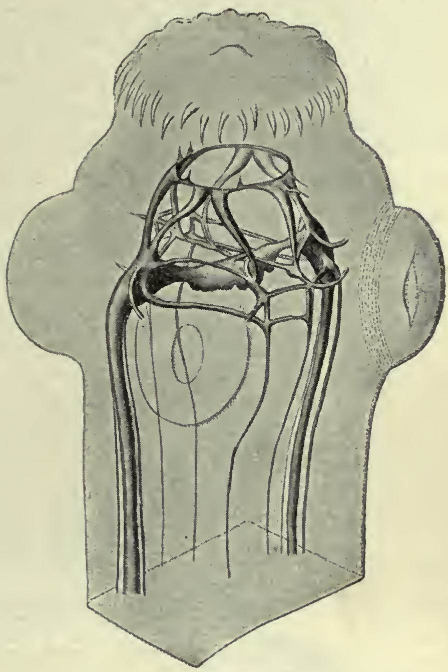


FIG. 188.—*Tænia cœnurus*, head and part of neck showing nervous system. Enlarged. (After Niemiec.)

This primitive type (fig. 189) of arrangement of collective tubes is subject to variation in most Cestodes, in the scolex as well as in the segments. Indeed, even the lumen of the four longitudinal tubes does not remain equal, as the dorsal or external tubes are more fully developed and become thicker, whereas the ventral or internal ones remain thin, and in some species quite disappear in the older segments (figs. 185, 187). Moreover, very frequently connections are established between the right and left longitudinal branches, as in the head, where a "frontal anastomosis" develops, which in the *Tæniidæ* usually takes the form of a ring encircling the rostellum (fig. 190), and in the segments of a transverse anastomosis at each posterior border, especially between the larger branches, and more rarely between the smaller collecting tubes also (fig. 191).

The so-called "island" formation is another modification, *i.e.*, at any spot a vessel may divide and after a longer or shorter course the two branches reunite, and this may appear in the collecting tubes themselves as well as in their anastomoses. The above-mentioned ring in the frontal commissure of the *Tæniidæ* is such an island; similar rings also frequently encircle the suckers (fig. 190). In extreme cases (*Triænophorus, Ligula, Dibothriocephalus*, etc.) this island formation extends to all the collecting tubes and their anastomoses. Instead of two or four longitudinal canals only, connected by transverse anastomoses at the posterior border of the segments, there is an irregular network of vessels, situated in the cortical layer, from which the

FIG. 189.—Young *Acanthobothrium coronatum*, v. Ben., with the excretory vessels outlined. Slightly enlarged. (After Pintner.)

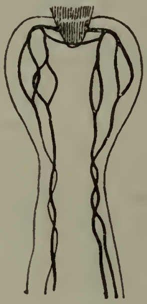


FIG. 190.—Scolex of a cysticercoid from *Arion sp.*, with the excretory vessels outlined. (After Pintner.)

longitudinal branches, having again subdivided, can only be distinguished at intervals, and even then not in their usual number.

The opening of the longitudinal branches at the posterior end requires more accurate investigation; it is true that a single terminal bladder is mentioned as being present in many species, but this is also disputed; when the original end proglottis has been cast off, the longitudinal branches discharge separately. Some species possess the so-called foramina secundaria, which serve as outlets for the collecting tubes; they are generally at the neck, but may be situated on the segments.

The contents of the excretory vessels is a clear fluid, the regurgitation of which is prevented by the valves present at the points of origin of the transverse anastomoses. The fluid contains in solution a substance similar to guanine and xanthine.

Genital Organs.—With the exception of one genus (*Diœcocestus*, Fuhrm.), in which the species are sexually differentiated, all the Cestodes are hermaphroditic; the genitalia develop gradually in the segments (never in the scolex), the male organs, as is usual in hermaphroditic animals, forming earlier than the female. The youngest proglottids generally do not exhibit even traces of genitalia: these, as a rule, develop first in the older segments, and the development proceeds onwards from segment to segment. In a few exceptional cases (*Ligula*) the sexual organs are already developed in

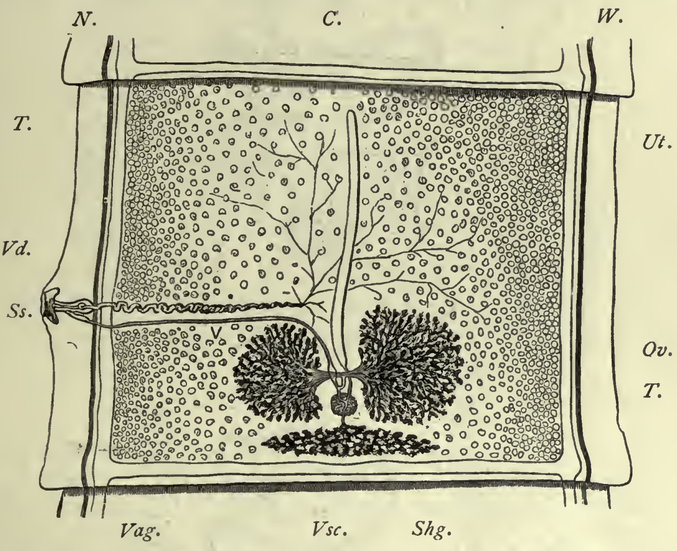


FIG. 191.—Proglottis of *Tænia saginata*, Goeze, showing genitalia. *C.*, transverse excretory canal; *N.*, lateral longitudinal nerve; *W.*, longitudinal excretory canal; *T.*, testicles scattered throughout the proglottis; *Ut.*, opposite the central uterine stem (a closed sac); *Ss.*, genital pore leading into the genital sinus; above the cirrus and coiled vas deferens (*V.d.*), below the vagina (*Vag.*), bearing near its termination a dilatation, the seminal receptacle; *Vsc.*, the triangular vitellarium, and above it (*Shg.*) the shell gland; leading from this to the uterus is seen the short uterine canal, on either side of this the two lobes of the ovary (*Ov.*). 10/1.

the larval stage, but are only functional after the entry of the parasite into the final host.

With the exception of the end portions of the vagina, cirrus and uterus, all the parts of the genital apparatus lie in the medullary layer, except only the vitellaria, which in many species are in the cortical layer. The male apparatus consists of the testes, of which, as a rule, there are a large number,[1] and which lie dorsal to the median plane (fig. 185, *T.*); a vas efferens arises from each testis, unites with

[1] There are, however, tapeworms with only one, others with only two or three testes in each segment.

contiguous vasa, and finally discharges into the muscular vas deferens that is situated in about the middle of the segment. According to the position of the genital pore, the vas deferens opens on the lateral margin or in the middle line in the front of the segment ; it is much

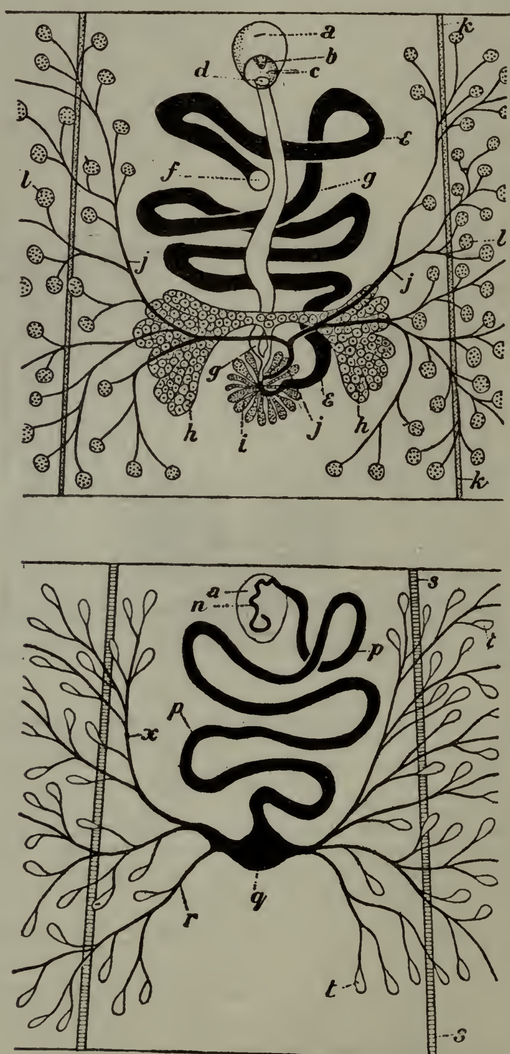


FIG. 192.—*Dibothriocephalus latus.* Upper figure : female genitalia, ventral view. Lower figure : male genitalia, dorsal view. The central portion only of the proglottis is shown. *a*, cirrus sac ; *b*, partly everted cirrus ; *c*, genital atrium and pore ; *d*, vaginal pore ; *e*, uterus ; *f*, uterine pore ; *g*, vagina ; *h*, ovary ; *i*, shell gland ; *j*, vitelline duct ; *k*, lateral nerve ; *l*, vitellarium ; *n*, vas deferens (muscular portion) ; *p*, vas deferens ; *q*, seminal vesicle ; *r* and *x*, vasa efferentia ; *s*, lateral excretory canal ; *t*, testicular follicles. (After Benham and Sommer and Landois.)

convoluted or twisted, and frequently possesses a dilatation termed the vesicula seminalis. It finally enters the cirrus pouch, which is usually elongated; within the cirrus pouch lies the protrusible cirrus, which is not uncommonly provided with hooklets.

The male sexual orifice almost always opens with that of the vagina into a genital atrium, the raised border of which rises above the edge of the segment and forms the genital papilla (fig. 191).

The vagina, like the vas deferens, usually runs inwardly and posteriorly, where it forms a spindle-shaped dilatation (receptaculum seminis); its continuation, the spermatic duct, unites with the

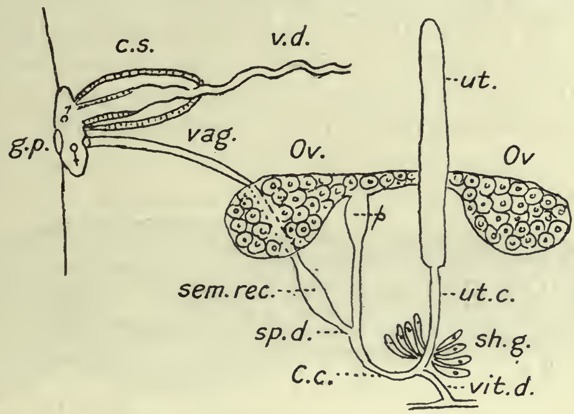


FIG. 193.—Diagram of genitalia of a Cestode. *g.p.*, genital pore; ♀ ♂, male and female ducts opening into genital sinus; *c.s.*, cirrus sac; *v.d.*, coiled vas deferens ("outer seminal vesicle"); *vag.*, vagina; *sem. rec.*, seminal receptacle; *sp. d.*, spermatic duct; *C.c.*, fertilization canal; *vit. d.*, vitelline duct; *sh. g.*, shell gland; *ut. c.*, uterine canal; *ut.*, uterus; *Ov.*, ovary; *p*, pumping organ. *Cf.* figs. 191 and 233. (Stephens.)

oviduct, the common duct of the ovaries (fig. 191). The ovaries, usually two in number, are compound tubular glands in the posterior half of the proglottis, which extend into the medullary layer, but ventral to the median plane.

At the origin of the oviduct there is frequently a dilatation provided with circular muscles (suction apparatus), which receives the ovarian cells and propels them forward. After the oviduct has received the spermatic duct the canal proceeds as the fertilization canal, and after a very short course receives the vitelline duct or ducts, and then the numerous ducts of the shell glands (oötype). [Although the nomenclature of these parts varies, we may consider the oviduct as extending from the ovary to the shell gland and as receiving the spermatic duct and then the vitelline duct and the ducts of the shell gland. The short piece into which the shell gland ducts open corresponds to the oötype in the flukes, but in the tapeworms this portion of the canal is seldom dilated. From this point the oviduct is continued as a shorter or longer tube, the uterine canal or true oviduct opening into the uterus proper.—J. W. W. S.] The vitellarium may be single, but often exhibits its primitive duplication more or less distinctly, in which case it is situated at the posterior border of the segments in the medullary layer (fig. 191). The original position of the double organ is, moreover, the same as in the Trematodes, *i.e.*, at the sides of the proglottids, and thence eventually extending more or less on both surfaces (figs. 192 and 194); the gland is then distinctly grape-like and the follicles lie mostly in the cortical layer.

The egg cell that has been fertilized and supplied with yolk cells receives the shell material at the point of entry of the shell gland ducts, and, as a complete egg, then moves onward to the uterus. In those cases in which the uterus in its further course presents a convoluted canal, and may form a rosette (pseudo-phyllidea), there is an external

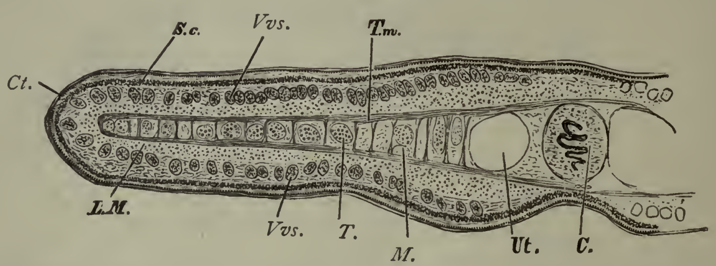


FIG. 194.—Part of a transverse section through a proglottis of *Dibothriocephalus latus*. *Ct.*, cuticle; *C.*, cirrus; *Vvs.*, vitelline follicles; *L.M.*, longitudinal muscles; *T.*, testicles; *M.*, medullary nerve; *S.c.*, subcuticle; *T.m.*, transverse muscles; *Ut.*, uterus. 20/1.

opening which is usually separate from the genital pore, and lies on the same or the opposite surface. In all other cases, however, the uterus terminates blindly and is represented by a longer or shorter sac lying in the longitudinal axis (fig. 191), but in many forms transversely. With the accumulation of eggs it becomes modified in various ways: (1) it sends out lateral branches (fig. 241), or (2) forms numerous isolated sacs (PARENCHYMAL CAPSULES) containing single eggs or groups of eggs (fig. 217); further, (3) in some cases at the blind end one or more special thick-walled cavities are formed (PARUTERINE ORGANS or UTERINE CAPSULES), in which all or most of the eggs are collected, the uterus then undergoing atrophy.

In species in which the uterus lacks an opening, simultaneously with the growth of this organ an atrophy of the male apparatus, at least of the testes and their excretory ducts, takes place; this atrophy also frequently occurs in the female glands, so that the entire mature segments have besides the uterus only traces of the genitalia left.

In the *Acoleïnæ* the vagina is more or less extensively atrophied, and in any case has no external opening.

A number of genera are distinguished by the duplication of the genitalia in every segment; the genital apparatus in its entirety, or with the exception of the uterus, is double, or the genital glands and the uterus are single, but the cirrus, vas deferens and vagina are double.

On comparing the genitalia of the Trematodes and Cestodes the parts will be found to agree, but the vagina of the Cestodes corresponds with the uterus of the Trematodes, and the uterus of the tapeworms to Laurer's canal of the Trematodes, which in most of the Cestodes has lost its external orifice.

Development of the Tapeworms.

Copulation.—As each proglottis possesses its own genital apparatus, and male as well as female organs are present, the following processes may occur: (1) self- or auto-fecundation (without immissio cirri); (2) self- or auto-copulation (with immissio cirri); (3) cross-copulation between proglottids of the same or different chains (of the same species); and (4) cross-copulation in the same proglottis in species with double genital pores. These various modes have actually been observed.

In those species which lack the vagina (*Acoleïnæ*) it appears that the cirri, which are always furnished with hooks, are driven into the tissues and for the most part reach the receptaculum seminis.

The *eggs* of all Cestodes are provided with shells, but the shells, like their contents, vary. In genera that possess a uterine pore the mature eggs frequently do not differ from those of the Distomata; they have a brown or yellow shell of oval form provided with an operculum, and contain a number of yolk cells in addition to the fertilized ovarian cell (fig. 128), but in other genera (with a uterine pore) the lid is absent and the egg-shell is very thin, the eggs of these genera resembling those of Cestodes in which the secretion of the vitellarium is a light albumin-like substance that contains only a few granules, and in which the egg-shell is very delicate and without operculum.

The eggs of *Tæniidæ*, for example, at first consist of egg-shell (oötype), ovum and yolk cells. The egg-shell is as a rule soft, colourless and frequently deciduous, and the yolk is scanty in amount and contains few granules. The eggs are, moreover, more complicated than this. They enlarge and change their shape and various envelopes are developed around the embryo. The egg-shell proper often disappears, and one or more embryonal envelopes, or protoplasmic layers, arise, so that eventually it is difficult to say whether the whole egg is present, and, if not, what the layers that remain really are.

The *embryonal development* in most species takes place during the stay of the eggs in the uterus; in other species it takes place after the eggs have been deposited and are in water. Separate cells or a layer of cells always separate from the segmentation cells, as well as from the cells of the developing embryo, and form one or more envelopes round the embryo; usually two such envelopes are formed, the inner one of which stands in intimate relationship with the embryo itself and is often erroneously termed the egg-shell, but more correctly the embryonal shell or *embryophore*. In some species it carries long cilia, as in *Dibothriocephalus latus*, by aid of which the young swim about when released from the egg-shell; as a general rule, however, there are no cilia and this envelope is homogeneous, or is composed of numerous rods and is calcified, as in *Tænia* spp. (fig. 197). The second outer envelope ("yolk envelope") (fig. 207, 3) lies close within

Fig. 195.—Egg of *Diplogonoporus grandis*, showing the morula surrounded by yolk cells and granules. 440/1. (After Kurimoto.)

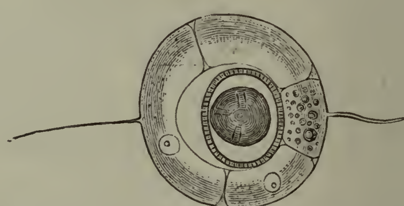


Fig. 196.—Uterine egg of *Tænia saginata*, G. Uterine shell with filaments; the oncosphere with embryonal shell (embryophore) in the centre. 500/1. (After Leuckart.)

the true (oötype) egg-shell, and remains within it when the embryo hatches out, and in many species, as in *Tænia* spp., it perishes at the end of the embryonal development with the delicate egg-shell which was formed in the oötype, so that one observes not the entire egg with egg-shell but only the embryo in its embryonal shell, *viz.*, the embryophore (fig. 197, *a.*).

The embryo (the ONCOSPHERE) enclosed within the embryonal shell (embryophore) is of spheroidal or ovoid form (fig. 197, *b.*), and is distinguished by the possession of three pairs of spines, a few terminal (flame) cells of the excretory system, and muscles to move the spines.

NO FURTHER DEVELOPMENT of the oncosphere takes place, either in the parent organism or in the open; in fact, in all cases in which the oncospheres are already formed within the proglottids they do not become free, but remain in their shell; it is only when the oncospheres are provided with a ciliated embryophore that they leave the egg-shell, and they even cast this ciliated envelope after having swum about in water by its means for a week or so. Sooner or later, however, all the oncospheres leave the host that harbours the parental tapeworm and reach the open, either still enclosed in the uterus of the evacuated proglottids, after the disintegration of which they then become free, or after being deposited as eggs in the intestine of the host; they then leave it with the fæces. In the former case also, the slightest injury to the mature proglottids while still in the intestine suffices to allow a part of the oncospheres in their embryophores to be released and mingled with the fæces. Here they are the generally, but falsely, so-called Tæniæ "eggs." For, as stated above, the "yolk" envelope and the true shell deposited in the oötype have before this disintegrated.

In other cases, *e.g.*, *Hymenolepis* spp., the uterine (oötype) shell persists in fæces (fig. 230).

In any case the oncospheres must be transmitted into suitable animals to effect their further development; in only very rare cases might an active invasion be possible, as, for instance, takes place with the miracidia of many Trematodes. The entry into an animal is, as a rule, entirely passive, that is to say, the oncospheres are swallowed with the food or water. Many animals are coprophagous and ingest the oncospheres direct with the fæces; others swallow them with water, mud, or food contaminated by such fæces. Infection is easily produced artificially by feeding suitable animals with mature proglottids of certain Cestodes or introducing the oncospheres with the food. As the mature tapeworm frequently finds the conditions suitable for its development in only one species of host, or in species nearly related, and perishes when artificially introduced into other hosts, experiment has taught us that to succeed in cultivating the oncospheres certain species of animals are necessary. Thus we are aware that the oncospheres of *Tænia solium*, which lives in the intestine of man, develop only in the pig, and only quite exceptionally develop into the stage characteristic of all Cestodes—the cysticercus in the wide sense of the word—in a few other mammals. The oncospheres of *T. saginata* develop further only in the ox; those of *T. marginata* (of the dog) in the pig, goat, and sheep; those of *T. serrata* (of the dog) in hares and rabbits; those of *Dipylidium caninum* (of the dog and cat) in parasitic insects of the dog and cat, etc. It is not unusual that young animals

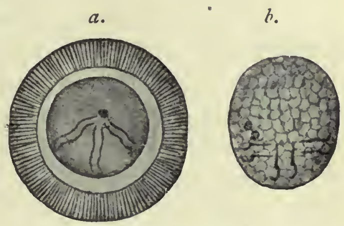


FIG. 197.—*a.*, oncosphere, in its radially striated embryophore (erroneously termed egg-shell) of *Tænia africana*. Greatly magnified. (After von Linstow.) *b.*, freed oncosphere of *Dipylidium caninum*. (After Grassi and Rovelli.) Both oncospheres show six spines.

only appear to be capable of infection, while older animals of the same species are not so.

Once introduced into a suitable animal, which is only exceptionally the same individual or belongs to the same species as the one which harbours the adult tapeworm, the oncosphere passes into the larval stage common to all Cestodes, but varying in structure according to the species. In the simplest case—as, *e.g.*, in *Dibothriocephalus*—such a larva resembles the scolex of the corresponding tapeworm, only that the head, provided with suckers, is retracted within the fore-part of the neck. Such a larval form is known as a *plerocercoid* (πλήρης, full; κέρκος, tail). They differ from the cysticercoids in being solid larval forms, elongated, tape-like or oval, with the head invaginated. The conditions appear to be similar in *Ligula, Schistocephalus, Triænophorus*, but here the larvæ are very large, indeed as large in the first-mentioned genera as the tapeworms originating from them, and the sexual organs are already outlined; doubtless, however, this stage is preceded by one that corresponds to the scolex of the genus in question, and which represents the actual larval stage. In such cases the development of the body of the tapeworm from the scolex has already begun within the first or intermediate host; in other cases, except in the single-jointed (monozootic) Cestodes, this only takes place in the definitive host. The direct metamorphosis of the oncosphere into the larval forms termed PLEROCERCOID has hitherto not been investigated, although *Ligula*, *Schistocephalus* and *Bothriocephalus* are very common parasites, but many circumstances point to the conclusions arrived at by us and by other observers. In the larval stages of other tapeworms we can always distinguish the scolex and a caudal-like appendage, vesicular in the cysticerci (fig. 200), compact in the cysticercoids (fig. 231). The scolex alone forms the future tapeworm, the variously formed appendage perishing.

It has now been proved that the appendage, the caudal vesicle, originates direct from the body of the oncosphere, and therefore is primary, and that the scolex only subsequently forms through proliferation on the surface of this appendage. On account of this origin the scolex is generally regarded as the daughter, and the part usually designated as the appendage as the mother, originating from the oncosphere.

Accordingly, two modes of development of the larval stage may be distinguished; in the one case, plerocerci and plerocercoids, the oncosphere changes directly into the scolex, thus forming the body of the tapeworm within the primary host; in the other case, cysticerci and cysticercoids, the scolex only forms secondarily in the transformed body of the oncosphere, which later on perishes, the scolex alone remaining as the originator of the tapeworm colony.

We may summarize briefly what has been said regarding these larval forms. We have, firstly, solid larval forms without any bladder. These arise *directly* from the oncosphere and are of two kinds, plerocercus and plerocercoid. *Plerocercus* is a solid *globular* larva with the head invaginated into the posterior portion. *Plerocercoid* (fig. 208) is a solid *elongated* larva also with the head invaginated into the posterior portion, which is sometimes very long. Secondly, we have larval forms with bladders from which the scolices arise thus *indirectly* from the oncosphere. They are of two kinds, cysticercoid and cysticercus.

Cysticercoid.—The bladder is but slightly developed and is usually absorbed again. The anterior portion is, moreover, retracted into the posterior, and in some cases there is a long or a stumpy tail (figs. 220, 231).

Cysticercus, or true bladder worms. (These may be divided into [1] cysticercus proper, consisting of a bladder and one scolex;

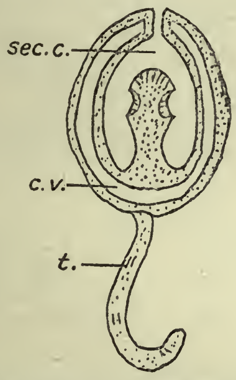


FIG. 198.—Diagram of a cysticercoid. *Cf.* figs. 220, 227. *c.v.*, caudal vesicle or bladder (small); *sec. c.*, secondary cavity caused by the growth forward of the hind-body; *t.*, tail bearing six spines. (Stephens.)

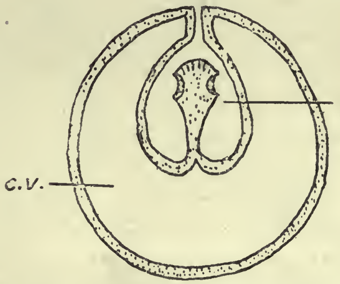


FIG. 199.—Diagram of a cysticercus. *c.v.*, caudal vesicle or bladder; *i.*, invagination of wall of bladder. (Stephens.)

[2] cœnurus, a bladder and many scolices; [3] echinococcus, a bladder in which daughter bladders or cysts are developed, and then in these multiple scolices.)

In the case of cysticerci a papilliform invagination forms, projecting into the interior of the bladder (fig. 201). The layer of cells forming the papilla becomes divided into two laminæ, the outer[1] of which forms a kind of investing membrane (receptaculum capitis) for the papilla. The head and suckers are now developed on the walls bounding the axial lumen of the papilla. The papilla eventually

[1] *I.e.*, regarded from the interior or centre of the invagination.

evaginates, so that the receptaculum capitis now forms the inner surface of the hollow head, which eventually becomes solid.

Our knowledge of the development of cysticerci in the wide sense of the word is limited almost exclusively to that of a few true "bladder worms" (cysticerci); in other cases we know either only the terminal stage, *i.e.*, the complete larva, or, exceptionally, one of the intermediate stages, but we are not acquainted with a complete series; the description must therefore be incomplete.

We know from feeding experiments that, after the introduction of mature proglottids or of the fully developed ova of *Tænia crassicollis* (of the cat) into the stomach of mice, the oncospheres escape from the shell in the middle portion of the small intestine, and a few hours later penetrate into the intestinal wall by means of a boring movement; they have been found in this position twenty-seven to thirty hours after the infection. By means of this migration, for which purpose they employ their spines, they attain the blood-vessels of the intestine; indeed, already nine hours after the infection and later they are found in the blood of the portal vein, and in the course of the second day after infection they are found in the capillaries of the liver, which these larvæ do not leave.

Leuckart, in experimental feeding of rabbits with oncospheres of *Tænia serrata* (of the dog), found free oncospheres in the stomach of the experimental animal, but not in the intestine: however, he came across them again in the blood of the portal vein. The passage through the blood-vessels to the liver is the normal one for those species of *Tænia* the eggs of which become larvæ in mammals; even in those cases in which the oncospheres develop further in the omentum or in the abdominal cavity (*Cysticercus tenuicollis, C. pisiformis*), there are distinct changes observable in the liver that lead one to the conclusion that there has been a secondary migration out of the liver into the abdominal cavity. Indeed, one must not imagine that the young stages of the Cestodes are absolutely passive; once they have invaded an organ they travel actively, and leave distinct traces of their passage.

In other cases the oncospheres leave the liver with the circulation, and are thus distributed further in the body; they may settle and develop in one or more organs or tissues. Many oncospheres may, by travelling through the intestinal wall, penetrate through it and attain the abdominal cavity direct; some, perhaps, pass also into the lymph stream. Where there are no blood and lymphatic vessels in the intestinal wall, as in insects, the oncospheres attain the body cavity or its organs direct; in short, they never remain in the intestinal lumen itself, and only rarely—as in *Hymenolepis murina* of the rat—do they remain in the intestinal wall.

When the infection has been intense, and the body is crowded with numerous oncospheres, acute feverish symptoms are induced, to which the infected animals usually succumb ("acute cestode tuberculosis"); while in other cases the alterations in the organs attacked—as the liver in mice and the brain in sheep—may cause death.

Sooner or later the oncospheres of tapeworms come to rest, and are first transformed into a bladder, which may be round or oval according to the species. The embryonal spines disappear sooner or later, or remain close together or spread over some part of the bladder wall (fig. 200). Their discovery by v. Stein in the bladder worm of the "meal worm" (the larva of a beetle, *Tenebrio molitor*) first led to the conclusion that bladder worms (cysticerci) actually originate from the oncospheres of *Tæniidæ*.

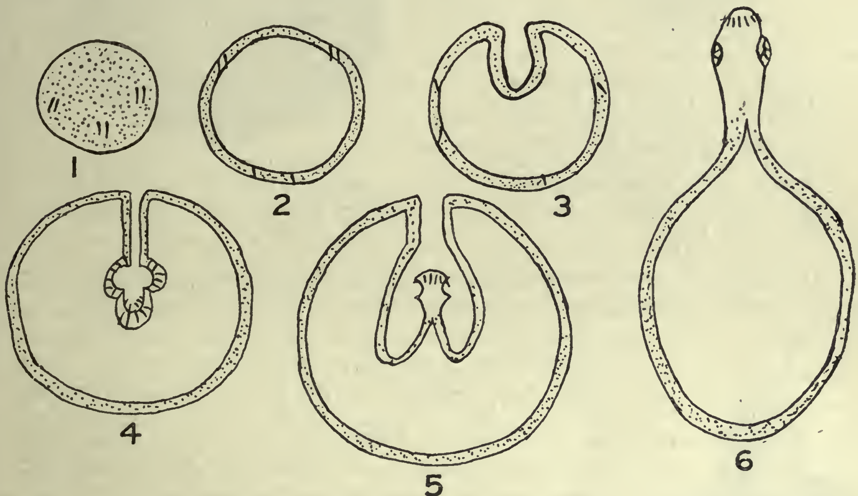


FIG. 200.—Diagram of development of a cysticercus. 1, solid oncosphere with six spines; 2, bladder formed by liquefaction of contents; 3, invagination of bladder wall; 4, formation of rostellum (with hooklets) and suckers at the bottom of the invagination; 5, evagination of head; 6, complete evagination effected by pressure. (Stephens.)

The bladder may remain as a bladder, and then by proliferation the scolex forms on its wall (fig. 202), or it may divide into an anterior so-called "cystic" portion and a solid tail-like appendage of various lengths, on which the embryonal hooks are to be found, and this is particularly the case in those larval forms (cysticercoids), *e.g.*, those of *Dipylidium caninum*, that develop in invertebrate animals, such as Arthropoda.

As mentioned above one may regard the scolex as an individual that originates through proliferation of the wall of the parent cyst, mostly singly, but in those cysticerci that are termed cœnurus (fig. 201) many scolices occur, whereas in those called echinococcus the parent cyst originating from the oncosphere of *Tænia echinococcus* (of the dog) first produces a number of daughter cysts, which in their turn form numerous scolices. Echinococcus-like conditions also occur in cysticercoids, as, for instance, in those peculiar to earthworms; and similar conditions prevail in a larval form known as *Staphylocystis*, found in the wood-louse (*Glomeris*). Thus it happens in these cases that finally *one* tapeworm egg produces not *one*, but numerous tapeworms, for, under favourable conditions, each scolex can form a tapeworm.

FIG. 201.—Section through a piece of a *Cœnurus cerebralis*, with four cephalic invaginations in different stages of development. At the bottom of the invaginations the rostellum, hooks and suckers develop. (From a wax model.)

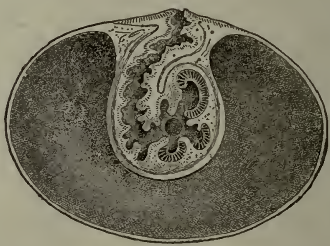


FIG. 202.—Median section through a cysticercus, with developed scolex at the bottom of the invagination. (After Leuckart.)

The rudiment of the scolex appears as a hollow bud, the cephalic invagination usually directed towards the interior of the bladder cavity; on its invaginated surface arise the four suckers, and the rostellum with the hook apparatus is formed in its blind end; we thus get a Tænia head, but with the position of the parts reversed (fig. 201). In many cysticerci the head rises up from the base of the cephalic invagination and is then surrounded by the latter. A more or less elongated piece of neck also develops, and even proglottids may appear, as in *Cysticercus fasciolaris* (the larva of *Tænia crassicollis* of the cat) of the Muridæ, a process somewhat analogous to that of Ligula, etc.

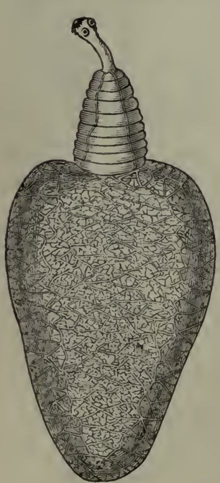


FIG. 203—*Cysticercus pisiformis* in an evaginated condition, with neck, fore-body and bladder, with excretory network in its wall. 18/1.

The period that elapses from the time of infection till the cysticercus is fully developed varies according to the species; the cysticercus of *Tænia saginata* requires twenty-eight weeks, that of *T. marginata* seven to eight weeks, that of *T. solium* three to four months, and that of *T. echinococcus* longer still.

With one single exception (*Archigetes*) the larvæ do not become sexually mature in the organ where they have developed; they must enter the terminal host, a matter that is usually purely passive, the carriers of the larvæ or infected parts of them being usually devoured by other animals. In this manner, for instance, the larvæ (*Cysticercus fasciolaris*) found in mice and rats reach the intestine of cats; those of the hare and rabbit (*C. pisiformis*) reach the intestine of dogs; those of the pig (*C. cellulosæ*) are introduced into man; those of insects are swallowed by insectivorous birds; those of crustaceans are ingested by ducks and other water fowl; perhaps, also, the infection of herbivorous mammals is caused by their accidentally swallowing smaller creatures infected by larvæ. Indeed, the researches of Grassi and Rovelli have taught us that such an intermediate host is not always necessary; *Hymenolepis murina* of rats and mice in its larval stage lives in the intestinal wall of these rodents, and as a larva it passes into the intestinal lumen and develops into a tapeworm in exactly the same way as the larvæ of other species that reach the intestine of the terminal host by means of an intermediate carrier. Probably this curtailed manner of transmission also occurs in many other species. In some cases the larvæ actively quit the body of the intermediate host, as in the case of *Ligula* and *Schistocephalus*, which travel out of the body cavity of infected fish and reach the water, where they may be observed in hundreds in summer, at all events in some localities. The larval stage of *Calliobothrium*—wrongly termed *Scolex*—has been observed swimming free in the sea, and the scolices of *Rhynchobothrium*, without their mother cysts, have been observed free within the tissues of several marine animals. In any case there is almost always a change of hosts, even in the single-jointed Cestodes, for the larva of *Caryophyllæus*, which lives in fishes of the carp family, is found in limicoline Oligochætes, that of *Gyrocotyle* (Chimæra) in shell-fish (Mactra), and different conditions can hardly be possible for *Amphilina*. *Archigetes* alone becomes sexually mature in the larval stage, but the life-history of this creature is not well known, so that it is not impossible that the attainment of sexual maturity as a larva in invertebrates (Oligochætes) is perhaps abnormal, and somewhat analogous to the maturity of some encysted Trematodes.

The METAMORPHOSIS OF THE LARVA into the tapeworm is rarely accomplished in a simple manner; the transformation, however, is not complex in the single-jointed Cestodes, nor in *Ligula* and *Schistocephalus*; the latter is swallowed by birds (*Mergus*, *Anas*, etc.), produces eggs after only a few days, and very soon quits the intestine of its terminal host. In all other cases it is the scolex only which, by proliferating at its posterior extremity, forms the proglottids, after having invaded as a larva the intestine of a suitable host. The mother cysts, or what corresponds to them, die, are digested, absorbed, or perhaps even eliminated; on the contrary, segments found on the scolex during the larval stage, also in the case of *Cysticercus fasciolaris*, are retained. It is not certain whether the larvæ of *Dibothriocephalus* lose any part.

The time required by the scolex to complete the entire chain of proglottids does not depend only on the number it has to produce, for *Tænia echinococcus*, which, as a rule, only possesses three or four segments, takes quite as long a time for their growth (eleven to twelve weeks) as *T. solium* with its numerous segments; *T. cœnurus* is fully developed in three to four weeks, and the same holds good for *Dibothriocephalus latus*, which possesses many more segments than the above-mentioned Tænia of the dog. In a number of species it has been possible to determine fairly accurately the average daily growth; for instance, in *Dibothriocephalus latus* the daily growth is 8 cm., in *Tænia saginata* 7 cm., etc.

The history of the development of the Cestodes demonstrates that persons and beasts harbouring larval tapeworms have become infected by having swallowed the oncospheres of the species of tapeworm to which they belong. In regard to *Hymenolepis murina* alone, it is known that the introduction of the oncospheres into those species of animals which harbour the adult tapeworm leads to the formation of the latter after the development of a larval stage in the intestinal wall; nevertheless, only young animals (rats) are capable of infection, for a previous infection, or the presence of mature tapeworms in the intestine, appears to produce a kind of immunity.

Biology.

In their adult stage, the tapeworms inhabit almost exclusively the alimentary canal of vertebrate animals, with but few exceptions the small intestine, and a few species select definite parts of it. A small number of *Rhynchobothriidæ* of marine fishes live apparently always in the stomach, while in rays and sharks the spiral intestine is their exclusive site. Bothriocephali generally attach themselves with their head on to the appendices of the pylorus of fishes; other species (*Hymenolepis diminuta*) occasionally fix their head in the ductus choledochus, and this is more frequent still in the tapeworms of the rock badger (*Hyrax*), which occasionally penetrate entirely into the biliary ducts. *Stilesia hepatica*, Wolffh., has so far only been found in the bile-ducts of its host (sheep and goat, East Africa).

In the disease of sheep induced by Cestodes, the worms have been observed also in the pancreas. Specimens found in the large intestines were probably being evacuated.

The Cestodes are looked upon as fairly inert creatures, this opinion having been formed by observing their condition in the cold cadavers of warm-blooded animals. Actually, however, they are exceedingly active, and accomplish local movements within the intestine, for they have been found in the ducts communicating with the bowel, or in the stomach, and may even make their way forward into the œsophagus.

They also invade other abdominal organs through abnormal communications, or through any that may be temporarily open between the intestine and such organs; they thus reach the abdominal cavity or the urinary bladder, or they work their way through the peritoneum.

They produce changes in the intestinal mucous membrane at the place of their attachment, the alterations varying in intensity according to the structure of the fixation organs. The mucous membrane is elevated in knob-like areas by the suckers; the epithelial cells become atrophied or may be entirely obliterated. *Dipylidium caninum* bores into the openings of Lieberkühn's glands with its rostellum, dilating the lumen to two or three times its normal size, while the suckers remain fixed between the basal parts of the cells. Species with powerful armatures penetrate deeper into the submucosa, and some that are not provided with exceptionally strong armatures, or are even unarmed, may be actually found with the scolex embedded in the muscles of the intestinal walls or even protruding beyond (*Tænia tetragona*, Mol., in fowls, etc.). Other species, again, even cause perforation of the walls of the intestine of their hosts.

It is generally assumed that tapeworms, which almost without exception live in the gut of vertebrates, get their nutriment from the gut contents, which apparently they absorb through the whole body surface (cuticular trophopores). In favour of this view is the existence of fat drops in the proglottids, the identity in colour in certain forms between that of the fresh worm and the gut contents and the passage of certain substances derived from medicines (iron and mercury preparation) into the worms in the gut, etc. Whether the suckers are concerned in the absorption of nutriment and to what extent is still questionable.

THE LENGTH OF LIFE OF THE ADULT TAPEWORM certainly varies; as a rule it appears to last only about a year; in other cases (*Ligula*) it averages only a few days, but we are likewise aware that certain species of Cestodes of man attain an age of several or many years (thirty-five). The natural death of Cestodes often appears to be brought about by alterations in the scolex, such as loss of the hooks, atrophy of the suckers and rostellum, finally the dropping off of the scolex; it is unknown whether a chain of segments deprived of its scolex then perishes or whether it first attains maturity. It has already been mentioned that in a few species the foremost proglottids are transformed into organs of fixation on the normal loss of the scolex.

Abnormalities and malformations are encountered relatively frequently in the Cestodes—such as abnormally short or long segments; the so-called triangular tapeworms, which—if belonging to the *Tæniidæ*—always possess six suckers; often also club-shaped segments occur between normal ones, or there may be a defect in one segment or in the centre of a number following one another (fenestrated segments); bifurcated chains of segments have likewise been observed, as well as incomplete or complete union of the proglottids, abnormal increase of the genital pores, reversion of the genitalia. Besides the above-mentioned increase of the number of suckers on the scolex (in Tæniæ), there may be a decrease in the number; in other cases the crown of hooks may be absent, or abnormally shaped hooks may be formed.

Classification of the Cestoda of Man.

Order. **Pseudophyllidea**, Carus, 1863.

Scolex without proboscis or rostellum. Head "stalk" absent.

Scolex never with four, generally with two (or one terminal) bothria.[1] Vitellaria numerous. Uterine opening present. Genitalia do not atrophy when uterus is developed. In large majority of proglottids eggs (or, if formed, their contents) are at the same stage of development.

Family. **Dibothriocephalidæ**, Lühe, 1902.

Syn.: *Diphyllobothriidæ*, Lühe, 1910.

Genitalia repeated in each proglottid (polyzootic Cestodes). Ventral and dorsal surfaces flat. Cirrus unarmed. Cirrus and vagina if non-marginal open on the same surface as the uterus. Uterus long, convoluted, often forming a "rosette," never dilates into a uterine cavity. Eggs thick shelled, operculated, constantly being formed in mature proglottids.

Sub-family. **Dibothriocephalinæ**, Lühe, 1899.

Syn.: *Diphyllobothriinæ*, Lühe, 1910.

Segmentation distinct. Scolex unarmed, elongated, sharply separated (generally by a neck) from the first proglottis. Cirrus and vagina open ventrally. Genital pores non-alternating. Vas deferens surrounded by a muscular bulb. Receptaculum seminis large, sharply separated from the spermatic duct.

Order. **Cyclophyllidea**, v. Beneden.

Four suckers always present. Uterine opening absent. Vitellarium single. Genitalia atrophy when uterus is fully developed.

---

[1] *Bothridia* or "*phyllidia*" are *outgrowths* from the scolex. They are concave and extremely mobile. By some authors the term "*phyllidium*" is used for the outgrowth, and the term "*bothridium*" is restricted to the muscular cup. *Bothria*, on the other hand, are grooves more or less wide, the musculature of which is only slightly developed and is not separated off internally from the parenchyma. *Acetabula*, or suckers in the usual sense, are hemispherical cups, without lips and with musculature separated internally from the parenchyma.

Family. **Dipylidiidæ**, Lühe, 1910.

Rostellum if present armed. Suckers unarmed. Uterus breaks up into egg capsules. Paruterine organs absent.

Family. **Hymenolepididæ**, Railliet and Henry, 1909.

Segment always broader than long. Genitalia single. Longitudinal muscles in two layers. Genital pores unilateral. Testes one to four. Uterus persistent, sac-like. Eggs with three shells.

Family. **Davaineidæ**, Fuhrmann, 1907.

Rostellum cushion-shaped. Armed with numerous (sixty to several thousand) hammer-shaped hooks in two (rarely one) rows.

Sub-family. **Davaineinæ**, Braun, 1900.

Suckers armed. Uterus breaks up into egg capsules. Paruterine organs absent.

Family. **Tæniidæ**, Ludwig, 1886.

Suckers unarmed. Uterus with median longitudinal stem and lateral branches. Female genitalia at the hind end of the proglottis. Genital pore irregularly alternating. Testes numerous in front of female genitalia. Ovary with two lobes (wings). Vitellarium behind the ovary. Embryophore radially striated.

THE CESTODES OF MAN.

Most of the species to be mentioned live in man in their adult stage and occupy the small intestine; man is the definite host of these parasites, but is not the specific host for all the species; some of these species, as well as others (of mammals), may occur in man also in the larval stage.

Family. **Dibothriocephalidæ**.

Sub-family. **Dibothriocephalinæ**.

Genus. **Dibothriocephalus**, Lühe, 1899.

Syn.: *Diphyllobothrium*, Cobbold, 1858; *Bothriocephalus*, p. p. Rud., 1819; *Dibothrius*, p. p. Rud., 1819; *Dibothrium*, p. p. Dies., 1850.

Scolex egg-shaped; dorsal and ventral bothria elongated, moderately strong, cutting rather deeply into the head; genitalia single in each proglottis; papillæ in the vicinity of the genital atrium; the testes and vitellaria are in the lateral fields, the former in the medullary layer, the latter in the cortical layer on both surfaces, and occasionally extending to the median line; the ovary ventral, the shell gland dorsal. The uterus is in the central field, taking a zigzag course, and frequently forms a rosette.

Dibothriocephalus latus, L., 1748.

Syn.: *Tænia lata*, L., 1748; *Tænia vulgaris*, L., 1748; *Tænia grisea*, Pallas, 1796; *Tænia membranacea*, Pall., 1781; *Tænia tenella*, Pall., 1781; *Tænia dentata*, Batsch, 1786; *Bothriocephalus latus*, Bremser, 1819; *Dibothrium latum*, Dies., 1850; *Bothriocephalus cristatus*, Davaine, 1874[1]; *Bothriocephalus balticus*, Kchnmstr., 1855; *Bothriocephalus latissimus*, Bugn., 1886.

Length 2 to 9 m. or more; colour yellowish-grey; after lying in water the lateral areas become brownish and the uterine rosette brown. The head is almond-shaped, 2 to 3 mm. in length, the dorso-ventral axis is longer than the transverse diameter; the head, therefore, generally lying flat, conceals the suctorial grooves at the borders; these suckers are deep and have sharp edges (fig. 205). The neck varies in length according to the degree of contraction and is very thin; there are 3,000 to 4,200 proglottids and there may be more; their breadth is usually greater than their length, but in the posterior third of the body they are almost square, and the very oldest are not uncommonly longer than they are broad. There are numerous testes situated dorsally in the medullary layer of the lateral fields; the vas deferens (fig. 192) passes dorsally in transverse loops in the central field anteriorly and forms a seminal vesicle before its entry into the large cirrus pouch.

The orifice of the vagina is close behind the orifice of the cirrus; the former passes almost straight along the median line posteriorly, and widens into a receptaculum seminis shortly before its junction with the oviduct; the ovary is bilobed, in shape like the wings of a butterfly, ventrally in the medullary layer; the shell glands lie in the posterior recess of the ovary; the uterus, forming numerous transverse convolutions, passes ventral to the vas deferens forwards. Eggs (fig. 207) large, with brownish shells and small lids, 68 μ to 71 μ by 45 μ; the ovarian cell, which is already, as a rule, in process of segmentation, is surrounded by numerous large yolk cells; the proglottids nearest the posterior extremity are frequently eggless.

The eggs, which are deposited in the intestine and evacuated

[1] Until recently this worm, which was understood to belong to a separate species, was proved on examination by R. Blanchard ("Mal. Par.," 1896), to be *Dibothriocephalus latus*. Compare also Galli-Valerio, in *Centralbl. f. Bakt., Path. und Infektionskr.*, 1900 (1), xxvii, p. 308.

with the fæces, hatch in water after a fortnight or more; the embryonal integument (embryophore) of the oncosphere is provided with cilia; after bursting open the lid of the egg the oncosphere in its embryophore (fig. 207) reaches the water and swims slowly about; often it slips out of its ciliated embryophore, sinks to the bottom and is capable of a creeping motion; sooner or later it dies in the water. The manner and means of its invasion of an intermediate host are still

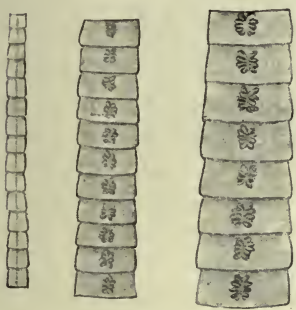


FIG. 204.—Various chains of segments of *Dibothriocephalus latus*, showing the central uterine rosette. (Natural size.)

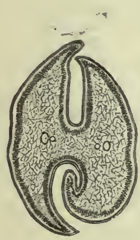


FIG. 205.—Transverse section of the head of *Dibothriocephalus latus*. 30/1.

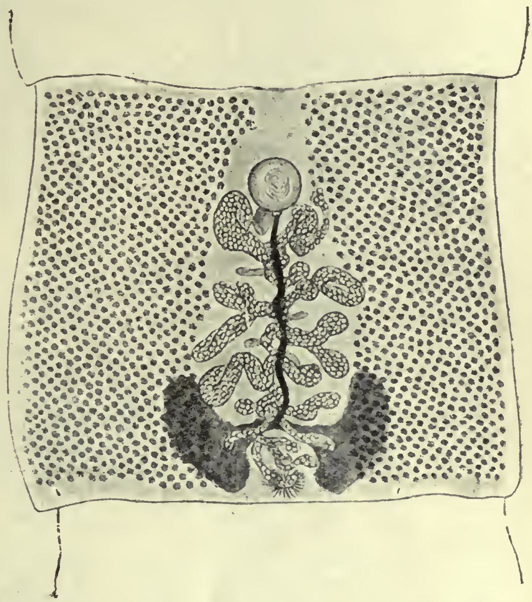


FIG. 206.—Fairly mature proglottis of *Dibothriocephalus latus*. The vitellaria are at the sides; the uterus, filled with eggs, is in the middle, also the vagina (the dark stripe passing almost straight from the front to the back), and the vas deferens (almost hidden by the uterus). Above in the centre is the cirrus sac, and below the shell gland and ovary are seen. 15/1. (From a stained preparation.)

unknown; yet we are aware that the larval stage (plerocercoid, fig. 208), which resembles the scolex and may reach a length of 30 mm., lives in the intestine, in the intestinal wall, in the liver, spleen, genital glands and muscular system (fig. 209) of various fresh-water fish, the pike (*Esox lucius*), the miller's thumb (*Lota vulgaris*), the perch (*Perca fluviatilis*), *Salmo umbla*, *Trutta vulgaris*, *Tr. lacustris*, *Thymallis vulgaris* (grayling), *Coregonus lavaretus*, *C. albula* (in Europe) and *Onchorhynchus perryi* (in Japan). The transmission of the plerocercoids from these fish to the dog, cat and man (Braun, Parona, Grassi and Ferrara, Grassi and Rovelli, Ijima, Zschokke, Schroeder) leads to the development of the broad tapeworm, the growth of which is rapid. In my experiments on human beings the average number of proglottids formed per diem averaged thirty-one to thirty-two for five weeks, with a length of 8 to 9 cm. According to Parona the eggs

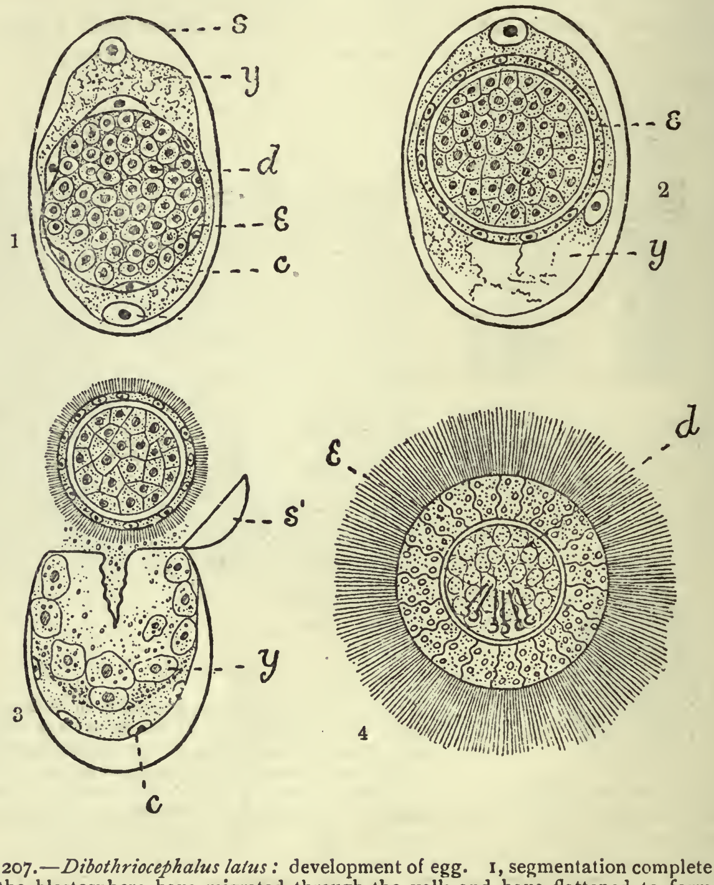


FIG. 207.—*Dibothriocephalus latus:* development of egg. 1, segmentation complete; some cells of the blastosphere have migrated through the yolk and have flattened to form *c*, the yolk envelope; others form a layer of flattened cells (*e*) forming the embryophore; the remaining cells (*d*) of the blastosphere form the hexacanth embryo. 2, embryophore (*e*) is becoming thicker. 3, the ciliated embryo has been pressed out of the shell; *s'*, the operculum; *c*, the yolk envelope remaining in the shell (*s*); *y*, the yolk consisting of separate cells. 4, a free-swimming larva much swollen by the water. (After Benham and Schauinsland.)

appear twenty-four days after man has been infected. Zschokke found the average growth in the experimental infection of man between 5·2 and 8·2 cm. per diem, and the person experimented upon by Ijima evacuated a piece of a *Dibothriocephalus latus*, 22·5 cm. in length, only twenty-one days after the infection.

The "broad tapeworm" is a frequent parasite of man in some districts, but it also occurs in the domestic dog, and on rare occasions is found in the domestic cat (together with *Dibothriocephalus felis*, Crepl.) and fox. French Switzerland and the Baltic Provinces of Russia are the centres of distribution; from the former districts the distribution radiates to France and Italy (Lombardy, Piedmont); from the Baltic Provinces over Ingermanland to Petrograd, over Finland to Sweden (on the shore of the Gulf of Bothnia), in a southerly direction to Poland, and into the Russian Empire and across it to Roumania, and towards the west along the coast of the Baltic Sea to the North Sea, where, however, its frequency considerably diminishes (Holland, Belgium, and the North of France).

FIG. 208.—Plerocercoid of *Dibothriocephalus latus*. *A*., with the head evaginated; *B*., with the head invaginated. From the muscle of the pike.

In Turkestan and Japan the "broad tapeworm" is the most frequent parasite of man; it has been reported in Africa from the vicinity of Lake N'gami as well as from Madagascar; cases, in

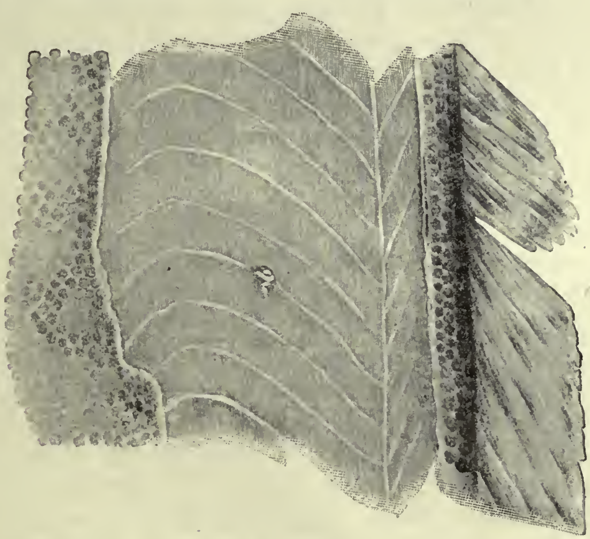


FIG. 209.—A piece of the body wall of the Burbot, *Lota vulgaris*. The tangential section has exposed the muscles of the trunk, with a plerocercoid of *Dibothriocephalus latus*. Natural size.

part at least imported, have also come under observation in North America.

In Germany *Dibothriocephalus latus*—apart from the fact that it is undoubtedly imported from Switzerland, Russia or Italy—is particularly frequent in East Prussia amongst the inhabitants of the Courland Lagoon district, on the Baltic; it is, moreover, also found in the Province and even in the City of Königsberg. In West Prussia and Pomerania it is very much scarcer.

It is also found in Munich and in the vicinity of the Lake of Starnberg (Bollinger).

Krabbe found it in 10 per cent. of the sufferers from tapeworms in Denmark; Szydlowski found the ova of this worm in Dorpat in 10 per cent. of the fæces examined; Kruse found the worm in 6 per cent. of *post-mortems*; Kessler, in Petrograd, found the eggs in the fæces in 7·8 per cent.; at *post-mortems* he found the worms in 1·17 per cent., though Winogradoff only found it in 0·8 per cent. In Moscow, according to Baranovsky, 8·9 per cent. of the fæces examined contained the ova of *Dibothriocephalus*. In the interior and southern provinces of Sweden the worm, according to Lönnberg, is only found sporadically, but, on the other hand, in Angermanland about 10 per cent. of the population is affected; while again in Norbotten the majority of persons are affected, and in Haparanda the entire population (with the exception of infants) harbour this parasite. In Switzerland *D. latus* is very frequent in close proximity to the lakes of Bieler, Neuchatel, Morat and Geneva (according to Zaeslin 10 to 15 to 20 per cent. of the population are affected); the parasite is less frequent in districts one to four hours removed from these lakes.

Of the fish from Swiss lakes examined by Schor those from Lake Geneva were most commonly infected, and especially *Lota* sp. and *Perca* sp.

The frequency and distribution have, nevertheless, decreased perceptibly in places; at the commencement of the eighteenth century the broad tapeworm was very common in Paris, at the present date it only occurs when imported (Blanchard); in Geneva, also, according to Zschokke, it has become rarer (formerly 10 per cent., now only 1 per cent.).

The disturbances produced in man by the presence of broad tapeworms are, as a rule, very trifling; in other cases they produce partly gastric disorders and partly nervous symptoms; in a number of cases, again, they set up severe anæmia, apparently caused by toxins produced by the worms and absorbed by the host. There is no danger of auto-infection, as the larval stage lives only in fishes, not in warm-blooded animals. The case reported by Meschede (ova like those of *Dibothriocephalus latus* in the brain of a man who had suffered from epilepsy for six years) must be otherwise explained.

Human beings, like other hosts, can only acquire the broad tapeworm by ingesting its plerocercoids with the previously mentioned fresh-water fishes; the opportunity for such infection is afforded the more readily by the fact that not only do the lower classes not pay sufficient attention to the cooking of fish, so that all the larvæ that are present may be killed, but also in certain localities the custom exists of eating some parts of these fishes in a raw condition; even the mere handling of the usually severely infected intermediary hosts may occasionally cause infection. The plerocercoids are as well known as, but differ materially in appearance from, the cysticerci (*Cysticercus cellulosæ*) of pig's flesh. In Germany the occurrence of the plerocercoids of *Dibothriocephalus latus* has been confirmed in the pike, miller's thumb and perch of East Prussia, and more particularly in those taken from the Courland Lagoon.

The life of *D. latus* is a very long one (six to fourteen years), as is deduced from persons who have left *D. latus* regions after they have been infected.

According to the experiments of M. Schor, plerocercoids of *D. latus* placed in slowly warmed water completely lose their movement at 54° to 55° C.; they survive the death of their host for several days; they are killed by low temperatures $-3°$ to $+1°$ C. in two days; strong acids and salt solutions kill them at once, also high temperatures, but all the same at least ten minutes is required in boiling or frying fish in order to kill the plerocercoids with certainty.

Dibothriocephalus cordatus, R. Lkt., 1863.

Syn.: *Bothriocephalus cordatus*, R. Lkt.

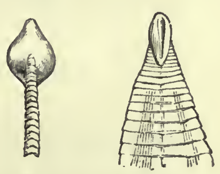


FIG. 210.—Cephalic end of *Dibothriocephalus cordatus;* on the left viewed sideways, on the right from the dorsal surface, showing a suctorial groove. (After Leuckart.)

Length, 80 to 115 cm.; the head is heart-shaped and measures 2 by 2 mm. The suctorial grooves are on the flat surface; the segments commence close behind the head and increase rapidly in breadth. At only 3 cm. behind the head they are already mature; the greatest breadth attained by them averages 7 to 8 mm., the length 3 to 4 mm.; the number of proglottids averages 600; the most posterior ones are usually square. The uterine rosette is generally formed of six to eight lateral loops. The eggs are operculated and measure 75 μ by 50 μ.

Dibothriocephalus cordatus is a common parasite of the seal, the walrus and the dog in Greenland and Iceland, occasionally of man also. No doubt its larva lives in fishes.

The statement that *D. cordatus* also occurs in Dorpat in human beings has been proved erroneous (*Zool. Anzeiger*, 1882, v, p. 46), as also has the report that this worm lives in hares in the neighbourhood of Berlin, whither it was supposed to have been carried by Esquimaux dogs (Rosenkranz in *Deutsch. med. Wochenschr.*, 1877, iii, p. 620). The parasite stated by the author to be *D. cordatus* is *Tænia pectinata*, Goeze, which has been known since 1766.

Dibothriocephalus parvus, Stephens, 1908.

Largest gravid segments 5 by 3 mm. Uterus forms a central rosette with four to five loops on each side of median line. In a proglottid measuring 3·5 by 2·25 mm. the genital atrium is situated 0·4 to 0·5 mm. behind the anterior margin and the uterine opening the same distance behind the genital atrium. Calcareous corpuscles absent in the preserved specimens. Eggs operculated, 59·2 μ by 40·7 μ.

Distinguished from *Dibothriocephalus latus*—(1) by the size of gravid segments (the minimum width of gravid segments of *D. latus* is 10 to 12 mm., so that *D. parvus* is a much smaller worm); (2) quadrate segments of *D. latus* measure 6 by 6 mm., those of *D. parvus* 4 by 4 mm.; (3) by the eggs.

From *D. cordatus* it is distinguished by—(1) *D. cordatus* has only fifty immature segments, *D. parvus* has at least 200, possibly more; (2) mature segments of *D. cordatus* measure 7 to 8 mm., maximum width of *D. parvus* is 5 mm.; (3) quadrate segments of *D. cordatus* measure 5 to 6 mm.; (4) *D. cordatus* has six to eight uterine loops; (5) *D. cordatus* measures 75 μ to 80 μ by 50 μ.

Habitat.—Intestine of man (Syrian, in Tasmania).

Genus. Diplogonoporus, Lönnbrg., 1892.

Syn.: *Krabbea*, R. Blanch., 1894.

The scolex is short and has powerful suctorial grooves; no neck; the proglottids are short and broad; there are two sets of genital organs side by side in each segment, which in all essentials resemble the single one of *Dibothriocephalus*.

Parasitic in whales and seals, occasionally in man.

Diplogonoporus grandis, R. Blanch., 1894.

Syn.: *Bothriocephalus* sp., Ijima et Kurimoto, 1894; *Krabbea grandis*, R. Blanch.

Scolex unknown; chain of proglottids over 10 m. in length, 1·5 mm. broad anteriorly, 25 mm. broad posteriorly. The proglottids are very short (0·45 mm.), but 14 to 16 mm. broad. On either side to the right and left of the worm, along the entire ventral surface, there is a longitudinal groove; these grooves are nearer to each other than to the lateral margin; in them lie the genital pores, and they are in the same sequence as in *Dibothriocephalus;* corresponding to the scanty length (0·45 mm.) of the proglottids, the ovary is only developed transversely; the uterus only makes a few loops. Eggs (fig. 195) thick shelled, brown, 63 μ by 48 μ to 50 μ. This parasite has hitherto been observed twice in Japanese. Similar species are known in Cetacea and seals.

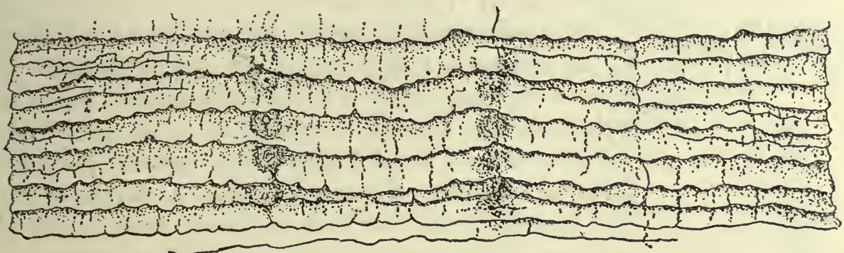


FIG. 211.—*Diplogonoporus grandis*, Lühe, 1899: ventral view of a portion of the strobila, showing two rows of genital pores and partially extruded cirri. (After Ijima and Kurimoto.)

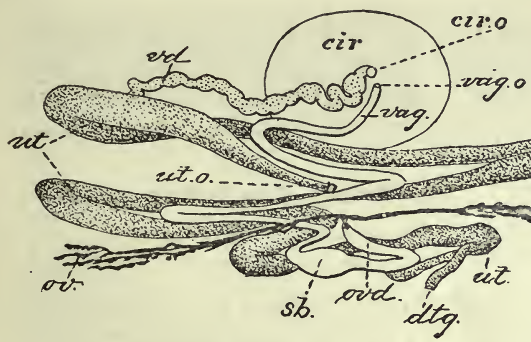


FIG. 212.—*Diplogonoporus grandis*: ventral view (diagrammatic) of genitalia of left side; *cir*, cirrus; *cir.o*, cirrus opening; *dtg.*, vitelline duct; *ov.*, ovary; *ovd.*, oviduct; *sb.*, receptaculum seminis; *ut.*, uterus; *ut.o.*, uterine pore; *vag.*, vagina; *vag.o.*, vaginal pore; *vd*, vas deferens. × 150. (After Ijima and Kurimoto.)

Sparganum, Diesing, 1854.

The term *Sparganum*, invented by Diesing, is used as a group name of larval bothriocephalid Cestodes whose development is not sufficiently advanced to enable them to be assigned to any particular genus.

Sparganum mansoni, Cobb., 1883.

Syn.: *Ligula mansoni*, Cobbold, 1883; *Bothriocephalus linguloides*, R. Lkt., 1886; *Bothriocephalus mansoni*, R. Blanch., 1886.

These plerocercoids were discovered in 1882 by P. Manson during the *post-mortem* on a Chinaman who had died in Amoy,

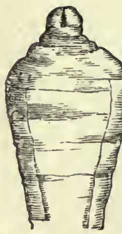


FIG. 213. — Cephalic end of *Sparganum mansoni*, Cobb. (After Leuckart.)

FIG. 214.—*Sparganum mansoni*: on the right in transverse section. Natural size. (After Ijima and Murata.)

twelve specimens being found beneath the peritoneum and one free in the abdominal cavity. Cobbold described them as *Ligula mansoni*, and Leuckart, who contemporaneously reported a case in Japan, termed them *Bothriocephalus liguloides*. Ijima and Murata reported eight further cases, and Miyake records nine further cases, seven of which are recorded in Japanese literature.

The plerocercoid, which hitherto alone is known to us, attains a length of 30 cm. and a breadth of 3 to 6 to 12 mm. The ribbon-shaped body is wrinkled, the lateral borders are often somewhat thickened, so that the transverse section has the form of a biscuit; the anterior end is usually wider and has the head provided with two weak suctorial grooves, either retracted or protracted.

The parasite makes migrations within the body, and thus may reach the urinary passages; then it is either evacuated with the urine or has to be removed from the urethra; not rarely it causes non-inflammatory tumours on various parts of the skin, which are at times painful and at times vary in size.

Nothing is known of its development and origin.

Sparganum proliferum, Ijima, 1905.

Syn.: *Plerocercoides prolifer*, Ijima, 1905; *Sparganum prolifer*, Verdun, Manson, 1907.

These plerocercoids produce an acne-like condition of the skin. The condition is really one of capsules in great abundance in the subcutaneous tissue and less so in the corium and in the intermuscular connective tissue. The encapsuled worms in the corium feel like embedded rice grains and raise the epidermis, giving rise to an acne-like condition. Many thousands occur scattered over the body; in Ijima's Japanese case there were over 10,000 in the left thigh. The worms when they first appear in the skin cause itching. The capsules are ovoid, generally about 1 to 2 mm. in diameter, but they may be smaller and also much larger. The larger ones occur in the subcutaneous tissue. The capsules consist of dense tough connective tissue.

Each capsule, as a rule, contains one worm, but as many as seven may occur. The skin of areas that have been long infected is swollen and indurated or adherent, giving a somewhat elephantoid appearance. The subcutaneous tissue is thick and filled with slimy fluid or in other parts sclerosed.

The Worm.—The chief peculiarity is its irregular shape and its reproduction in the larval stage by forming supernumerary heads, which are supposed to wander about the body.

The simplest forms are thread-like bodies, flat or round, 3 mm. long and 0·3 mm. in diameter, but they may be 12 mm. long by 2·5 mm. broad. The narrow end is the head, which in life invaginates and evaginates, but there is no indication of any suckers, except an inconstant terminal depression. In addition to these simple forms the most complicated and irregular forms occur, due to the formation of buds (heads) at various parts.

FIG. 215.—*Sparganum prolifer*: left with buds, right extended. × 4. (After Ijima.)

FIG. 216.—*Sparganum proliferum.* × 10. (After Stiles.)

The detachment and growth of a head account for the presence of more than one worm in a cyst. The irregularity in form is also increased by the presence in the subcuticular tissue of the worm of *reserve food bodies.* These bodies are supposed to be of this nature and are spherical, 100 μ to 300 μ in diameter, but also much elongated.

Calcareous bodies in the Japanese worms were 7·5 μ to 12 μ; in the Florida worms 8·8 μ to 17·6 μ.

Mode of Infection.—Probably from eating uncooked fish.

Distribution.—Japan, Florida.

Family. **Dipylidiidæ**, Lühe, 1910.

Genus. **Dipylidium**, R. Lkt., 1863.

Rostellum retractile, with several rings of alternating hooks; the latter with a disc-like base, having the shape of the thorns of a rose. Genital pores opposite; genitalia double. Testes very numerous in the central field; ovary with two lobes; the vitellaria, which are smaller, behind them; the uterus forms a reticulum, in the network of which the testicular vesicles lie; later on it breaks up into sacs enclosing one or several eggs. The eggs have a double shell.

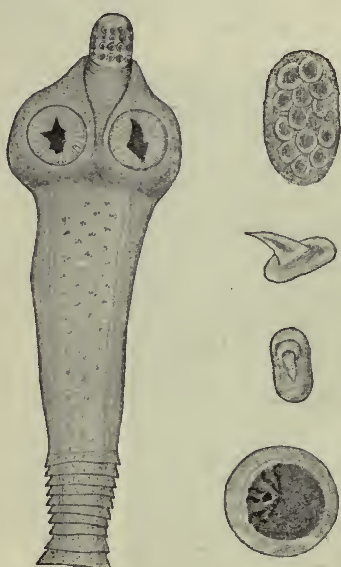


FIG. 217.—*Dipylidium caninum:* on the left, the scolex, neck and the first proglottids; on the right, at the top, a packet of ova; below, hooks of the rostellum, side and front views; below, an ovum. Various magnifications. (After Diamare.)

Dipylidium caninum, L., 1758.

Syn.: *Tænia canina*, L., 1758, p. p.; *Tænia moniliformis*, Pallas, 1781; *Tænia cucumerina*, Bloch, 1782; *Tænia elliptica*, Batsch, 1786; *Dipylidium cucumerinum*, Lkt., 1863.

This worm measures 15 to 35 cm. in length and 1·5 to 3 mm. in breadth. The scolex is small, rhomboidal, and has a club-shaped rostellum on which

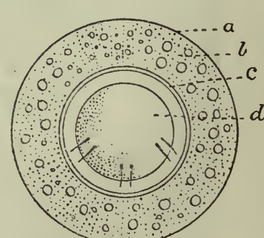


FIG. 218.—*Dipylidium caninum:* egg showing *a*, egg-shell (vitelline membrane of Moniez); *b*, albuminous coat; *c*, internal shell formed of or secreted by an outer layer of blastomeres (Moniez); *d*, hexacanth embryo. (After Benham and Moniez.)

there are, in three to four rings, forty-eight to sixty hooks resembling rose thorns, the size of those in the foremost being 11 μ to 15 μ and those in the hindmost ring 6 μ. The neck is very short, the most anterior segments broad and short, the middle as long as they are broad; the

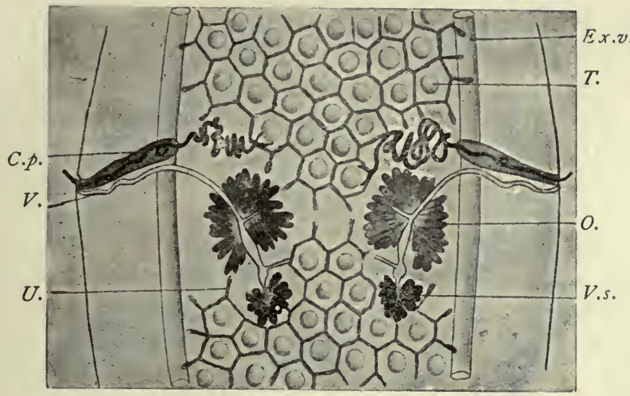


FIG. 219.—*Dipylidium caninum*: central portion of a proglottis. *C.p.*, cirrus sac; *V.s.*, vitellaria; *Ex.v.*, excretory vessels; *T.*, testicles lying in the meshes of the uterine reticulum which laterally forms pouches; *O.*, ovary; *U.*, reticulum of uterus; *V.*, vagina and seminal receptacle (below ovary). Magnified. (After Neumann and Railliet.)

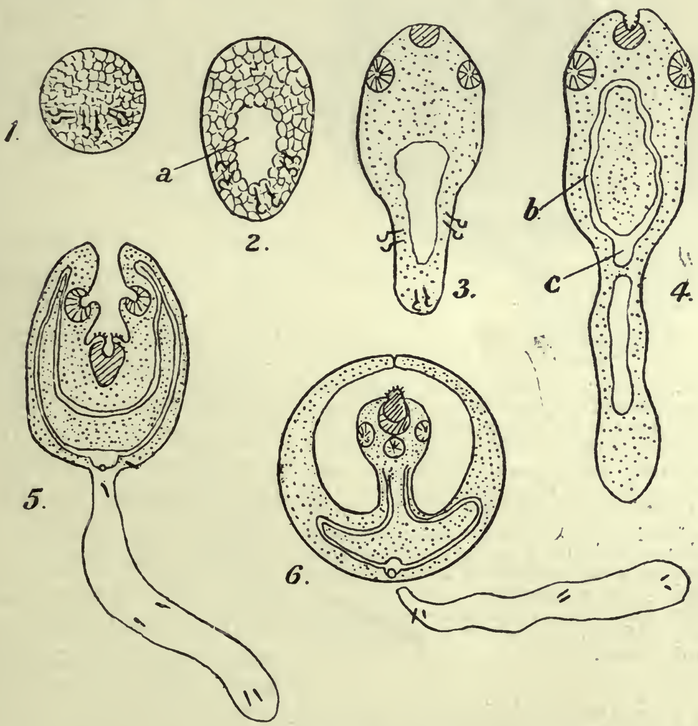


FIG. 220.—*Dipylidium caninum*: development of embryo. 1, solid hexacanth embryo; 2, primitive lacuna (*a*) in the embryo; 3, elongation of hinder part, rudiments of sucker and rostellum appearing; 4, "body" and "tail" distinct, (*b*) and (*c*) excretory system; 5, fore-body invaginates into hind-body, excretory bladder has a pore; 6, tail has dropped off; scolex growing up into secondary cavity formed by fore-body; the primitive cavity has been absorbed at stage 4. (After Benham, Grassi and Rovelli.)

mature segments are longer than wide (6 to 7 mm. by 2 to 3 mm.), fairly thick, are frequently of a reddish colour, and when cast off resemble cucumber seeds. The genital pores lie symmetrically at the lateral margins; the roundish egg sacs, arising from the uterine reticulum, contain eight to fifteen eggs embedded in a reddish cement substance (in life). The eggs are globular (43 μ to 50 μ); the embryonal shell (embryophore) is thin, the oncosphere measures 32 μ to 36 μ. Surrounding the embryophore is an albuminous coating, and outside this the thin vitelline envelope (fig. 218).

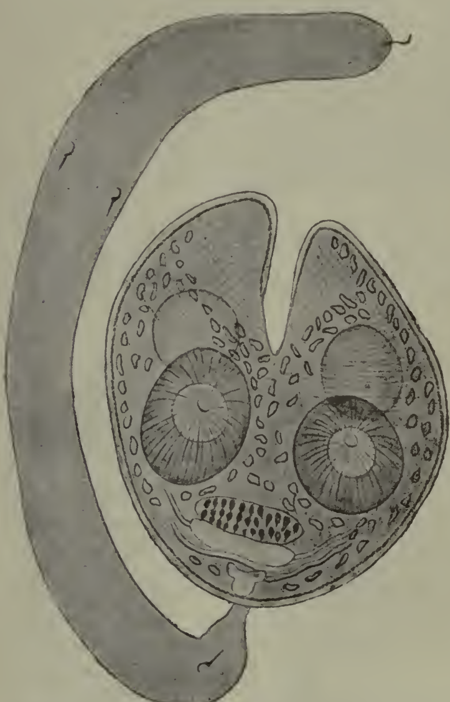


FIG. 221.—Larva (cysticercoid) of *Dipylidium caninum*, consisting of body and tail. The latter is solid and bears on it the embryonal spines. The bladder, which was only slightly developed, has disappeared, and the fore-part of the body bearing the rostellum is now seen invaginated into the hind portion. The hooklets are shown in front of the excretory system which has now developed. At a further stage the tail drops off; the head now evaginates, but is still enclosed in a double-walled sac formed by the prolongation upwards on each side of the topmost parts of the body shown in the figure. *Cf.* fig. 220, 6. Enlarged. (After Grassi and Rovelli.)

Dipylidium caninum is a common intestinal parasite of dogs, in which it grows larger (*Tænia cucumerina*, Bloch) than in cats (*T. elliptica*, Batsch); it has, however, also been found in jackals, as well as in human beings, though in the latter it is of comparatively rare occurrence (twenty-four cases), and almost always affects children, generally of tender age. One-third of all the cases in children were sucklings, about a quarter of all the cases recorded were adults, and these occurred throughout all Europe with the exception of Spain and Italy.

The proglottids, which leave the intestine spontaneously, are recognizable by the naked eye on account of their form and reddish colour, as well as their two genital pores. As a rule, the presence of this parasite sets up no marked symptom in the patient.

The corresponding larval form (cysticercoid) lives in the louse of the dog (*Trichodectes canis*), a fact that was first established by Melnikow and Leuckart; according to Grassi and Rovelli, as well as Sonsino, it also lives in the flea of the dog (*Ctenocephalus canis*) and in the flea of man (*Pulex irritans*), but not in its larva. The adult segments, which also leave the rectum of dogs and cats spontaneously, creep about around the anus and get into the hair, and are thus partly dried and disintegrated. Part of the segments, or the oncospheres released by disintegration, are then taken up by lice and fleas, within which they develop into larvæ (cysticercoids). Dogs and cats are thus infected by their own skin parasites, which they bite and swallow whilst gnawing at their fur. The infection of human beings must occur in an analogous manner, by transmission of the cysticercoids present on the lips or tongue of dogs when the latter lick them, or it may be that the vermin of cats and dogs harbouring cysticercoids are accidentally and directly swallowed by human beings.

Family. **Hymenolepididæ**, Railliet and Henry, 1909.

Genus. **Hymenolepis**,[1] Weinland, 1858.

Accessory sac (opening into genital atrium) usually absent. Vas deferens with an external (outside cirrus sac) and an internal (inside cirrus sac) "seminal vesicle." Three testes in each proglottis. The eggs are round or oval with two to four distinct envelopes. In mammals and birds.

Hymenolepis nana, v. Sieb., 1852.

Syn.: *Tænia nana*, v. Sieb., 1852, *nec* van Beneden, 1867; *Tænia ægyptiaca*, Bil., 1852; *Diplacanthus-nanus*, Weinld., 1858; *Tænia* (*Hymenolepis*) *nana*, Lkt., 1863.

The worm is 10 to 45 mm. in length and 0·5 to 0·7 mm. in breadth; the head is globular, 0·25 to 0·30 mm. in diameter. The rostellum has a single circlet consisting of twenty-four or twenty-eight to thirty hooks, which are only 14 μ to 18 μ in length. The neck is moderately long; the proglottids are very narrow, up to 200 in number, 0·4 to 0·9 mm. in breadth, and 0·014 to 0·030 mm. in length. The eggs are globular or oval, 30 μ to 37 μ to 48 μ; the oncospheres measure 16 μ to 19 μ in diameter, with two coats, separated by an intervening semi-fluid substance (fig. 224).

This species was discovered by Bilharz in Cairo in 1851; it was found by him in great numbers in the intestine of a boy who had

[1] The genus is by some authors divided into two sub-genera—Hymenolepis, s. str., and Drepanidotænia, Raill.

Drepanidotænia.—Body, broad lanceolate, testes three, female genitalia antiporal beside the testes. Scolex small, with eight hooks. Neck very short, longitudinal muscle bundles very numerous. No accessory sac opening into genital atrium.

Hymenolepis.—Narrow, female genitalia ventral to or between testes.

died of meningitis. For several years this was the only case, until 1885, since when numerous cases have come to light. Spooner (1873) even reported a case from North America, which may, however, have related to *Hymenolepis diminuta*. In Europe the worm is particularly frequent in Sicily, but it has also been repeatedly observed in North Italy; it has, moreover, been reported from Russia, Servia, England, France, Germany, North and South America, the Philippines,

FIG. 222.—*Hymenolepis nana*, v. Sieb. About 12/1. (After Leuckart.)

FIG. 223.—*Hymenolepis nana*: head. Enlarged. (After Mertens.)

FIG. 224.—*Hymenolepis nana*: an egg. Highly magnified. (After Grassi.)

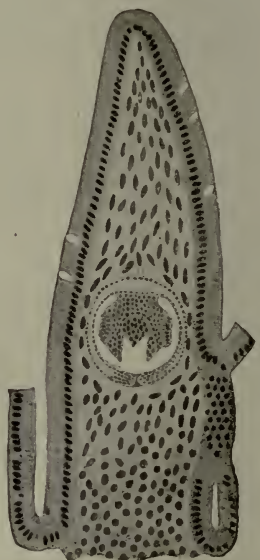


FIG. 225.—Longitudinal section through the intestinal villus of a rat, with the larva (cysticercoid) of *Hymenolepis murina*. Magnified. (After Grassi and Rovelli.)

Siam and Japan, in all over 100 cases. Notwithstanding its small size this worm causes considerable disorders in its hosts—mostly children—as it sets up loss of appetite, diarrhœa, various nervous disturbances, and even epilepsy; all these symptoms, however, disappear after the expulsion of the parasites, which are generally present in large numbers.

The development as well as the manner of infection is still unknown; Grassi is of opinion that *Hymenolepis nana* is indeed merely a variety of *Hymenolepis murina*, Duj., which lives in rats.

According to Grassi direct development takes place with omission of the intermediate host, but with the retention of the larval stage; that is to say, rats infect themselves directly with *Hymenolepis murina*, by ingesting the mature segments or oncospheres of this species, from which subsequently the small larvæ originate in the intestinal wall

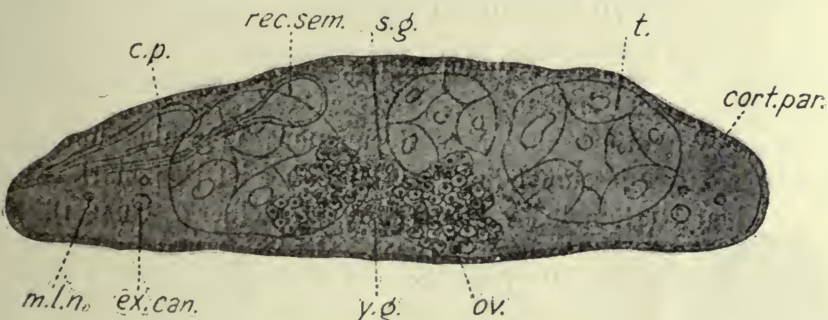


FIG. 226.—*Hymenolepis nana* (*murina*): cross section of proglottis from a rat. *c.p.*, cirrus sac; *rec. sem.*, receptaculum seminis; *s.g.*, shell gland; *ov.*, ovary; *t.*, testis; *cort. par.*, cortical parenchyma; *m.l.n.*, main lateral nerve; *ex. can.*, excretory canal; *y.g.*, vitellarium. (After v. Linstow.)

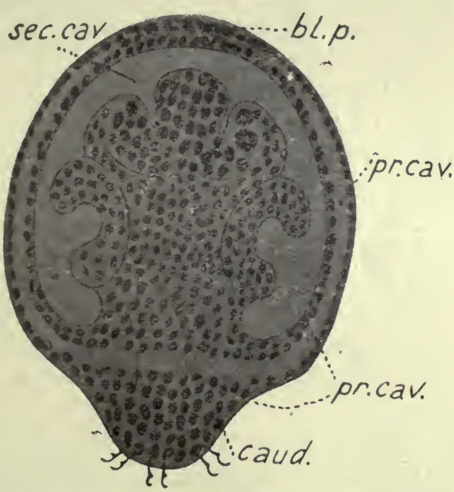


FIG. 227.—*Hymenolepis nana*: longitudinal section of an embryo. *bl.p.*, anterior opening of secondary cavity; *caud.*, caudal appendage; *pr. cav.*, primary cavity; *sec. cav.*, secondary cavity. Enlarged. (After Grassi and Rovelli.)

(fig. 225); when fully developed they fall into the intestinal lumen and become tapeworms. The identity of the two forms has nevertheless been disputed (Moniez, R. Blanchard, v. Linstow), though their near relationship cannot be denied. Grassi gave mature segments of *Hymenolepis murina* to six persons, but only one person evacuated a tapeworm. This, however, proves nothing in a district where

Hymenolepis nana frequently occurs in man; it was, moreover, not possible to infect rats with segments of *Hymenolepis nana* (of man). Accordingly this form may represent an independent species, which, however, like *Hymenolepis murina*, also omits an intermediate host.

Hymenolepis diminuta, Rud., 1819.

Syn.: *Tænia diminuta*, Rud., 1819; *Tænia leptocephala*, Crepl., 1825; *Tænia flavopunctata*, Weinld., 1858; *Tænia varesina*, E. Parona, 1884; *Tænia minima*, Grassi, 1886.

This species measures 20 to 60 cm. in length, and up to 3·5 mm. in breadth; there are from 600 to 1,000 segments. The head is very small (0·2 to 0·5 mm.), it is club-shaped and has a rudimentary unarmed rostellum; the neck is short; the mature segments are 3·5 mm. in breadth, 0·66 mm. in length; the eggs are round or oval. The outer egg-shell is yellowish and thickened, with indistinct radial stripes; the inner embryonal shell (embryophore) double, thin; the outer layer is somewhat pointed at the poles; oncosphere 28 μ by 36 μ. Between the inner and outer shells is a middle granular layer.

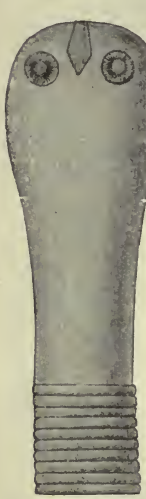


Fig. 228. — *Hymenolepis diminuta*; scolex. Magnified. (After Zschokke.)

Hymenolepis diminuta lives in the intestine of rats—*Mus decumanus* (the sewer rat), *Mus rattus* (the black rat), and *Mus alexandrinus*, rarely in mice; it is occasionally also found in human beings.

Weinland described it from specimens collected by Dr. E. Palmer in 1842, in Boston, from a child aged 19 months, as *T. flavopunctata*. A second case relating to a three year old child, from Philadelphia, was only reported in 1889 by Leidy; a third case was simultaneously reported of a two year old girl in Varese (*T. varesina*); and Grassi described another case relating to a twelve year old girl from Catania (Sicily). Sonsino and Previtera reported

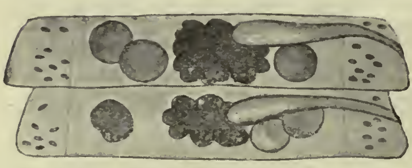


Fig. 229.—*Hymenolepis diminuta*: two proglottids showing testes (3), ovary and vagina. Slightly enlarged. (After Grassi.)

Fig. 230.—*Hymenolepis diminuta*: egg from man. (After Bizzozero.)

the same species in Italy, Zschokke in France, Lutz and Magalhães in South America, and Packard in North America : a total of twelve cases, five from America, the rest from Europe (Ransom).

According to Grassi and Rovelli the larval stage lives in a small moth (*Asopia farinalis*), as well as in its larva, in an orthopteron (*Anisolabis annulipes*), and in coleoptera (*Acis spinosa* and *Scaurus striatus*). Experimental infections have been successful on rats as

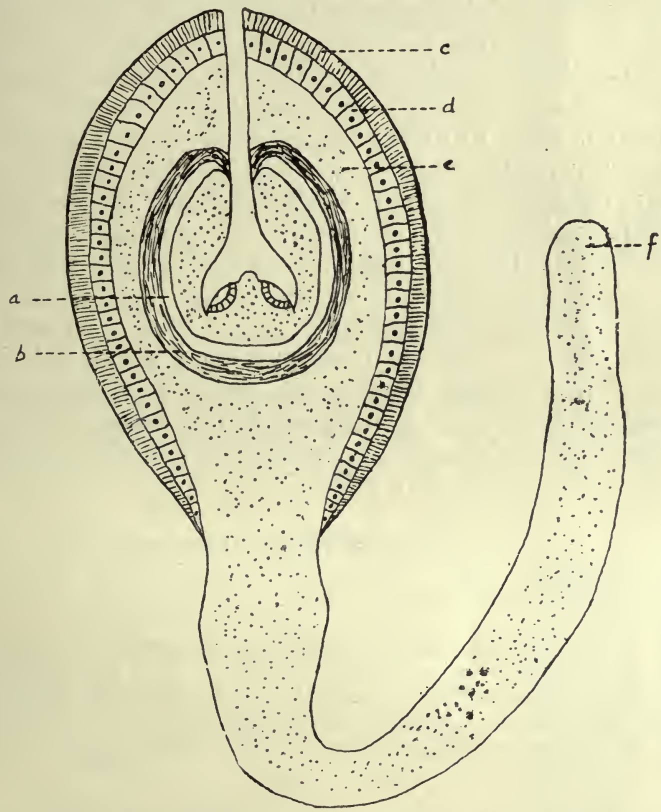


FIG. 231.—*Hymenolepis diminuta*: cysticercoid from the rat flea (*Ceratophyllus fasciatus*) *a*, remains of primary vesicle ; *b*, fibrous layer ; *c*, radially striated layer resembling cuticle ; *d*, layer of columnar cells ; *e*, parenchymatous layer of irregularly disposed cells ; *f*, parenchymatous layer. (Stephens, after Nicoll and Minchin.)

well as on human beings. In America other species of insects may be the intermediary hosts.

Nicoll and Minchin[1] found in the body cavity of 4 per cent. of rat fleas (*Ceratophyllus fasciatus*) the cysticercoid of *Hymenolepis diminuta*. That it belonged to this species was shown by its unarmed rostellum and by feeding; 340 fleas were fed to white rats and fourteen

[1] *Proc. Zool. Soc.*, 1911, p. 9.

worms obtained, *i.e.*, about 4 per cent., thus corresponding to the infection of the fleas. The development in the flea probably begins in the pupal stage, the eggs being ingested by the older flea larvæ. The larva is 0·31 by 0·25 mm.; tail 0·8 mm., scolex 0·075 by 0·09 mm., suckers, 0·055 mm. in diameter. Microscopically it shows—(1) externally a radially striated layer resembling cuticle, (2) a layer of columnar cells, (3) parenchymatous layer continuous with the tail, (4) fibrous layer around the small caudal vesicle, then the parenchymatous scolex at the bottom of the secondary cavity.

Nicoll and Minchin (*loc. cit.*) found a cysticercoid[1] in the rat flea *Ceratophyllus fasciatus* which was probably that of *Hymenolepis murina*. Body 0·16 mm., tail 0·19 mm., scolex 0·096 mm. in diameter. Rostellum has twenty-three spines in a single row. Length 0·017 mm., handle 0·01 mm., guard 0·007 mm., prong 0·007 mm. Sucker 0·042 mm. Although this cycle, then, for *H. murina* also exists, it is not probable that rats (or man in the case of *H. nana* if this be considered distinct) infect themselves in this way, as they hardly ingest all the necessary fleas to account for the massive infection which frequently exists in rats (and man), so that Grassi's cycle holds good as the predominant method. *Xenopsylla cheopis* has also been found by Johnston to harbour both cysticercoids in Australia.

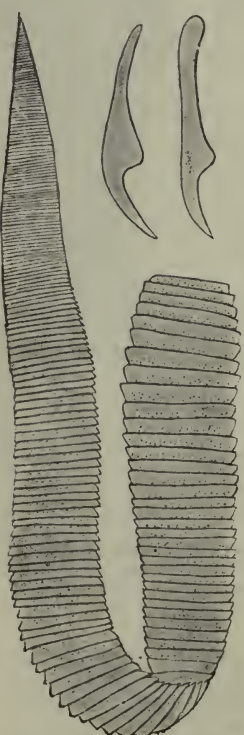


FIG. 232. — *Hymenolepis lanceolata.* Natural size. (After Goeze.) To the right above, two hooks. 120/1. (After Krabbe.)

Hymenolepis lanceolata, Bloch, 1782.

Syn.: *Tænia lanceolata*, Bloch, 1782; *Drepanidotænia lanceolata*, Railliet, 1892.

The parasite measures 30 to 130 mm. in length and 5 to 18 mm. in breadth; the head is globular and very small; the

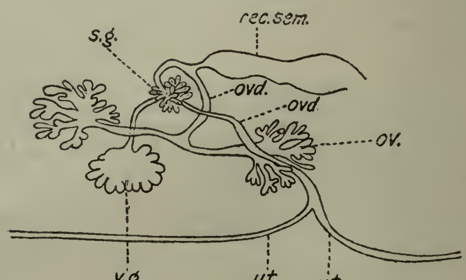


FIG. 233.—*Hymenolepis lanceolata:* diagram of female genitalia. *ov.*, ovary; *ovd.*, oviduct; *rec. sem.*, receptaculum seminis; *s.g.*, shell gland; *ut.*, uterus; *y.g.*, vitellarium. (After Wolfhügel.)

[1] A third cysticercoid resembling this, but without hooks, has also been found.

rostellum is cylindrical, with a circlet composed of eight hooks (31 μ to 35 μ in length). The neck is very short. The short segments increase gradually and equally in breadth, but only a little in length; the female glands lie on the side opposite to that on which the genital pore is situated; the three elliptical testes are on the same side as the pores; the cirrus is armed and slender. The eggs have three envelopes and are oval (50 μ by 35 μ), the external envelope is thin, the middle intermediate layer or envelope is not so marked as in *H. diminuta*, and the internal one is very thin and sometimes has polar papillæ, as in *Hymenolepis diminuta* and *H. nana*.

It inhabits the intestine of the following birds: Domesticated ducks and geese, the Muscovy duck (*Cairina moschata*), white-headed duck (*Erismatura leucocephala*), the pochard (*Nyroca rufiña*), and the flamingo (*Phœnicopterus antiquorum*). It has been recorded from Great Britain, France, Denmark, Austria and Germany.

Zschokke reports the receipt of two specimens which a twelve year old boy in Breslau evacuated spontaneously at two different times.

The corresponding larva, according to Mrázek, lives in fresh water *Cyclops*; according to Dadai it is likewise found in another copepod, *Diaptomus spinosus*, but the hooks of Dadai's larva differed in size.

Family. **Davaineidæ**, Fuhrmann, 1907.

Sub-family. **Davaineinæ**, Braun, 1900.

Genus. **Davainea**, R. Blanch., 1891.

The large scolex is more or less globular, much wider than the rostellum, which is furnished with two rings of very small and numerous hooks. Neck absent, proglottids few, genitalia single. Parasitic chiefly in birds.[1]

Davainea madagascariensis, Davaine, 1869.

Syn.: *Tænia madagascariensis*, Dav.; *Tænia demerariensis*, Daniels, 1895.

This worm measures 25 to 30 cm. in length; the head has four large round suckers; the rostellum has ninety hooks (18 μ in length); there are 500 to 700 segments, of which the last 100 are filled with eggs and form half of the entire worm. The segments, when mature, measure 2 mm. in length by 1·4 mm. in breadth; genital pores unilateral; about fifty testes; the uterus consists of a number of

[1] [The larval stage of the Davaineas occurs in slugs (*Limax*) and snails (*Helix*).—F. V. T.]

loops, which at each side are rolled up into an almost spherical ball; when filled with eggs the convolutions unwind, permeate the segment and then lose their wall; the eggs lying free in the parenchyma become finally surrounded, one, or several together, by proliferating parenchymatous cells; this is how the 300 to 400 egg masses, taking up the entire mature segment, are formed. The globular oncosphere (8 μ) is surrounded by two perfectly transparent shells, the outer of which terminates in two pointed processes.

Davainea madagascariensis has hitherto been found in man only (eight times). Davaine described this species from fragments sent to him from Mayotta (Comoro Islands), which were found in two Creole children. Chevreau observed four cases in Port Louis (Mauritius), likewise in children; Leuckart received the first perfect specimen—it was obtained from a three year old boy, the son of a Danish captain, in Bangkok; Daniels, at the *post-mortem* of an adult native of George Town, Guiana, found two specimens (*Tænia demerariensis*); and finally Blanchard describes another perfect specimen which was in Davaine's collection of helminthes in Paris, and which was obtained from a little girl 3 years old, of Nossi-Bé (Madagascar). The intermediate host is unknown.

FIG. 234.—Scolex of *Davainea madagascariensis.* The hooks have fallen off. 14/1. (After Blanchard.)

Davainea (?) asiatica, v. Linst., 1901.

Syn.: *Tænia asiatica*, v. Linstow.

There exists only one headless specimen of this species, which is not quite adult, and which is preserved in the Zoological Museum of the Imperial Academy of Science in Petrograd. It came from a human being and was found by Anger in Aschabad (Asiatic Russia, near the northern frontier of Persia). The specimen measures 298 mm. in length. The breadth anteriorly is only 0·16 mm., the posterior part measures 1·78 mm. across. The number of segments is about 750. The genita pores are unilateral; the testes are globular and lie in a dorsal and ventral layer in the medullary layer; the cirrus pouch is pyriform, 0·079 mm. in length and 0·049 mm. in breadth; the female glands lie in the fore-part of the segments, the ovary reaching to the excretory vessels; the vitellarium is small and round. The vagina has a large fusiform receptaculum seminis; the uterus breaks up into sixty to seventy large, irregularly polyhedric eggsacs.

Family. Tæniidæ, Ludwig, 1886.

Genus. Tænia, L., 1758.[1]

With the characters of the family. In the genus Cladotænia recognized by some authors, the testes encroach on the mid field and the uterine stem reaches the anterior end of the segment.

Tænia solium, L., *p. p.*, 1767.

Syn.: *Tænia cucurbitina*, Pall., 1781; *Tænia pellucida*, Goeze, 1782; *Tænia vulgaris*, Werner, 1782; *Tænia dentata*, Gmel., 1790; *Halysis solium*, Zeder, 1800; *Tænia humana armata*, Brera, 1802; *Tænia* (*Cystotænia*) *solium*, Lkt., 1862.

The average length of the entire tapeworm is about 2 to 3 m., but may be even more; the head is globular, 0·6 to 0·8 to 1·0 mm. in diameter. The rostellum is short with a double circlet of hooks, twenty-two to thirty-two in number, usually twenty-six to twenty-eight; large and small hooks alternate regularly; the length of the large hooks is 0·16 to 0·18 mm., of the small ones 0·11 to 0·14 mm. The rostellum is sometimes pigmented. The suckers are hemispherical, 0·4 to 0·5 mm. in diameter. The neck is fairly thin and long (5 to 10 mm.). The proglottids, the number of which averages from 800 to 900, increase in size very gradually; at about 1 m. behind the head they are square and have the genitalia fully developed. Segments sufficiently mature for detachment measure 10 to 12 mm. in length by 5 to 6 mm. in breadth. The genital pores alternate fairly evenly at the lateral margin a little behind the middle of each segment. The fully developed uterus consists of a median trunk, with seven to ten lateral branches at either side, some of which are again ramified. The eggs are oval, the egg-shell very thin and delicate; the embryonal shell (embryophore) is thick, with radial stripes; it is of a pale yellowish colour, globular, and measures 31 μ to 36 μ in diameter; the oncospheres, with six hooks, are likewise globular, and measure 20 μ in diameter (fig. 238).

---

[1] The Greeks termed the tapeworms ἕλμινθες πλατεῖαι, more rarely χηρία (= fascia); the Romans called them *tænia*, *tinea*, *tæniola*, later *lumbrici*, usually with the addition *lati*, to distinguish them from the *Lumbrici teretes* (*Ascaridæ*). The proglottids were called *Vermes cucurbitini*; the cysticerci χάλαζαι (hailstones), later hydatids. Plater (1602) was the first to differentiate *Tænia intestinorum* (=*Bothriocephalus latus*) amongst the *Lumbrici lati* of man from *Tænia longissima* (= *Tænia solium*). The term *solium* was already used by Arnoldus Villanovanus, who lived about 1300; and, according to him, it signifies "cingulum" (belt, chain), while N. Andry, in 1700, traces this word from "solus," because the worm occurs always singly in man. Leuckart and Krehl derive the word "solium" from the Syrian "schuschl" (the chain), which in Arabian has become "susl" or "sosl," and in Latin has become "sol-ium." What Linnæus described under the term *Tænia solium* was really *Tænia saginata*; the latter was first distinguished by Goeze, but was forgotten until Küchenmeister, in 1852, again called attention to the differences.

Malformations are not so common as in *T. saginata;* they consist in two or several proglottids being partly or entirely fused, formation of single club-shaped segments, fenestration of long or short series of segments and so-called double formation, in which the head has six suckers and the segments exhibit a Y-shaped transverse section. The oncospheres occasionally also possess more than six hooklets. Very slender specimens have led to the description of a particular species or variety (*T. tenella*).

In its fully developed condition *T. solium* is found exclusively in man; the head is usually attached in the anterior third of the small intestine and the chain, in numerous convolutions, extends backwards; a few mature detached proglottids usually lie at the most posterior part, and these are usually evacuated during defæcation. In exceptional cases single proglottids or whole worms may reach contiguous organs if abnormal communications with them

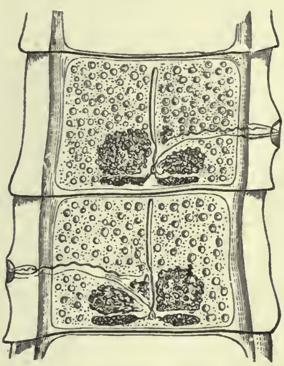


FIG. 235.—Two fairly mature proglottids of *Tænia solium*, showing ovaries (one bi-lobed), vitellaria, central uterine stem, cirrus and vas deferens (above), vagina (below), testes (scattered), longitudinal and transverse excretory vessels.

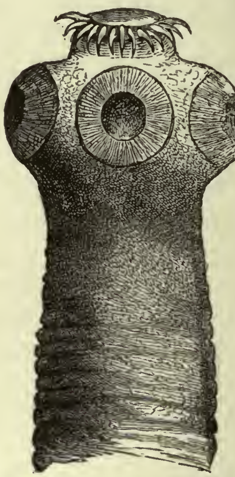


FIG. 236.—Head of *Tænia solium*. 45/1.

exist; thus they may reach the abdominal cavity and the urinary bladder, or they may be found in a so-called worm abscess of the peritoneum; occasionally, in vomiting, single segments or several together may be brought up. Exceptionally it induces severe anæmia.

The *larval stage* (*Cysticercus cellulosæ*) that gives rise to *Tænia solium* lives normally in the intramuscular connective tissue and other organs of the domestic pig, but it is known to exist also in a few other mammals, such as the wild boar, the sheep,[1] the stag, dog, cat, brown bear and monkey, as well as in man. The cysticercus

[1] The larvæ which on rare occasions are found in the muscular system of sheep are either strayed specimens of *Cysticercus tenuicollis*, which normally develop in organs of the abdominal cavity, and appertain to *Tænia marginata* of the dog, or actually *Cysticercus cellulosæ*. (*Cf.* Bongert, in *Zeitschr. f. Fleisch- u. Milchhyg.*, 1899, ix, p. 86.)

of the pig is an elliptical vesicle with a longitudinal diameter of 6 to 20 mm., and a transverse diameter of 5 to 10 mm.

Even with the naked eye a white spot may be observed in the centre of the long equator, this being the invaginated head; it is easy to make it project by pressing on the vesicle (after tearing off with the finger-nail the investing connective tissue), and on examining it under the microscope one can convince oneself that it corresponds with the head of *Tænia solium.*

Numerous experiments have proved that the *Cysticercus cellulosæ* of the pig, if introduced into the intestine of man, grows to a *Tænia solium* (Küchenmeister, 1855; Humbert, 1856; Leuckart, 1856; Hollenbach, 1859; Heller, 1876); the cysticercus has frequently also been

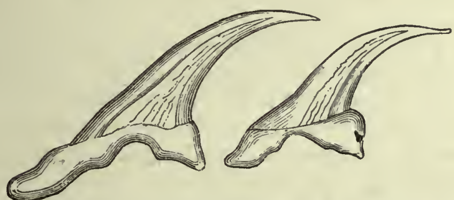


FIG. 237.—Large and small hooks of *Tænia solium.* 280/1. (After Leuckart.)

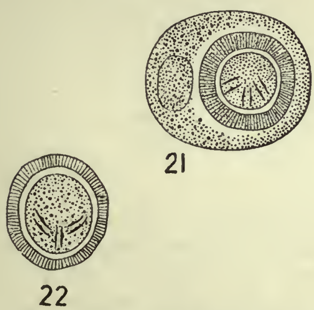


FIG. 238.—*Tænia solium.* 21, Egg with external membrane; 22, without (embryophore). (After Leuckart.)

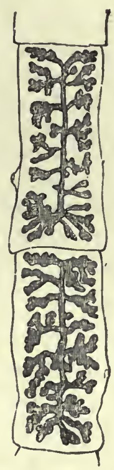


FIG. 239. — Two mature proglottids of *Tænia solium* with fully developed uterus. 2/1.

cultivated purposely by feeding pigs with mature proglottids of *T. solium* (P. J. van Beneden, 1853; Haubner and Küchenmeister, 1855; Leuckart, 1856; Mosler, 1865; Gerlach, 1870; etc.), but success did not attend the efforts to make *Cysticercus cellulosæ* establish themselves in the intestines of pigs, dogs, guinea-pigs, rabbits and monkeys (*Macacus cynomolgus*), and so become adult Tæniæ; the attempts, also, to infect dogs with cysticerci by means of ova were likewise, as a rule, abortive.[1]

[1] According to Gerlach only young pigs (up to 6 months old) are capable of infection, and perhaps the failure may have been due to the animals chosen for experiment being of the wrong age.

The development of *Cysticercus cellulosæ* takes two and a half to three or four months ; it is not known how long the cysticerci remain alive in animals ; not uncommonly they perish at earlier or later stages, and become calcified or caseated. Extracted cysticerci die in water at a temperature of 47° to 48° C., in flesh at normal temperature they remain alive for twenty-nine days or more. On account of the present rapid means of pickling and smoking meat, the cysticerci as a rule are not killed, also the effect of cold on them for some time in cold chambers of slaughter-houses is not lethal, but freezing is fatal (Ostertag).

There is not the least doubt that human beings are almost exclusively infected with *Tænia solium* by eating pork containing cysticerci in a condition that does not endanger the life of the cysticerci. The infection may likewise be caused in man by eating the infected meat of other animals subject to this species of bladder worm, mainly, as a matter of fact, deer and wild boar.

The frequency of cysticerci in pigs' flesh has considerably decreased since the introduction of meat inspection ; in the Kingdom of Prussia there was on an average 1 infected pig to every 305 slaughtered between 1876 to 1882 ; from 1886 to 1889, there was 1 to 551 ; from 1890 to 1892, there was 1 to 817 ; in 1896, 1 to 1,470 ; and in 1899, 1 to 2,102 ; in the Kingdom of Saxony in 1894 there was 1 infected pig to every 636 ; in 1895 there was 1 to every 2,049, and in 1896 only 1 infected pig was found of 5,886 slaughtered. In South Germany pigs with cysticerci are very rare, but are more frequent in the eastern provinces of Prussia ; in 1892 the number of infected pigs compared with the total slaughtered was as follows :—

In the district of Marienwerder	1 : 28
" " Oppeln...	1 : 80
" " Königsberg	1 : 108
" " Stralsund and Posen	1 : 187
" " Danzig, Frankfort a. O. and Bromberg ...	1 : 250
As compared with the district of Arnsberg...	1 : 865
" " " Coblenz	1 : 975
" " " Düsseldorf	1 : 1,070
" " " Münster and Wiesbaden ...	1 : 1,900

The average for the whole of Prussia in the same year was 1 : 1,290; for the eastern provinces, on the other hand, 1 : 604. Even more unfavourable are the proportions in Russian Poland (over 1 per cent. of pigs measly), in Prague (over 3 per cent.), in Bosnia and Herzegovina (6 to 7 per cent.). The cause for this is most likely attributable to the manner in which the pigs are kept. When allowed to be in the farmyards of the small farmers for the whole day, or allowed to wander in the village streets and pasture lands, they are more liable to take up the oncospheres of the *T. solium* than when shut up in good pig-styes.

The geographical distribution of *T. solium* generally corresponds with that of the domestic pig and the custom of eating pork in any form insufficiently cooked or raw. There are, or were, some isolated districts in Germany, France, Italy and England where the "armed tapeworm" was frequent (for instance, Thuringia, Brunswick, Saxony, Hesse, Westphalia, whereas it is and was very scarce in South Germany) ; it is thus easily understood why it occurs very rarely in the East, in Asia and in Africa, in consequence of the Mahommedans, Jews, etc., not eating pork. In North America, also, *T. solium* is very rare; the tapeworm which is known there by this name is generally *T. saginata*, Stiles. During the last decade *T. solium* infection has, however, very markedly decreased in North and East Germany in consequence of the precautions exercised by the public in the choice of pork to avoid trichinosis, especially, however, because measly meat must be sold as such and must be thoroughly cooked before being placed on the market; indeed, if badly infected it may not be sold for food, but can be turned to account for industrial purposes.

The occurrence of *Cysticercus cellulosæ* in man has been known since 1558 (Rumler, *Obs. med.*, liii, p. 32); there is hardly an organ in man in which cystercerci have not been observed at some time; they are most frequently found in the brain,[1] where they grow to a variety known as *Cysticercus racemosus;* next in frequency they are found in the eye, in the muscular system, in the heart, in the subcutaneous connective tissue, the liver, lungs, abdominal cavity, etc. The number of cysticerci observed in one man varies between a few and several thousands. Of the sexes, men are most subject (60 to 66 per cent. of the number attacked). The disturbances caused in man by cysticerci vary according to the nature or position of the organs attacked; when situated in the cerebral meninges they have the same effect as tumours.

During the last decades, however, these cases have also become less common. In Rudolphi's time 2 per cent. of *post-mortems* in Berlin showed cysticerci; in the 'sixties, according to Virchow, about the same; in 1875 the number fell to 1·6 per cent; in 1881 to 0·5 per cent.; in 1882 to 0·2 per cent.; in 1900 to 0·15 per cent., and in 1903 to 0·16 per cent. Hirschberg between 1869 and 1885 discovered cysticerci in the eye seventy times in 60,000 ophthalmic cases, but during the following six years the parasite was only present twice amongst a total of 46,000 cases of ophthalmic diseases, and since 1895 no ophthalmic case has been met with.

The infection of human beings with the cysticerci can only take place by the introduction of the oncospheres of *Tænia solium* into the stomach with vegetable foods, salads that have been washed in impure water containing oncospheres, also by drinking contaminated water; the carriers of *T. solium*, moreover, infect themselves still more frequently through uncleanliness in defæcation, the privies

[1] Dressel, for instance, examined eighty-seven persons suffering from cysticercus, and found it seventy-two times in the brain, thirteen times in the muscles; K. Müller, in thirty-six cases, found it twenty-one times in the brain, twelve times in the muscles, three times in the heart; Haugg, in twenty-five cases, found it thirteen times in the brain, six times in the muscles, twice in the skin, etc. According to Graefe, amongst 1,000 ophthalmic cases in Halle and Berlin, there was one with cysticercus in the eye; in Stuttgart there was only one in 4,000, in Paris one in 6,000, and in Copenhagen one in 8,000.

in public localities and many private houses affording striking testimony of this. The minute oncospheres can thus easily reach the fingers and thence the mouth (as in twirling the moustache, biting the nail). More rarely a third manner of transmission or internal auto-infection may possibly take place, as when, in the act of vomiting, mature proglottids near the stomach are drawn into it; the oncospheres or segments there retained are then in the same position as if they had been introduced through the mouth.

On account of these dangers of internal or external auto-infection, it is therefore the duty of the medical attendant, after recognizing the presence of tapeworms, to expel them,[1] and in doing so to employ every possible means to prevent vomiting setting in; it is, however, equally important to take the necessary steps to destroy the parasites evacuated. It may be incidentally mentioned that in using certain remedies the scolex not rarely remains in the intestine; the cure in such cases has not been accomplished, as the scolex again produces new proglottids, and after about eleven weeks the first formed ones are again mature and appear in the fæces.

Amongst the cysticerci also many malformations appear; thus absence of the rostellum and the hooks, or double formation with six suckers, or abnormalities of growth on account of the surroundings, which have had a special name given to them, *viz.*, *Cysticercus racemosus*, Zenk. (= *C. botryoides*, Hell.; *C. multilocularis*, Kchnmstr.); these forms are more especially found at the base of the brain, are irregularly ramified and often without the head.

A certain interest is attached to those forms that have led to the establishment of a distinct species:—

Cysticercus acanthotrias, Weinld., 1858.

In making the autopsy of a white Virginian woman who had died of phthisis, a cysticercus was found in the dura mater, and eleven or twelve specimens in the muscles and subcutaneous tissue. Weinland and Leuckart, who examined the specimens, found that they resembled *Cysticercus cellulosæ* in form and size, but that they carried on the rostellum a triple crown, each consisting of fourteen to sixteen hooks, which differed from the hooks of *C. cellulosæ* or of *Tænia solium* by the greater length of the posterior root process and the more slender form of the hooks; the large hooks measured 0·153 to 0·196 mm., the medium-sized hooks, 0·114 to 0·14 mm., and the small ones 0·063 to 0·07 mm.

On account of these differences a distinct species of cysticercus was established, and this naturally presupposed a corresponding species of Tænia (*T. acanthotrias*, Lkt.); this could be done with

[1] The diagnoiss as a rule is not difficult; the patients themselves frequently observe the pumpkin seed-like segments in the fæces. But in such cases the diagnosis must still be confirmed. In other cases the discovery of the oncospheres in their embryonal shells (embryophores), which cannot be confounded with the other constituents of the fæces, gives complete certainty, although the differential diagnosis between *T. solium* and *T. saginata* is hardly possible from the embryophores; but, if evacuated segments are placed between two slides and lightly pressed, the species is easily recognizable by the shape of the uterus (*cf.* figs. 239 and 241).

justice so long as the case remained isolated, *i.e.*, in America, as there was the possibility of the corresponding Tænia being found. In this respect, however, the position has changed; Delore first described a cysticercus the size of a nut from the biceps muscle of the arm of a silk-worker in Lyons; according to Bertolis this specimen possessed hooks of three different sizes, the dimensions of which corresponded with the figures given by Weinland and Leuckart; the correctness of the diagnosis could hardly be doubted, as Bertolis was known to be a very exact observer. A second case has become known through Cobbold, who regards a specimen of a cysticercus in Dallinger's collection as likewise belonging to *Cysticercus acanthotrias;* this specimen also came from a man's brain; finally a third case, also from France, has been published by Redon. This author, amongst numerous *C. cellulosæ* of a man, found one that had forty-one hooks in three rows, and he was the first to express the opinion that *C. acanthotrias* does not represent a distinct species, but is only an abnormality of *C. cellulosæ*. This view was also taken by Blanchard and Railliet, and is probably correct, as the discovery of the large corresponding Tænia furnished with three rows of hooks is not to be expected in European beasts of prey, and in Redon's case *C. acanthotrias* as well as *C. cellulosæ* occurred simultaneously.

The duration of life of *C. cellulosæ* in man is very long; cysticerci of the eye have been known to persist for twenty years, and in cysticercus of the brain ten to nineteen years may elapse from the first appearance of cerebral symptoms until death. Dead cysticerci may shrivel up or become calcified, perhaps also undergo fatty degeneration and then absorption. Finally, it may be mentioned that if particular proof is required that *C. cellulosæ* of man belongs to the cycle of development of the *Tænia solium*, such proof has been furnished by Redon.

NOTE.—*Tænia tenella*, mentioned on p. 332, was ascribed by Cobbold to cysticerci of the muscular system of sheep. It has, however, been demonstrated that these cysticerci belong to the cycle of development of *Tænia marginata* (dog) (*Cysticercus tenuicollis*, from the omentum of sheep); but as already stated, *C. cellulosæ* also occurs in sheep. Chatin himself swallowed the cysticercus, which Cobbold termed *C. ovis*, without causing a Tænia to develop in his intestine. Müller also vainly sought to induce infection with *C. tenuicollis* in his own person. On the other hand, the feeding of a dog with *Cysticercus ovis* resulted in the production of *Tænia marginata*.

Tænia bremneri, Stephens, 1908.

Characterized by the large size of the gravid segments. The largest was 32 by 9 mm. Smallest 21 by 6 mm. Average 28·6 by 8·5 mm. Mode 21 by 6 mm. Uterine branches twenty-two to twenty-four in number. Calcareous bodies numerous, 15·2 μ in diameter. Eggs maximum 45·6 μ by 41·8 μ. Smallest 34·2 μ by 30·4 μ. Mode 38 μ by 30·4 μ.

Tænia marginata, Batsch, 1786.

Syn.: T. e. *Cysticerco tenuicolli*, Küchenmeister, 1853.

This species, which in structure resembles *Tænia solium*, lives in the intestine of the dog and the wolf. It attains 1·5 to 4 m. in length, possesses a double crown of thirty to forty hooks, on an average thirty-six to thirty-eight hooks, and in its larval stage (*Cysticercus tenuicollis*) lives in the peritoneal cavity of ruminants and the pig, occasionally in the monkey and squirrel.

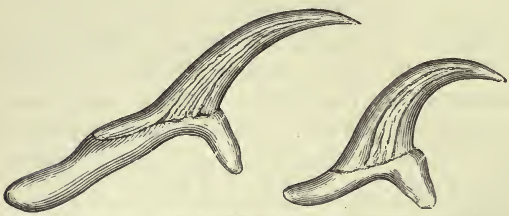


FIG. 240.—Large and small hooklets of *Tænia marginata*. 280/1. (After Leuckart.)

It is included in this work because, according to one statement, *C. tenuicollis* is supposed to have been observed in man in North America; but the case is not quite certain, as the number of hooks was less than in *C. tenuicollis* and coincided with *C. cellulosæ*, although the size of the cysticercus appeared to point to *C. tenuicollis*. A yet earlier statement of Eschricht, that *Cysticercus tenuicollis* had been observed in Iceland in the liver of a man, is undoubtedly due to an error.

Tænia serrata, Goeze, 1782.

This parasite attains a length of from 0·5 to 2 m., possesses a double crown of thirty-four to forty-eight (mostly forty) hooks. It lives exclusively in the intestine of the dog, the corresponding cysticercus (*Cysticercus pisiformis*) living in the mesentery of the hare and rabbit. We mention this species with all reserve amongst the parasites of man, because Vital states that he has observed it twice in Constantine (Algeria) in human beings. The data, however, are not sufficient to characterize the species. It is highly probable that they relate to *Tænia solium*. Galli-Valerio even swallowed five specimens of *Cysticercus pisiformis*, but without result.

Tænia crassicollis, Rud., 1810.

I only mention this species from the intestine of the domestic cat because Krabbe regards its occurrence in man as possible. It attains a length of 60 cm. and is armed; its cysticercus (*Cysticercus fasciolaris*) lives in the liver of mice and rats. In Jutland, according to Krabbe, chopped-up mice (spread on bread) are eaten raw, being a national remedy for retention of urine, and this custom affords the possibility of the introduction of *C. fasciolaris* into the intestine of man (*Nord. med. Arkiv*, 1880, xii).

Tænia saginata, Goeze, 1782.

Syn.: *Tænia solium*, L., 1767 (*pro parte*); *Tænia cucurbitina*, Pallas, 1781 (*p.p.*); *Tænia inermis*, Brera, 1802. Moquin-Tandon, 1860; *Tænia dentata*, Nicolai, 1830; *Tænia lata*, Pruner, 1847; *Bothriocephalis tropicus*, Schmidtmuller, 1847; *Tænia mediocanellata*, Küchenmeister, 1855; *Tænia zittavensis*, Küchenmeister, 1855; *Tænia tropica*, Moquin-Tandon, 1860; *Tænia* (*Cystotænia*) *mediocanellata*, Leuckart, 1863.

The length of the entire tapeworm averages 4 to 8 to 10 m. and more, even up to 36 m. According to Bérenger-Feraud it attains a length of 74 m. (?) The head is cubical in shape, 1·5 to 2 mm. in diameter; the suckers are hemispherical (0·8 mm.) and are frequently pigmented; there is a sucker-like organ in place of the rostellum, and this also is frequently pigmented. The neck is moderately long and about half the breadth of the head; the proglottids, the number of which averages more than 1,000, gradually increase in size; the mature detached segments are shaped exactly like pumpkin-seeds, and are about 16 to 20 mm. in length and 4 to 7 mm. in breadth. The genital pores alternate irregularly and are situated somewhat behind the middle of the lateral margin. There are twenty to thirty-five lateral branches at each side of the median trunk of the uterus, and these again ramify. The eggs are more or less globular, the egg-shell frequently remains intact and carries one or two filaments; the embryonal shell (embryophore) is thick, radially striated, is transparent and oval; it is 30 μ to 40 μ in length, and 20 μ to 30 μ in breadth. Several segments simultaneously are usually passed spontaneously with defæcation.

FIG. 241.—Mature segment of *Tænia saginata*, G., with distended uterus. 2/1.

FIG. 242. — Cephalic end of *Tænia saginata* in the contracted condition. 8/1.

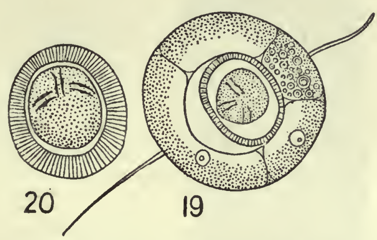


FIG. 243.—*Tænia saginata*. 19, egg with external shell. 20, without (embryophore). (After Leuckart.)

Malformations are not uncommon, and resemble those of *Tænia solium*; a triangular form has been termed *T. capensis* by Küchenmeister, and *T. lophosoma* by Cobbold, names that naturally possess as little value as does the term *T. fenestrata* for fenestrated specimens. Moreover, *T. solium*, var. *abietina*, Weinld., 1858, which was evacuated by an Indian, was probably a *T. saginata* with somewhat close uterine branches. It is regarded by Stiles and Goldberger as a doubtful subspecies.

T. saginata in its adult condition lives exclusively in the intestinal canal of man.[1] The corresponding cysticerus is *Cysticercus bovis*, and is found almost exclusively in the ox; it is small, 7·5 to 9 mm. in length and 5·5 mm. in breadth, may easily escape notice, and requires from three to six months for its development. Numerous experiments have confirmed the connection of *Cysticercus bovis* with *Tænia saginata;* indeed, the cysticercus was only discovered by feeding experiments after attention had been called to the ox as the probable intermediary host of this Tænia.

Medical men observed that weakly children who were ordered to eat raw scraped beef to strengthen them contracted *T. saginata*. It was found, moreover, that Jews, who are prohibited from eating pork from religious motives, suffered especially from *T. saginata;* when *T. solium* was found to occur in a Jew he often confessed to having eaten pork; and finally it was found that certain nations—for instance, the Abyssinians—frequently harbour *T. saginata*, and only eat beef—raw by preference.

FIG. 244.—A piece of the muscle of the ox, with three specimens of *Cysticercus bovis*. Natural size. (After Ostertag.)

These observations led Leuckart, in 1861, to feed young calves with the proglottids of *T. saginata* in order to discover the corresponding cysticercus, which was then not known. This experiment was successful. Similar experiments, with similar results, were then conducted by Mosler (1863), Cobbold and Simonds (1864 and 1872), Röll (1865), Gerlach (1870), Zürn (1872), Saint Cyr, Jolicœur (1873), Masse and Pourquier (1876), and Perroncito, in 1876. The attempts to infect goats, sheep, dogs, pigs, rabbits and monkeys were unsuccessful. Only Zenker and Heller were able to infect kids, and Heller infected one sheep, but these are exceptions.

Artificial infections of human beings with *Cysticercus bovis* to obtain the tapeworm were less numerous, and indeed quite superfluous, yet this was also done by Oliver (1869) in India, and Perroncito (1877) in Italy. The experiments of the latter prove that the extracted cysticerci of the ox certainly perish in water at 47° to 48° C.

It is a remarkable circumstance that, at least as regards Central Europe, *C. bovis* in the ox, after natural infection, was so seldom found that almost every case was published as a rarity; whereas the Tænia is very frequent in man. The reason for this is that in Germany cattle are not severely infected, and that the small, easily dried-up cysticerci easily escape notice in the large body of the host. Hertwig, the late director of the town cattle market in Berlin, in 1888, pointed out

[1] Abnormal migrations of this species have also been known. Compare, amongst others, Stieda, A., "Durchbohr. d. Duod. u. d. Pancreas durch eine Tænia," *Centralbl. f. Bakt., Path. und Infektionsk.*, 1900, xxviii (1), p. 430.

that the cysticercus of the ox is found chiefly in the musculi pterygo.de externi and interni, and since that time a far greater number of infected oxen have been found in Berlin.

Year	Number of oxen slaughtered	Infected	Proportion
1888—89	141,814	113	1 : 1,255
1889—90	154,218	390	1 : 395
1890—91	124,593	263	1 : 474
1891—92	136,368	252	1 : 541
1892—93	142,874	214	1 : 672

Since 1892 an increase has taken place in the number of oxen infected with cysticercus, but this is probably attributable to the more general and searching examinations. In the slaughter-houses of Prussia the number of infected beasts was as follows :—

1892	...	567
1893	...	686
1894	...	748
1895	...	1,143
1896	...	1,981
1897	...	2,629

The condition was most frequent in Neisse (3·2 to 4 per cent.), Eisenach (1·91 per cent.), Ohlau (1·57 per cent.), Oels i. Schles. (1 per cent.), Marienwerder (0·34 to 1·2 per cent.). The flesh of oxen only slightly infected (containing not more than ten living cysticerci) is sold in pieces of not more than 5 lb. to consumers after having been rendered innocuous by cooking, or by pickling for twenty-one days in 25 per cent. salt brine, or hanging for twenty-one days in suitable refrigerators; oxen in which only one cysticercus is found are allowed free commerce, and those strongly infected (*i.e.*, containing more than ten living cysticerci) may only be used for industrial purposes.

It is a striking fact that more bulls than cows are infected (according to Reissmann, in Berlin, from 1895 to 1902, 0·446 per cent. bulls, 0·439 per cent. oxen, and 0·262 per cent. cows), the explanation of which, according to Ostertag, is that most oxen are killed when young, when also infection most readily takes place, and, further, that the larva later on in life can be completely atrophied.

The cysticercus of the ox has hitherto been found in man on very rare occasions. Arndt (*Zeitschr. f. Psychiat.*, xxiv) mentions a case in the brain, Heller in the eye, and Nabiers and Dubreith also in the brain (*Journ. méd. Bordeaux*, 1889—1890, p. 209) ; but the diagnoses are not quite certain, as absence of hooks occasionally occurs in *Cysticercus cellulosæ*.

Tænia saginata is the most frequent tapeworm of man (with the exception of *Dibothriocephalus latus* in a few districts), and the parasite is widely distributed over the surface of the globe ; it has been known in the East for ages, so far as data are available ; it is frequent in Africa, America, and Europe. Its frequency has perceptibly increased during the last few years, but a decrease should soon take place in consequence of the extent and improvement of the official inspection of meat.

The following table shows the relative frequency of the Cestodes of man:—

Author	Year	Number of cases	*T. saginata*	*T. solium*	*Dibr. latus*	*Dipyl. canin.*	Undetermined
Parona (Milan)	1899	150	121	11	4	—	14
Parona (Italy)	1868—99	513	397	71	26	—	19
Krabbe (Denmark) ...	1869	100	37	53	9	1	—
,, ,, ...	1869—86	200	153	24	16	8	—
,, ,, ...	1887—95	100	89	—	5	6	—
,, ,, ...	1896—1904	50	41	1	5	3	—
Blanchard (Paris)... ...	1895	?	1,000	21	—	—	—
Stiles (United States) ...	1895	more than 300	more than 300	—	3	—	—
Schoch (Switzerland) ...	1869	19	16	1	2	—	—
Zaeslein (Switzerland) ...	1881	?	180	19	?	—	—
Kessler (Petrograd) ...	1888	?	22	16	47	—	—
Mosler (Greifswald) ...	1894	181	112	64	5	—	—
Bollinger (Munich) ...	1885	25	16	1	8	—	—
Vierordt (Tübingen) ...	1885	121	113	8	—	—	—
Mangold (Tübingen) ...	1885—94	128	120	6	8	—	—

Tænia africana, v. Linst., 1900.

This worm measures over 1·3 m. in length. The segments are all broader than they are long. The scolex is unarmed and is provided with an apical sucker (0·16 mm.). The parasite measures 1·38 mm. in breadth, 1·03 mm. in width; the suckers measure 0·63 mm. in diameter. The neck is very short and somewhat broader

FIG. 245.—Mature segment of *Tænia africana*. The ovary is in the middle, and behind it are the shell gland and vitellarium; at the sides are the testicles, and externally the excretory canals; the cirrus pouch, the vas deferens and the vagina are on the left. Magnified. (After v. Linstow.)

than the scolex; number of segments about 600; the hindmost segments measure 7 mm. in length and 12 to 15 mm. in breadth. The genital pores alternate irregularly in the middle of the lateral margin; the testes are very numerous and occupy the entire medullary layer; the vas deferens is much convoluted; the cirrus pouch is pyriform and thick walled; the cirrus and vagina are beset with bristles directed outwards; the receptaculum seminis is fusiform; the ovary is large and double, and consists of radially placed club-shaped tubes that do not anastomose and do not branch; the vitellarium is

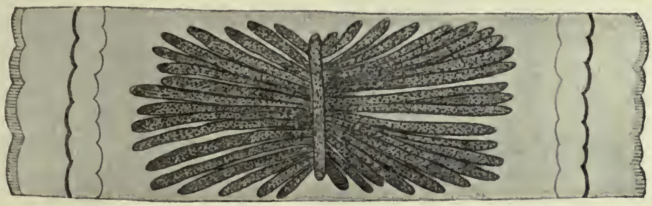


FIG. 246.—Proglottis of *Tænia africana*, with uterus. Magnified. (After v. Linstow.)

at the posterior border of the proglottids, the round shell gland in front of it; the uterus consists of a median trunk and fifteen to twenty-four non-ramified lateral branches on each side; the embryonal shell is thick and has radial stripes—it may be round ($31 \cdot 2\,\mu$ to $33 \cdot 8\,\mu$) or oval ($39\,\mu$ by $33 \cdot 8\,\mu$); the spines of the oncospheres measure $7\,\mu$ to $8\,\mu$ in length (fig. 197).

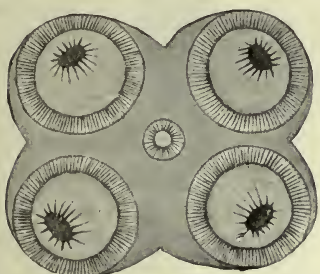


FIG. 247.—Head of *Tænia africana;* apical surface. Magnified. (After v. Linstow.)

At present only two specimens are known; they came from a black soldier from the vicinity of Lake Nyasa. The cysticercus is unknown; perhaps it lives in the zebu, the flesh of which the Askaris are in the habit of devouring uncooked.

Tænia confusa, Ward, 1896.

Length $8 \cdot 5$ m., breadth about 5 mm. The scolex is unknown; there is no neck; number of proglottids 700 to 800, always longer than they are broad; the hindmost measure 35 mm. in length, 4 to 5 mm. in breadth; the genital pores alternate irregularly behind the middle of the lateral margin; testicles numerous; vas deferens not much coiled; the cirrus pouch thick walled, elongated and club-shaped, with globular vesicula seminalis; the cirrus is beset with little hairs; the receptaculum seminis is globular; ovary small, double; each half is bean-shaped; vitellarium narrow, triangular; shell gland globular; uterus with median trunk and fourteen to eighteen short ramified lateral branches on either side. The embryophores are oval ($39\,\mu$ by $30\,\mu$), thick and radially striated.

Of this species only two specimens have been recorded; they occurred in human beings and were sent at different times to the

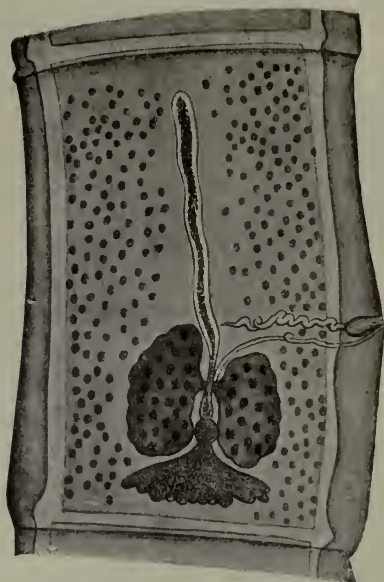


FIG. 248. — *Tænia confusa:* mature segment showing central uterine stem, bilobed ovary, globular shell gland, triangular vitellarium, scattered testes, cirrus, vas deferens, and vagina. 15/1. (After Guyer.)

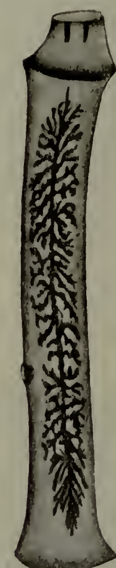


FIG. 249.—*Tænia confusa:* gravid segment. 25/1. (After Ward.)

first describer of them by a doctor in Lincoln (Nebr.). Perhaps *Tænia solium*, var. *abietina*, Weinld., which was found in a Chipeway Indian, is of the same species in spite of the shorter segments.

Tænia echinococcus, v. Sieb., 1853.

Syn.: *Tænia nana*, v. Ben., 1861 (*nec* v. Sieb., 1853); *Echinococcifer echinococcus*, Weinld., 1861.

Tænia echinococcus measures 2·5 to 5 or 6 mm. in length; the head is 0·3 mm. in breadth, and has a double row of twenty-eight to fifty hooklets (on an average thirty-six to thirty-eight) on the rostellum. The size and form of these hooklets vary (the larger ones are 0·040 to 0·045 mm. in length, the smaller ones are 0·030 to 0·038 mm. in length). The suckers measure 0·13 mm. in diameter; the neck is short; there are only three or four segments, the posterior segment being about 2 mm. in length and 0·5 mm. in breadth. The genital pores alternate; there are forty to fifty testicles; the vas deferens is spirally coiled; the cirrus pouch is pyriform. The ovary is horseshoe-shaped with the concavity directed backwards; the vitellarium double, each half almost bean-shaped, at right angles to the plane of the segment; the shell gland is round. The median trunk of the uterus is dilated when filled with eggs and (instead of lateral branches) has lateral diverticula. It is not unusual for the eggs to form local heaps. The embryonal shell (embryophore) is moderately thin, with radial striæ, almost globular, 30 μ to 36 μ in diameter.

When mature this parasite lives in the small intestine of the domestic dog, the jackal, and the wolf, and apparently also in *Felis concolor*, and is usually present in great numbers; it can also be transmitted experimentally to the domestic cat, one successful result out of seven (Dévé).[1] The larval stage (*Echinococcus polymorphus*) lives in various organs—chiefly in the liver and lungs—of numerous species of mammals (twenty-seven), especially in sheep, ox and pig, and it is even not uncommon in man, though the Tænia itself has never been found in a human being; accordingly man can only acquire the echinococcus by ingesting the eggs of the "dog worm." The dogs disseminate the eggs of *Tænia echinococcus* wherever they go, or carry them to their mouths and coats by biting up the evacuated segments, and are thus able to transmit them directly to human beings (by licking them or making use of the same crockery, etc.). In other cases the oncospheres, enclosed in the embryophores, must withstand desiccation for a time and then (as when the dogs are "kissed" or otherwise caressed) are transmitted into or on to

FIG. 250. — *Tænia echinococcus:* the cirrus sac, the vagina, uterus, ovary, shell gland and vitellarium, and the testicles at the sides are recognizable in the second proglottis; the posterior proglottis shows the uterus partly filled with eggs, as well as the cirrus sac and the vagina. 50/1.

[1] In Iceland 28 per cent. of the dogs are infected with this Tænia, in Lyons 7·1 per cent., in Zurich 3·9 per cent., in Berlin 1 per cent., and in Copenhagen 0·4 per cent. In Australia even 40 to 50 per cent. of the dogs are affected. It is, however, a question whether, in addition to *Tænia echinococcus*, a second analogous form is not involved, as the form from *Canis dingo* attains a length of 10 to 30 mm.

man. As echinococcus disease in man is always very dangerous, it would be a matter of general interest to prevent dogs being infected by destroying the echinococci,[1] and all measures would be justifiable which would diminish the superfluous number of house-dogs (for instance, high taxes); measures should also be adopted to limit the association of men with dogs, particularly in such frequented places as restaurants, railway carriages and tram-cars.

Echinococcus is very common in slaughtered animals; in Germany, however, the figures in the reports of the abattoirs present an erroneous view in so far as, besides the total number of animals slaughtered, only the numbers of those organs (liver and lungs) are published that were so severely infected with echinococci that, even when the parasites were "shelled" out, the flesh could not be placed upon the market and was therefore "condemned."

In Berlin the following animals were slaughtered :—

Year	1889—90	1890—91	1891—92	1892—93	1896—97	1902
Oxen ...	154,218	124,593	136,368	142,874	146,612	153,748
Sheep...	430,362	371,943	367,933	355,949	395,769	434,155
Pigs ...	442,115	472,859	530,551	518,073	694,170	778,538

During the same years the following were condemned in consequence of being infected with echinococci :—

	Lung	Liver	Lung	Liver	Lung	Liver	Lung	Liver	Lung	Liver	Lung	Liver
Oxen ...	7,266	2,418	5,792	1,938	4,497	1,721	2,563	739	3,284	1,156	2,507	791
Sheep...	5,479	2,742	4,595	2,059	4,435	1,669	3,331	1,161	4,561	1,939	11,138	4,437
Pigs ...	6,523	5,078	5,083	3,735	6,037	4,374	6,785	4,312	7,888	5,398	9,544	9,233

Nevertheless there are statistics that give the total number of animals infected with echinococcus :—

Author	Place	Oxen	Sheep	Pigs
Längrich	Rostock i. M.	26·2 per cent.	37·0 per cent.	5·4 per cent.
Olt	Stettin ...	7·1 ,,	25·8 ,,	7·3 ,,
Steuding	Gotha	24·6 ,,	35·4 ,,	21·4 ,,
Prettner	Prague ..	23·2 ,,	5·5 ,,	?

In Güstrow, in Mecklenburg, half of the animals slaughtered are said to be infected with echinococcus; in Wismar 25 per cent. of the oxen, 15 per cent. of the sheep and 5 per cent. of the pigs are infected; according to Mayer, in Leipzig, 3·79 per cent. native pigs, 24·47 per cent. Hungarian pigs, and 13·09 per cent. of sheep were infected with echinococcus; at the same time it was stated that in regard to the native pigs the liver was more frequently affected than the lungs (3·81 per cent. as compared with 0·26 per cent.); in sheep the lungs were more frequently infected

[1] Mosler, F., "Ueb. Mittel z. Bekampfg. endem. vork. Echinococcuskrank.," *Deutsch. med. Zeit.*, 1889, No. 72.

(12·71 per cent. to 3·73 per cent.), whereas in the Hungarian pigs both organs were almost equally infected (14·78 per cent. to 12·03 per cent.).

The data of Lichtenheld, in Leipzig, give the frequency with which various organs were affected, as shown in the following table:—

	Cattle	Pigs		Sheep	Horses
		♂	♀		
Lungs	69·3 per cent.	16·2 per cent.	21·4 per cent.	52·2 per cent.	5·5 per cent.
Liver	27·0 ,,	74·2 ,,	72·0 ,,	44·9 ,,	94·5 ,,
Spleen	2·2 ,,	3·2 ,,	2·7 ,,	2·9 ,,	—
Heart	0·75 ,,	3·2 ,,	1·3 ,,	—	—
Kidneys	0·75 ,,	3·2 ,,	1·3 ,,	—	—
Subperitoneal tissue ...	—	—	1·3 ,,	—	—

Structure and Development of Echinococcus (Hydatid).

An echinococcus is a spherical or roundish bladder full of a watery liquid, which originates by liquefaction of the oncosphere, and in man may attain the size of a child's head, but remains smaller in

Fig. 251. — *Echinococcus veterinorum:* the fibrous sac enclosing the echinococcus has been opened and laid back in five parts, so that the surface of the bladder worm may be seen, with the brood capsules, visible to the naked eye, showing through it. Natural size. (After Leuckart.)

cattle (the size of an orange or apple). The thin wall of the bladder is composed of an external laminated cuticle (ectocyst) and an internal germinal or parenchymatous layer (endocyst). The latter again exhibits two layers : an outer layer of small cells that are less sharply defined, and an inner layer of larger cells. It contains, in addition, calcareous corpuscles, muscular fibres and excretory vessels. It is rich in glycogen.

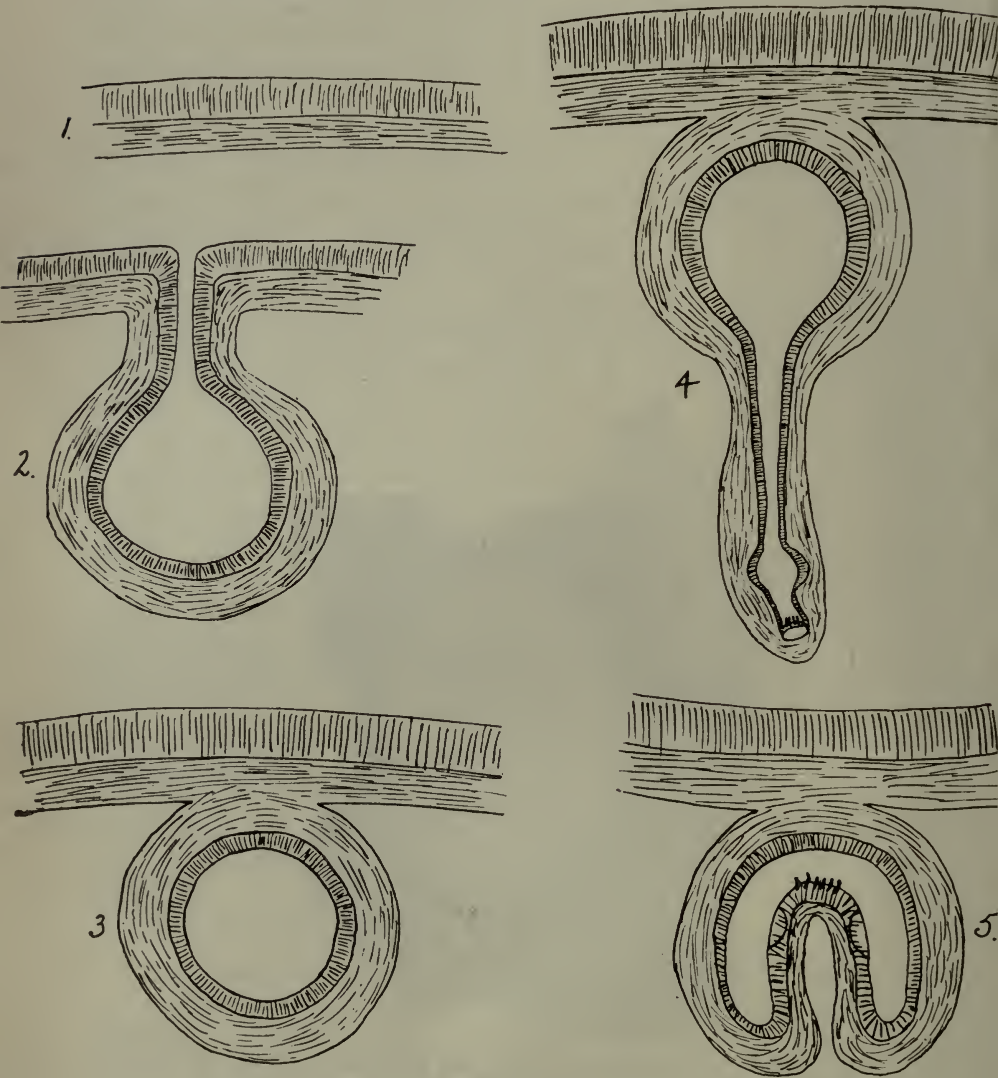


FIG. 252.

FIGS. 252 and 252A.—Diagrams of mode of formation of brood capsule and scolices. (1) Wall of mother cyst, consisting of ectocyst and endocyst ; (2) theoretical stage of invagination of wall ; (3) a brood capsule with the layers of the wall in the reverse position to that in the mother cyst ; (4) evagination of wall ; (5) invagination ; (6) fusion to form the solid scolex ; (7) invagination of fore-part of scolex into hind-part. (*Note.*—The size of the scolex is much out of proportion to the brood capsule.) (Stephens.)

The development in cattle often remains stationary at the bladder stage, and they are then called "acephalocysts," or *Echinococcus cysticus sterilis*. According to Lichtenheld, sterile cysts occur in 80 per cent. of cases in cattle, in 20 per cent. in pigs, and in 7·5 per cent. in sheep. In other cases large numbers of small, hollow BROOD CAPSULES are formed in the germ layer, but are not arranged in any particular order. The order of the layers is just the reverse in them to what it is in the parent cyst, that is to say, they have inside a thin non-laminated cuticle and the parenchymatous layer on their external surface. These, theoretically at least, may be regarded as invaginations of the bladder wall giving rise to a cavity with the cuticle internal and the parenchymatous layer external. If we suppose the orifice to close, we should then get an isolated cavity with cuticle internal and parenchymatous layer external, as in the brood capsule (fig. 252).

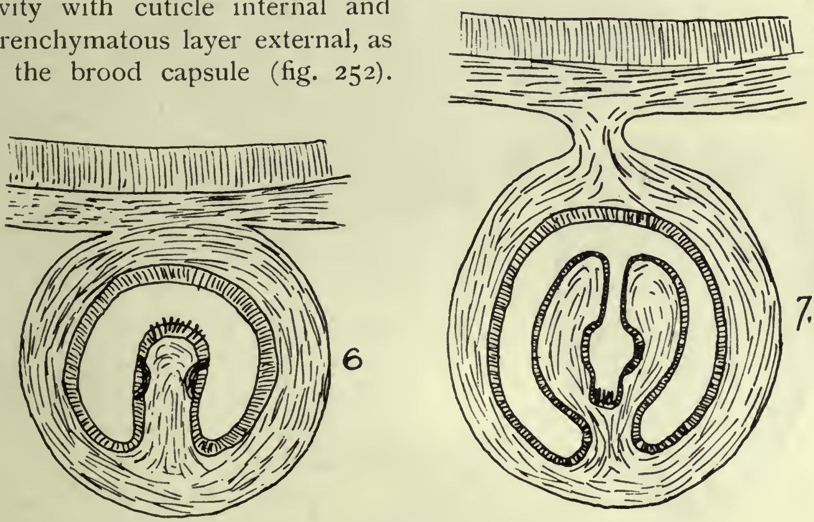


FIG. 252A.

If we next suppose an evagination of the wall of the brood capsule to occur at one point we should get a hollow process *lined* with cuticle; at the bottom of this we get the scolex and hooklets formed, and a little higher up the tube the suckers (fig. 252, 4). If this hollow scolex is now pictured as being invaginated we get a hollow scolex *covered* with cuticle and lined by a parenchymatous layer projecting into the cavity of the brood capsule. The two sides of this hollow scolex now fuse and we get a solid scolex projecting into the cavity. Finally, if we imagine once more the rostellum and suckers invaginated into the posterior part of the scolex we get the condition as frequently found in the brood capsules, *i.e.*, a scolex covered with cuticle projecting into the cavity, with the rostellum and suckers invaginated into the posterior portion of the scolex (fig. 252A, 7).

A large hydatid may contain many thousands of brood capsules. Each brood capsule is about as big as a pin's head, and may contain ten to thirty or more scolices. The delicate wall of the brood capsules may rupture, so that the scolices are now free in the mother cyst. These free scolices and also free brood capsules constitute what is known as "hydatid sand," which settles at the bottom of a glass when hydatid fluid is poured into it. This form occurs chiefly in domesticated animals and is termed *E. veterinorum*, Rud., or *E. cysticus fertilis*.

In man, and only rarely in cattle, the mother cyst first forms "daughter cysts" (*E. hominis*, Rud. [fig. 255]), which, though smaller than the "mother cyst," resemble it in the structure of their walls; thus they are covered externally by a laminated cuticle and internally by the parenchymatous layer. They originate:

FIG. 253.—Section through an invaginated echinococcus scolex. *Cf.* fig. 252A, 7. × 300. (After Dévé.)

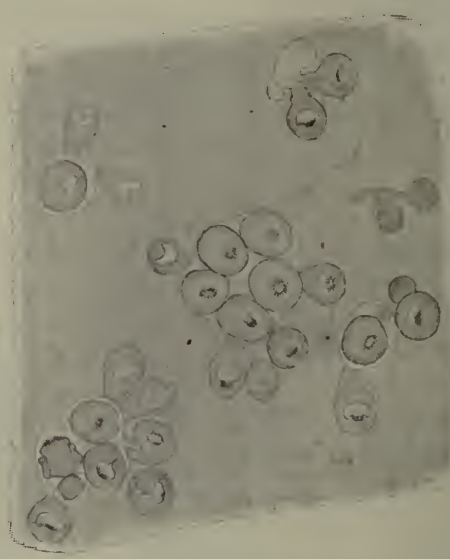


FIG. 254.—A piece of the wall of an *Echinococcus veterinorum* stretched out and seen from the internal surface. A few brood capsules (the outline of which is only faintly shown), with scolices directed towards their interior and exterior. 50/1.

(1) Between the laminæ of the cuticle of the mother cyst from small, detached portions of the parenchymatous layer; during their growth they bulge inwardly or outwardly and may separate themselves entirely from their parent cyst. In the latter case they lie between the mother cyst and the capsule of connective tissue formed by the host (*E. granulosus* or *E. hydatidosus exogenus*); when growing inwardly they reach the interior of the mother cyst (*E. hydatidosus endogenus*). Their number is very variable and does not depend on the size of the mother cyst. They are as big as, or bigger than, gooseberries.

(2) According to some authors, endogenous daughter cysts arise also

from a *metamorphosis of scolices* that have separated off from the brood capsule. This takes place in the following way: Fluid accumulates in the interior of the scolex, so that eventually nothing remains except a sac consisting of cuticle lined by parenchyma. The cuticle gradually thickens and several layers form (fig. 257).

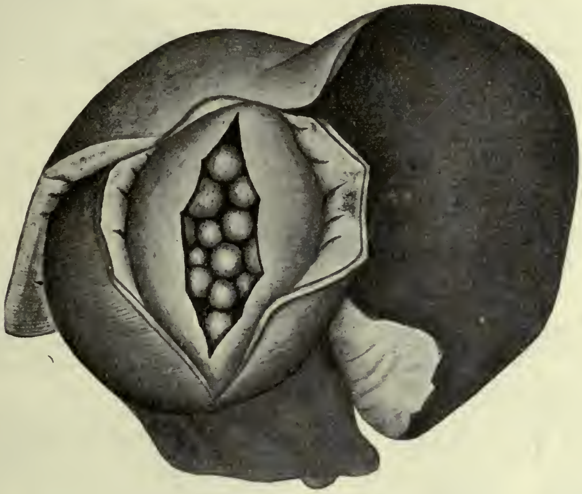


FIG. 255.—*Echinococcus hominis* in the liver. The fibrous capsule and the wall of the echinococcus have been incised, so that the endogenous daughter cysts may be seen. Reduced. (After Ostertag, from Thoma.)

(3) *Transformation of Brood Capsules into Daughter Cysts.*—This is also held to be possible by various observers. New epithelial layers are deposited between the cuticle which lines the brood capsule and the outer parenchymatous layer. This parenchymatous layer gradually disappears and a new parenchymatous layer forms in the interior from the parenchyma of the scolex or scolices. Although it appears strange that a completely formed scolex with specifically differentiated tissues and organs should retrogress to more primitively organized matter, and again become a proliferating bladder, yet we can hardly doubt that the older observations, regarding such a vesicular metamorphosis, of Bremser (1819), v. Siebold (1837), Naunyn (1862), Rasmusser (1866), Leuckart (1881), Alexinsky (1898), Riemann (1899), Dévé (1901), and Perroncito (1902) are correct.

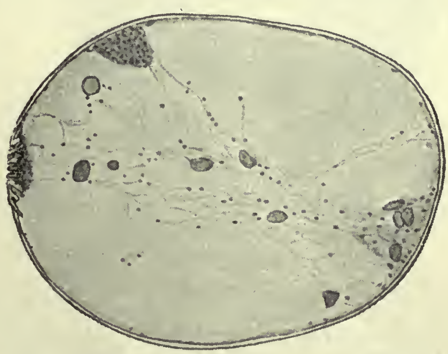


FIG. 256.—Section through an echinococcus scolex in process of vesicular metamorphosis, twenty-six days after insertion in the pleural cavity. × 250. (After Dévé.)

(4) Further, *a fourth method* of formation of daughter cysts is described by Naunyn as occurring in sterile hydatids, *i.e.*, those containing no brood capsules. In this case a portion of the mother wall of the hydatid gets constricted off.

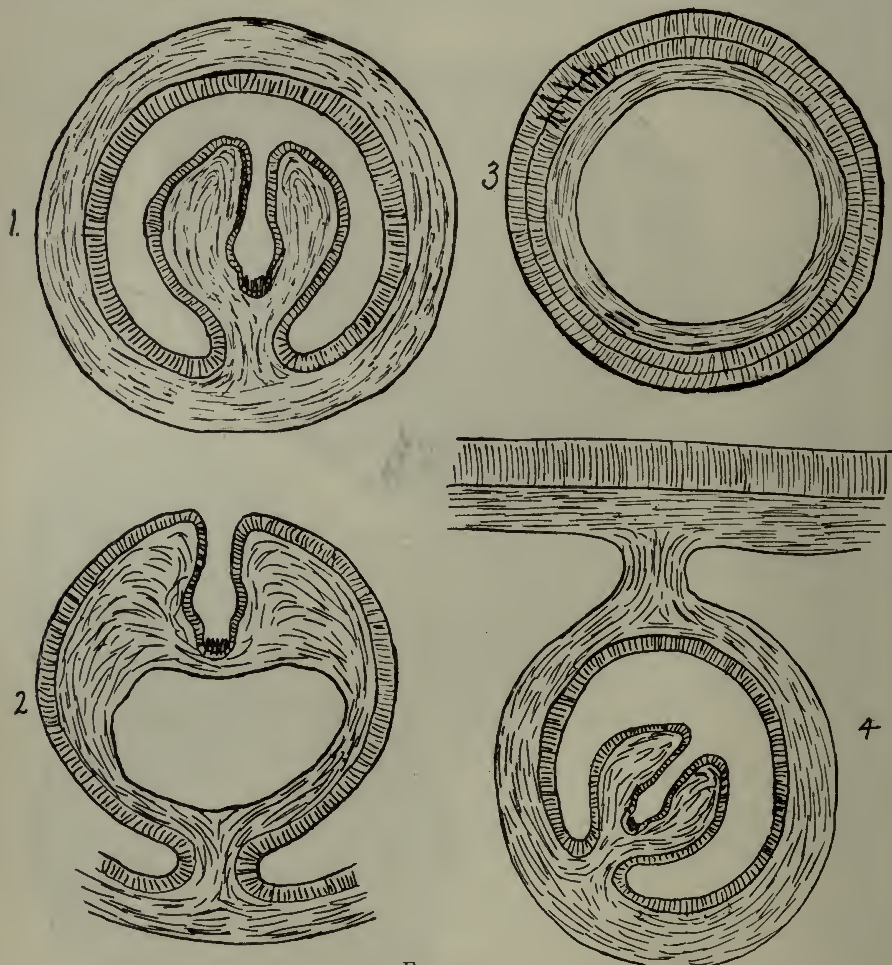


FIG. 257.

FIGS. 257 and 257A.—Diagram of transformation of a scolex into a daughter cyst (1 to 3): 1, scolex in brood capsule; 2, liquefaction of scolex; 3, daughter cyst; and (4 to 6) of a brood capsule into a daughter cyst: 4, brood capsule with scolex; 5, deposition of new epithelial layers on the inner layer of the parenchyma; 6, disappearance of outer parenchyma and formation of inner parenchyma from the parenchyma of scolex, which has now disappeared. (*Note.*—The scolices are out of proportion to the brood capsules and to the daughter cysts. (Stephens.)

It has also been established that not only daughter cysts transplanted into animals develop further (Lebedeff, Andrejew, Stadnitzky, Alexinsky, Riemann), but that this also holds good if only hydatid *scolices* from man or animals are transplanted into animals (rabbits). They develop into echinococci and can then give rise to brood capsules and scolices. As Dévé further established, hydatid *scolices* are not capable of developing in guinea-pigs, while corresponding experiments with rabbits are in the large majority of cases successful where the scolices are introduced subcutaneously or into the pleural or peritoneal cavities. It is only in the case of *daughter cysts* that further growth is obtained in the case of guinea-pigs. Finally it appears, as has been already stated, that brood capsules can transform themselves into daughter cysts, but according to Dévé only within the mother cyst, not after transplantation. Daughter cysts that have been formed in the mother cyst of man and animals behave themselves just as the mother cyst does, *i.e.*, they can remain sterile, or give rise to brood capsules and scolices, or even again to fresh cysts—granddaughter cysts. The mother cyst can also die, so that the daughter cysts then lie in the cavity of the connective tissue capsule. The number of the daughter cysts in either case may attain several thousands.

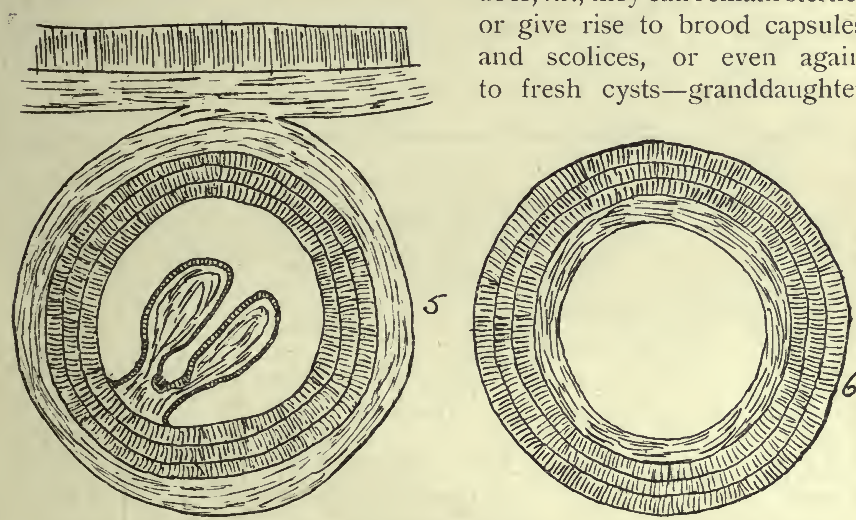


FIG. 257A.

The echinococcus fluid, which originally is formed from the blood of the host, is light yellow, with a neutral or slightly acid reaction ; its specific gravity averages 1009 to 1015. It contains about 1·5 per cent. of inorganic salts, half of which is common salt; in addition (besides water) it contains sugar, inosite, leucine, tyrosin, succinic acid (associated with lime or soda) and albumens which are not coagulated by heat ; occasionally also the fluid has been found to contain hæmatoidin and uric acid salts (in echinococcus of the kidneys), which doubtless demonstrates that the echinococcus liquid originates from the host. It has been generally assumed that echinococcus fluid contains a toxic substance the escape of which into the body cavity (at operation or by bursting of a hydatid cyst) produces more or less severe symptoms (fever, peritonitis, urticaria), so much so that one speaks of hydatid intoxication. The investigations of Kobert, Joest, etc., have, however, shown the harmlessness of fresh undecomposed hydatid and cysticercus fluid for rabbits, mice and guinea-pigs, whether inoculated intraperitoneally, subcutaneously or intravenously. Contrary data or clinical experience must accordingly depend on other factors.

According to the researches of Leuckart, the growth of the echinococcus is very slow ; four weeks after infection the average size is only 0·25 to 0·35 mm., at the age of eight weeks it is 1 to 2·5 mm., and at this period the formation of the central cavity commences ; at the age of five months, and with a size of 15 to 20 mm., the first brood capsules with scolices are formed. The consequence of this gradual increase of size is that the organ attacked can maintain its functions by vicarious hypertrophy, and that many echinococci induce no special symptoms and cannot even be diagnosed, the latter circumstance being due to their hidden position.

The echinococcus cannot be said to be scarce in man, as is shown by the following table for Central Europe :—

Place	Period	No. of *post-mortems*	No. of cases of echino.	Percentage
Rostock	1861—83	1,026	25	2·43
Greifswald	1862—93	3,429	51	1·48
Jena	1866—87	4,998	42	0·84
Breslau	1866—76	5,128	39	0·761
Berlin	1859—68	4,770	33	0·69
Würzburg	—	2,280	11	0·48
Göttingen	—	639	3	0·469
Dresden...	1852—62	1,939	7	0·36
Münich	1854—87	14,183	35	0·25
Vienna	1860	1,229	3	0·24
Prague	—	1,287	3	0·23
Kiel	1872—87	3,581	7	0·19
Zürich, Basle, Berne	—	7,982	11	0·13
Erlangen	1862—73	1,755	2	0·11

These, however, are only cases that have become known by *post-mortem ;* in addition, there are cases that have been treated medically, of which there are a few statements, at all events relating to the principal districts of Germany. According to Madelung, one case of echinococcus occurs in every 1,056 inhabitants in the town of Rostock, in the district of Rostock one to every 1,283, in Schwerin one to every 5,887, and in Ludwigsort one to every 23,685 ; according to Peiper, in Upper Pomerania one case occurs to every 3,336, in the district of Greifswald one to every 1,535 inhabitants. The northern districts of Pomerania are more affected than the southern ones.

Accordingly, echinococcus is also considerably more frequent in cattle in Pomerania. On an average in Germany 10·39 per cent. oxen, 9·83 per cent. sheep, and 6·47 per cent. pigs are infected, whereas in Upper Pomerania 37·73 per cent.

oxen, 27·1 per cent. sheep, and 12·8 per cent. pigs are infected; in Greifswald, indeed, 64·58 per cent. oxen, 51·02 per cent. sheep, but only 4·93 per cent. pigs are infected. In accordance with these figures *Tænia echinococcus* must be frequent in dogs in Pomerania, especially in Upper Pomerania; on the other hand, the conjecture that the frequency of echinococcus in Mecklenburg is explained by the occurrence of *Tænia echinococcus* in foxes has not been confirmed, as the fox does not harbour this worm in Mecklenburg.

Beyond the European continent, echinococcus is frequent in the inhabitants of Iceland, Argentine, Paraguay and Australia. In Iceland, according to Finsen, 1 in every 43 inhabitants is affected with echinococcus; according to Jonassen the proportion is 1 to 63; this is due to the habits of the people of Iceland or, in fact, to the frequency of *Tænia echinococcus* in dogs, and the prevalence of the hydatid in cattle. In certain districts of Australia it is just as frequent. In Cape Colony, Egypt and Algeria echinococcus is not rare, but it is scarce in America and in Asia, with the exception of the nomadic tribes of Lake Baikal.

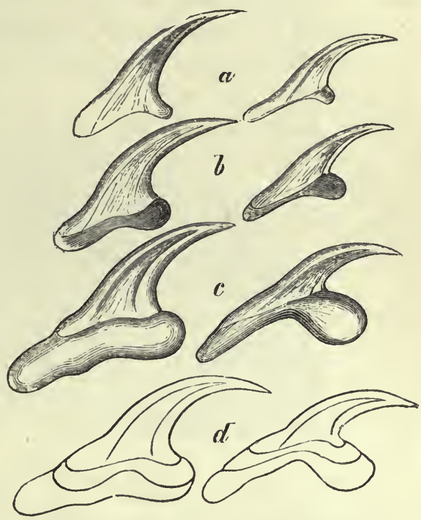


FIG. 258.—Hooklets of echinococcus. *a*, of *Echinococcus veterinorum*; *b*, of *Tænia echinococcus*, three weeks after infection; *c*, of the adult *Tænia echinococcus*; *d*, the three forms of hooklets outlined one within the other. 600/1. (After Leuckart.)

Echinococcus attacks persons of every age, though it is rare in children up to 10 years of age and in old people. It occurs most frequently between the ages of 21 and 40 years. According to all statistics it preponderates in women (about two-thirds of the cases). The liver is its favourite seat (57·1 per cent. of the cases); next in order come the lungs (8 per cent.), kidneys (6 per cent.), cranial cavity, genitalia, organs of circulation, spleen (3·8 per cent.), etc. As a rule one organ only is invaded; multiple occurrence may originate from one infection, or eventually from a later infection (?), or it may come to pass that from some cause (through the spontaneous rupture of an echinococcus, or the rupture of one caused by an injury or surgical operation) daughter cysts, brood capsules or scolices escape into the abdominal cavity,[1] where they settle or become transformed and go

[1] In such cases the toxic effects of the echinococcus fluid usually—if not always—manifest themselves. Such effects are manifested by severe symptoms of poisoning being set up, by urticaria, peritonitis, and ascites, and not infrequently they cause a fatal termination.

on growing. In the distribution of this secondary echinococcus the great powers of motility of the free scolices must be taken into account (Sabrazès, Muratet, and Husnot).

Human echinococci may also die at various stages of development, become caseous or calcified, or may be absorbed, the cause for this being either disease of the hydatid itself or inflammation of its connective tissue capsule; the discovery of the laminated cuticle, which has great powers of resistance, or the finding of the hooklets of the scolices is sufficient to form a conclusion as to the nature of such formations.

Siebold (1853) was the first to rear *Tænia echinococcus* in the dog by feeding it with the echinococcus of cattle and especially of sheep. Küchenmeister, van Beneden, Leuckart, Railliet and others obtained similar results, and Thomas, Naunyn, Krabbe and Finsen succeeded in rearing *T. echinococcus* in dogs from the bladder worms of human beings; these grow comparatively slowly (one to three months[1]) and only during the process of growth develop their hooklets in their definite form (fig. 258). It lies in the nature of things that dogs, whether experimentally or naturally infected, almost always harbour *T. echinococcus* in large quantities. That cats exceptionally harbour these worms has been already mentioned (Dévé). Finally, Leuckart infected young pigs by feeding them with mature segments.

Echinococcus multilocularis (alveolar colloid).

In addition to the form of echinococcus already described, and which is also frequently termed *Echinococcus unilocularis*, there is a second form which occurs in man as well as in animals, and which is termed *E. multilocularis*, s. *alveolaris* (alveolar colloid).

It was originally regarded as a tumour; its animal nature was first established by Zeller and R. Virchow. The parasite, which varies in size from that of a fist to a child's head, presents a collection of numerous cysts, measuring between 0·1 and 3 to 4 mm. to 5 mm. in diameter, which are embedded at first in a soft, connective tissue stroma; the cut surface has therefore a honeycomb appearance. The cysts are surrounded by a pellucid and laminated cuticle, and each according to its size encloses either a small-celled tissue or a cavity lined by a parenchymatous layer; the fluid contained in such a cavity may be transparent, or is rendered opaque by globules of fat, bile-pigment, hæmatoidin and fat crystals. According to some authors all or most of these cysts intercommunicate; others state that this is the case at least as regards the cuticle. The scolices are by no means

[1] According to Perroncito the scolices had not formed proglottids nine days after feeding, but the latter were present twenty-four days after feeding, although the formation of eggs had not begun.

found in all the cysts, and when present only a few, rarely half, of the cysts contain scolices (one or more); it is supposed that at least some of these scolices are formed in brood capsules, and that the former are capable of undergoing a cystic metamorphosis.

One circumstance is peculiar to the multilocular echinococcus of man, namely, the disintegration that sets in at certain stages; in the centre of the parasite a cavity forms that frequently becomes very large and is filled with a purulent or brownish or brownish-green viscid fluid; in this fluid one finds shreds of the wall of the cavity, calcareous bodies, echinococcus cysts, also scolices and hooklets, as well as fat globules and crystals of hæmatoidin, margarine and cholesterin and concretions of lime. Such ulcerative processes, according to Ostertag, are never present in the multilocular echinococcus of oxen,[1] in which the separate cysts are larger and the connective tissue integument less powerfully developed.

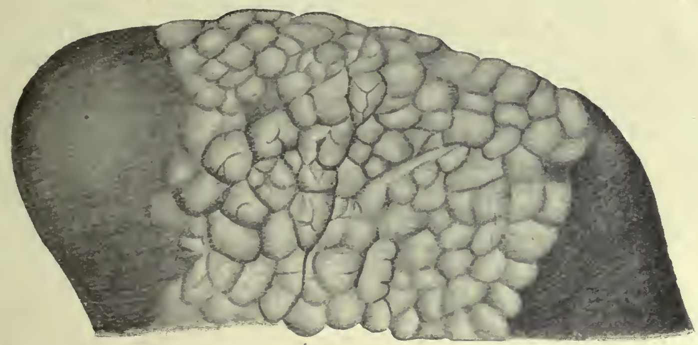


FIG. 259.—*Echinococcus multilocularis* in the liver of the ox. Natural size. (After Ostertag.)

Hardly anything positive is known with regard to the development of the alveolar echinococcus; its peculiar conformation is attributed by some to enormous infection of oncospheres, by others to the abnormal situation of one oncosphere; a few authors ascribe it to infection of lymphatic vessels, others to infection of the biliary ducts or to peculiarities of the surrounding hepatic tissue; Leuckart ascribes it to a grape-like variety of form which continues budding; a few more recent authors consider multilocular echinococcus to be specifically different from unilocular echinococcus, and therefore also different the species of Tænia arising from them. Melnikow-Raswedenkow is also of this opinion. According to this author the oncospheres infect the lumen of a branch of the portal vein in

[1] This may perhaps be explained by the fact that the hosts are slaughtered before the parasites have attained the size or other conditions necessary to disintegration.

Glisson's capsule of the liver and grow into an irregularly shaped formation (chitinous coil), which breaks through the vascular walls and thus forms the alveoli. So far the data coincide well with Leuckart's opinion of the original grape-like form of the *Echinococcus multilocularis*; according to Melnikow-Raswedenkow the "granular protoplasmic substance" (parenchymatous layer) is not only present in the interior of the loculi but also outside, and, moreover, "ovoid embryos" are supposed to develop in the chitinous coils, which, "thanks to their amœboid movements, reach the lumen of a vessel, where, under favourable circumstances, they begin to develop further," that is to say, they become "chitinous cysts with fantastic outlines," or also "single-chambered chitinous cysts"; scolices may develop in both. Dévé, however, considers that these embryos are only prolongations of the protoplasmic layer which secondarily cuticularize.

The multilocular echinococcus, which in man produces a severe disease and almost always leads to premature death, infects most frequently the liver, but may also be found primarily in the brain, the spleen and the suprarenal capsule; from the liver by means of metastasis it may reach the most various organs, especially those of the abdomen, but also the lungs, the heart, etc. Up to 1902, 235 cases have been described and up to 1906, 265, being 70 from Russia, 56 from Bavaria, 32 from Switzerland, 30 from the Austrian Alps, 25 from Würtemberg; the remaining cases are distributed over Central Germany, Baden, Alsace, France, Upper Italy, North America. In some the origin is doubtful; in any case after Russia, the mountainous South of Europe is the principal region of distribution. As to the domesticated animals, the same parasite is found principally in the ox (according to Meyer, in Leipzig, in 7 per cent. of the oxen affected with echinococcus); it is rarer in the sheep and very scarce in the pig.

It has already been mentioned above that recently the multilocular echinococcus has been stated to be specifically different from hydatid or unilocular echinococcus. To this may be added the fact that Mangold, who fed a young pig with oncospheres of a Tænia reared from the multilocular echinococcus, found two growths in the liver four months later, which he took to be *E. multilocularis*, and consequently one has to assume the existence of two different worms. The chief defender of this view, already put forward by Vogler, Mangold, and Müller, is Possett. He bases his opinions on (1) the more restricted distribution of the multilocular hydatid, the former occurring in districts where only cattle are raised, the latter where sheep-breeding is established; (2) that those engaged in looking after sheep are attacked by multilocular, whereas those looking after cattle are attacked by unilocular hydatid; (3) that among the cases of unilocular hydatid occurring in the distribution areas of multilocular hydatid no transitions between the two forms are observed; (4) on the difference in the hooks both in the hydatid as well as in the Tænia stage ; the hooks of *Tænia echinococcus* are plump, sharply curved, and have a short posterior root process the length of which is to that of the total length as 1 to 4·7, whereas on the contrary the hooks of the alveolar echinococcus are more slender, slightly bent, and have a long posterior root process (1 to 2·5) ; and (5) on the form of the uterus, which in the alveolar Tænia has the form of a spherically distended sac anteriorly.

Serum Diagnosis of Echinococcus.

(1) *Precipitin Reaction.*—Mix equal parts of hydatid fluid (of the sheep) and serum of patient. Keep at 37° C. The reaction is not decisive as it may be given by normal sera.

(2) *Complement Deviation.*—Required : (1) Hydatid fluid of sheep (antigen), (2) guinea-pig complement, (3) patient's serum, (4) red cells of sheep, (5) hæmolytic serum (of rabbit) against sheep's red cells, (6) 0·8 per cent. salt solution. Mix the antigen + patient's serum (heated) + complement + salt solution at 37° C. for one hour. Add red cells of sheep + hæmolytic serum. Allow to stand for half an hour at 37° C. It is imperative to make adequate control observations. An example will indicate the method. Salt solution 1·3 c.c. + patient's serum (heated) 0·2 c.c. + hydatid fluid 0·4 c.c. + complement 0·1 c.c. of serum diluted to a quarter strength + hæmolytic serum and red cell emulsion 1 c.c. Result : no hæmolysis, *i.e.*, the patient's serum contains specific (echinococcus) antibodies.

C. NEMATHELMINTHES.

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

Bilaterally symmetrical animals, without limbs and with a body cavity in which the gut or other organs float. They are generally cylindrical.

Class. NEMATODA.

Nemathelminthes with an alimentary canal.

Nematodes are as a rule elongated round worms of a filiform or fusiform shape; their length varies according to the species from about 1 mm. to 40 to 80 cm. The outer surface of the body is smooth or annulated, and at certain points provided with papillæ, occasionally also with bristles and alar appendages. The anterior end carrying the oral aperture is usually rather slender, occasionally quite thin; the posterior end is pointed or rounded; the anus, as a rule, lies somewhat in front of the posterior extremity. The sexes are almost always separate, and the male can as a rule be easily distinguished from the female because the former is smaller and more slender, its posterior extremity is often spiral or incurved, or carries an alar appendage, whereas the female is larger and thicker, and its posterior extremity is straight. In the male the genitalia open into the anus; the sexual orifice of the female opens ventrally along the median line in the anterior half of the body, in the middle, or a little further back. Both sexes, moreover, have an orifice, the excretory pore, which is situated ventrally in the median line and about the level of the œsophageal nerve ring.

In large species, even with the naked eye, two lighter transparent bands—the lateral lines—may be distinguished; they run along the sides of the body from the anterior to the posterior end, while two other bands, the median lines, running along the ventral and dorsal mid-lines, are less evident; in exceptional cases there are also four sub-median lines. These bands or lines are inward projections of the ectoderm, and in them lie the nerves and excretory vessels (fig. 260).

Some Nematodes live free in fresh or salt water, in soil, mud or decaying vegetable matter, others parasitically in the most various organs of animals, frequently also in plants.

Anatomy of the Nematodes.

All the Nematodes are covered by (1) a cuticle, which in the small species is thin and delicate, while in the larger species it is thickened, and may consist of several layers of complicated structure. Canalicular pores do not occur. According to general opinion, which is confirmed by the history of development, the cuticle is a product of (2) the epithelium or ectoderm that had formerly existed or is still found beneath it; in young specimens and small species it is perceptible, but in older worms it frequently alters so considerably that not only do the borders of the cells disappear,[1] but a fine fibrous differentiation appears in their cytoplasm. The matrix or ectoderm then has the appearance of an ectodermal syncytium permeated by fibres and strewn with nuclei, so that it is hardly distinguishable from the tissue of (3) the CUTIS, which is always present, though developed to a varying degree. Both layers, matrix and cutis, project internally as ridges and form the lateral lines, while the less marked median lines are produced apparently only by the ectoderm (fig. 260).

Unicellular cutaneous glands are known in parasitic as well as in free-living species; they vary in number and arrangement, and are found discharging some at the anterior extremity and others in the vicinity of the genital orifices. In other cases large numbers of them are present along the lateral lines; they are strongly developed in most of the *Trichotrachelidæ*, where they discharge either along a part of the ventral surface or along the lateral and median lines; they are placed so closely together that the ridges of the cuticle perforated by the orifices have long been known, and have been described, as "rodlet borders," or "fields of rods."

As the cutis is immediately adjacent to (4) the DERMO-MUSCULAR TUBE the simple layer of the muscular cells is divided into four quadrants by the longitudinal lines—two dorsal and two ventral (fig. 260). The MUSCLES are in the simplest cases large rhomboid cells that lie two by two in each quadrant, so that on transverse section of the entire worm only eight cells are perceptible. The outer border of the cells is converted into contractile fibrils, while the contiguous inner portion has remained protoplasmic, and contains the nucleus. In large species the muscular cells do not only increase in length (up to 3 mm.) and in number in every quadrant, but their contractile portion curves up to form a groove (like that of a dead leaf) thereby even becoming thicker; simultaneously space is gained for more cells, the protoplasmic parts of these cells (on transverse section) project out of the grooves like vesicles. In all cases there is only one layer of longitudinal muscular cells, which, by contracting, can shorten the body or, by contracting one side, can bend it. In the latter case the muscles of the opposite side have an antagonistic effect, or when all the muscles are contracted, the elasticity of the cuticle acts in the same way. Special muscles exist at the beginning of the gut and at sections of the genital apparatus.

The existence of a cavity between the body and the gut wall has hitherto been generally assumed, and has been referred to the cleavage cavity, and consequently designated as a primary body cavity. More

[1] In the *Ascaridæ* isolated epidermal cells grow to a considerable size, and have to do with the sensory apparatus of the lips (Goldschmidt).

recent investigators, however, state that such a cavity does not exist, but that the space between the longitudinal muscles or their protoplasmic portions and the gut epithelium is filled by a complicated "isolation tissue." This in the main proceeds from a large cell (*Is.*, fig. 262) which lies directly behind the nerve ring dorsal to the œsophagus, and consists of a system of lamellæ which sheathe the muscles and penetrate through them to the cutis and also cover the gut in a thin layer.

We may now consider the "tuft-like" or "phagocytic" organs, which attain 1 cm. in size, and consist of four, six, or even more ramified cells, which lie close to the walls of the body (fig. 261).

FIG. 260.—Diagram of a transverse section of *Ascaris lumbricoides*, showing thick cuticle, and beneath it the matrix or syncytial ectoderm. The flat intestine is in the middle, and to the right and left near it in the body wall the lateral lines with excretory vessel and lateral nerves; above and below in the centre the dorsal or ventral median lines with the nerves radiating to the muscles, also the muscle cells with their striated outer contractile portion and inner nucleated vesicular protoplasmic portion. About 50/1. (After Brandes.)

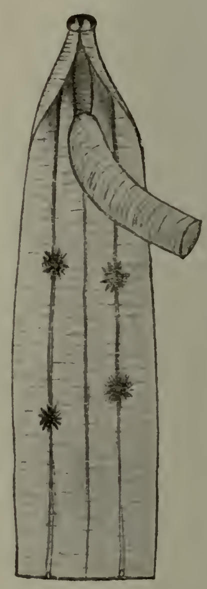


FIG. 261. — Anterior end of an *Ascaris megalocephala* cut open and showing the four tuft-like organs lying on the lateral lines. Natural size. (After Nassonow.)

They are found either only in the anterior part of the body (Ascaris), or throughout the whole length of the body (Strongylus, syn., Sclerostomum), and their position usually corresponds to the lateral lines. In some species there are small protoplasmic cells on the processes of these organs. In consequence of their size they can be recognized with the naked eye, especially when they are loaded with granules of stain (carmine, Indian ink) injected into the body cavity.

INTESTINAL CANAL.—The oral aperture, which is situated at the tip of the anterior extremity, is frequently surrounded by thick lips, or small bristles, or papillæ; it leads to a more or less strongly developed buccal cavity, which is lined by a continuation of the body cuticle, and which in some species is provided with "teeth," representing differentiated portions of the cuticle.

THE ŒSOPHAGUS (fig. 262), which arises from the base of the oral cavity, is as a rule a short, bottle-shaped tube with triradiate lumen; its wall is chiefly composed of radiating muscular fibres, which give it the appearance of being transversely striped when viewed from the surface. There exist also in its wall three large gland cells (œsophageal glands) and nerves arising from the lateral lines and running forward. The radial fibres cause a dilatation of the lumen, and exercise an effect antagonistic to the elasticity of the cuticle lining the inner surface. The latter has its own particular layer, which is not in direct connection with that of the oral cavity. Special dilator muscles, arising from the dermo-muscular tube and situated at the commencement of the œsophagus, are only known in a few species. The posterior end of the œsophagus presents a bulb-like dilatation, and is frequently provided with small chitinous movable valves. In a few forms, which belong to the *Trichotrachelidæ* (Trichocephalus, Trichinella), the œsophagus is a very long cuticular tube, beset on its dorsal surface with a series of large nucleated cells. In others (Cucullanus, Ascaris, etc.), a tube, the so-called glandular stomach, lined only by epithelial cells, follows behind the muscular œsophagus. This glandular stomach is, from its structure, easily distinguished from the mid-gut, or chyle intestine, which is likewise cellular. The so-called mid-gut is a tube lined by flat, cubical, or cylindrical cells (fig. 260) surrounded by "isolation tissue"; its transverse section is circular or flattened dorso-ventrally; the lumen may run in a straight line, or it runs a sinuous course through the alternating prominences of the then flat epithelial cells.

The ectodermal hind gut s, as a rule, very short. At the anal opening the cuticle and the subcuticular layers are reflected inwards, forming the lining of the hind gut. In large species the subcuticular tissue forms large cells on which anteriorly lie in addition large "glandular cells."[1] n the male the ejaculatory duct opens at this point. Around the end part of the gut, either on the chyle intestine or at the beginning of the end gut, there exists a sphincter muscle arising from a muscle cell which acts antagonistically to the two diaphragm-like dilator muscle cells which stretch from the gut to the

[1] In Ankylostomes according to Looss these cells have no glandular function, but are ligaments.

body wall. In many species large stretches of the gut are provided with dilator muscles. There is sometimes a retrogressive absorption of the gut in the adult stage of a few parasitic species.

INTESTINAL CÆCA and ŒSOPHAGEAL GLANDS sometimes exist as intestinal appendages; the former are tubular appendages of various size, running backwards or forwards, and arising from the posterior extremity of the œsophagus. They are lacking in many species. The œsophageal glands are unicellular; a dorsal and two subventral glands may be distinguished according to their position; as a rule they open into the œsophagus at a distance from one another. The body of the gland lies in the bulb of the œsophagus, or in the dorsal *cul-de-sac* arising from it.

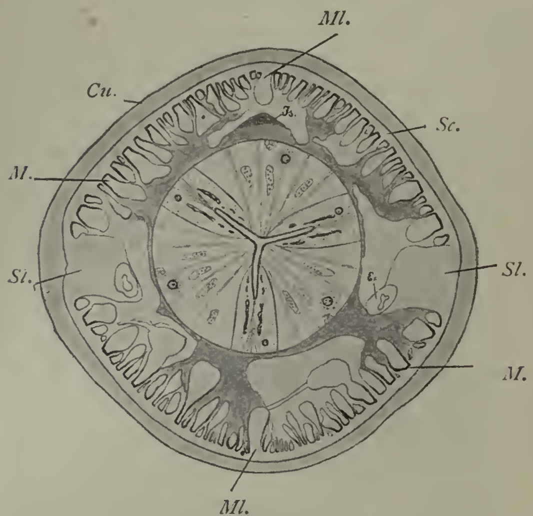


FIG. 262.—Transverse section through *Ascaris lumbricoides* at the level of the œsophagus behind the nerve ring. *Cu.*, cuticle; *Sc.*, subcuticular layer; *Ex.*, excretory vessel; *Is.*, isolation cell and the system of lamellæ proceeding from it; *M.*, muscles; *Ml.*, median line; *Sl.*, lateral line. Magnified. (After Goldschmidt.)

THE NERVOUS SYSTEM is sufficiently known in a few species only; it consists of a ring containing fifty to sixty fibres closely surrounding the œsophagus, various groups of ganglion cells, and a certain number of nerves extending anteriorly as well as posteriorly. The remarkably small number of fibres, as well as ganglion cells, is characteristic of the nervous system of all Nematodes. Immediately behind the œsophageal ring (fig. 263, *Lg.*) an agglomeration of ganglion cells lies at either side (lateral ganglia); part of their off-shoots form the œsophageal ring, and part are directed posteriorly and ventrally, and unite partly in front of and partly at the back of the excretory pore, with fibres originating direct from the œsophageal ring, and passing along the ventral median line to the back; these fibres then together form the ventral median nerve (fig. 263, *V.m.n.*). This nerve, originally consisting of thirty to fifty fibres, becomes in the female attenuated quite evenly in its further course. There is also an agglomeration of ganglion cells close in front of the anus (anal ganglia), and then the median nerve divides in order to combine with the lateral nerves on either side. In the male the median nerve enlarges to nearly the original number of fibres in front of the anal ganglion, which contains seven cells; there is also an anal ring embracing the terminal gut, and there are two ganglion cells in it on each side. In the dorsal median line the dorsal median nerve is alike in both sexes; arising in front with a single root from the œsophageal ring, it gathers its fibres from the lateral ganglia; in the anterior part of the body it consists of thirteen to twenty fibres; in the posterior part of the body the fibres are reduced to four or six; behind the anus it divides and combines with the lateral nerves; the latter consists of two fascicles at either side right up to their most posterior extent—one dorsal and one ventral—which in the greater part of the body do not run in, but beside the lateral lines, and exhibit a different origin anteriorly. The ventral fascicle at each side branches off from the ventral median nerve in front of the excretory pore, whereas the dorsal fascicles originate from the œsophageal ring close to the lateral ganglia. Each of the four fascicles contains only two or three fibres, which run backwards parallel to the lateral lines; a few centimetres in front of the caudal extremity they enter the lateral lines and remain separate from one another up to the level of the anal ganglion; here they amalgamate on either side, after each interpolating one ganglion cell, with the single short lateral nerve which first takes up the forked ends of the ventral and then of the dorsal median nerve; finally, both lateral nerves unite with each other at the back in an arch-like manner.

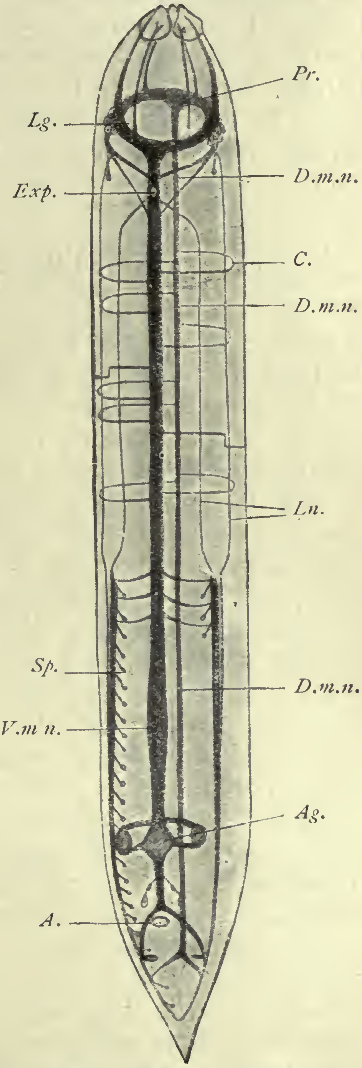


FIG. 263.—Schematic representation of the nervous system of a male *Ascaris megalocephala*. *A.*, anus; *Ag.*, anal ganglion; *C.*, commissures; *D.m.n.*, dorsal median nerve; *Exp.*, excretory pore; *Pr.*, œsophageal sensory ring; *Lg.*, lateral ganglia; *Ln.*, lateral nerve; *Sp.*, papilla; *V.m.n.*, ventral median nerve. (After Brandes.)

In the male each ventral part of the lateral nerves becomes thickened by taking up fibres from the ventral nerves, which become thickened posteriorly to the nervus bursalis, which towards the middle gives off a mass of fibres to the "genital papillæ" situated in front of and behind the anus; the number of these fibres averages eighty to 100; in its further course the bursal nerve resembles the corresponding ventral part of the lateral nerves of the female.

The ventral and dorsal nerves are connected by a number of semicircular commissures, which originate from the ventral nerves and serve to supply the dorsal nerve, which is always being decreased by fibres departing from it. It is remarkable that these commissures are not placed symmetrically, and their position also is different in the two sexes; in the female there are thirty-one on the right side and only thirteen on the left side. In the male there are thirty-three commissures on the right side and fourteen on the left, which run into the subcuticular layer, generally in pairs, and usually cross at the level of the lateral lines.

The fibres of the two median nerves are chiefly motor; fascicular processes run from each protoplasmic part of the muscular cells to the median nerves; from these they take up bundles of primitive fibrils, which separate, pass through the protoplasmic part and enter the contractile part (fig. 260). One part of the fibrils, however, penetrates beyond the muscles into the subcuticular layer, where they form a network, probably of a sensory nature, with contiguous fibrils. Nerves directed anteriorly finally originate from the œsophageal ring; they consist each of three fibres, carry three ganglion cells at their point of origin, and enter the sensory organs of the three papillæ surrounding the oral aperture. Two of these little trunks lie in the lateral lines, the remaining four are situated in the middle of the four quadrants (Nn. sub-mediani anteriores).

Parasitic species lack higher ORGANS OF SENSE; free-living worms occasionally have two rust-red eyes, sometimes with lenses, at the anterior part of the body. In addition to the above-mentioned sensory papillæ surrounding the oral aperture and the genital papillæ of the male at the end of the body, another pair exist in the vicinity of the lateral ganglia, the "cervical papillæ," and two dorsal papillæ in the central region of the body and two lateral ones near the tip of the tail (*Ascaridæ*). The differences in the distribution and number of the sensory papillæ serve for characterizing the larger and smaller groups of Nematodes.

THE EXCRETORY ORGANS of the Nematodes are variable. In a great many cases the apparatus is symmetrical, and consists of a vessel commencing in the posterior extremity in each lateral line (fig. 260), and passing anteriorly. In the vicinity of the anterior extremity both tubes pass out of the lateral lines, bend ventrally, and, in the median ventral line, unite into a short vesicle formed by an ectodermal cell—the cavity of which is lined by a continuation of the cuticle of the body—which opens into the excretory pore (fig. 263, *Exp.*). Asymmetry is occasioned through the excretory duct proceeding from the ventral pore to the lateral line, and it here proceeds as (or takes up) the left excretory canal, which anteriorly is a broader tube and runs along the left lateral line; shortly before its union with the excretory duct it throws out a branch to the right towards the lateral line, which, however, always remains weak, and runs posteriorly in the right lateral line; a few smaller branches in addition spring from the left main stem. In other species the right branch is completely suppressed; the entire organ thus lies in the left lateral line, and consists of the excretory duct, which occasionally opens quite in front near the lips, as well as the excretory canal, which throws out a number of lateral branches.

This excretory vesicle is a single elongated or horse-shoe-shaped cell, with a large nucleus and an intracellular tubular system, which is connected with the excretory duct arising from the excretory pore on the outer surface (fig. 326). The so-called ventral gland is the only excretory organ of marine Nematodes, and probably represents a primitive form. Goldschmidt, who has investigated the excretory apparatus of *Ascaris lumbricoides*, considers that the vessels running in the lateral lines are only ducts to which belong a glandular system hitherto overlooked or otherwise interpreted. This system also lies in the lateral lines, and takes the form of two glandular tracts, forming a syncytial tissue in which lie the ducts, one dorsal, one ventral. In parts these tracts are connected by commissures, although their junction with the excretory vessels cannot be clearly made out. These statements, however, require confirmation. The author has further found that the anterior ends of the lateral canals, directly before they bend ventrally, anastomose with one another and give off anteriorly a small blind process, which can be interpreted as a rudiment of a canal coming from the head end, and as a matter of fact, according to Golowin, such anterior excretory canals exist in a number of genera.

In a number of Nematodes (Cheiracanthus, Capillaria, Trichocephalus, Trichinella, etc.), however, special excretory organs are lacking; possibly the cutaneous glands, which are in these species generally powerfully developed, replace these organs.

Sexual organs.—With the exception of a few species, the Nematodes are sexually differentiated.

(*a*) *Female Sexual Organs.*—The sexual orifice (vulva), surrounded by thick labia, is, as a rule, ventral and varies in position from near the head to near the anus. It leads into a short or long vagina (ectodermic), bifurcating into the two uteri, which may be long or short; the long filiform ovaries are continuations of them (fig. 264). Further there is often, *e.g.*, in Ankylostoma, a differentiation into the following parts:

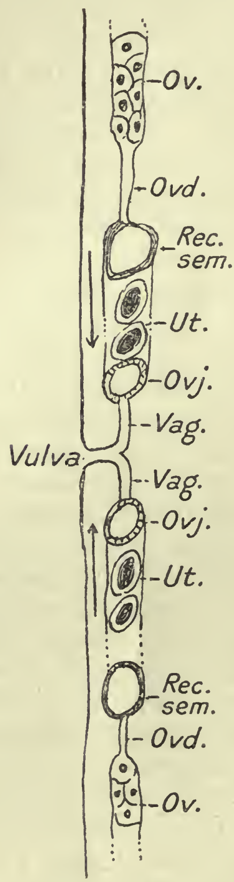


FIG. 264.—Diagram of female genitalia. *Ov.*, ovary (in part); *Ovd.*, oviduct; *Rec. sem.*, seminal receptacle; *Ut.*, uterus (in part); *Ovj.*, ovejector; *Vag.*, vagina.

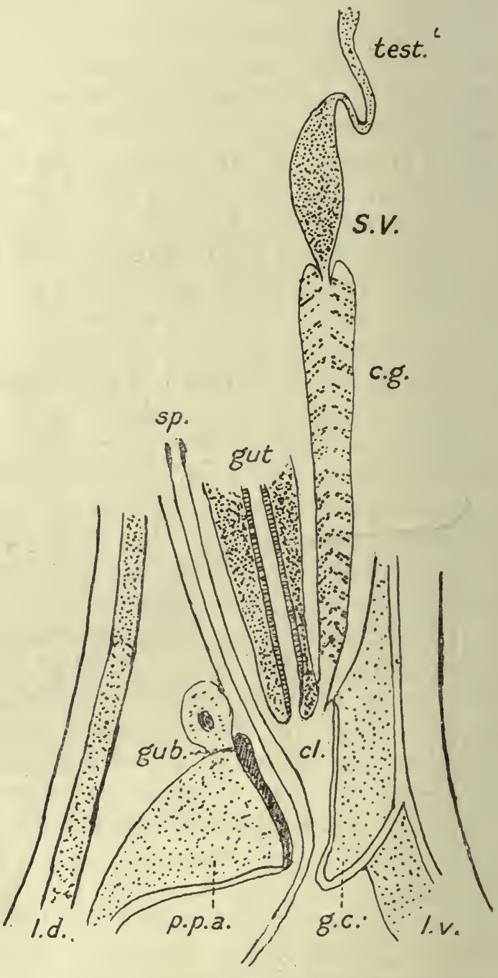


FIG. 264A.—Diagram of male genitalia of a strongylid. *Test.*, testis (in part); *S. V.*, seminal vesicle; *c.g.*, cement gland surrounding ejaculatory duct; *sp.*, spicules; *cl.*, cloaca; *gub.*, gubernaculum; *p.p.a.*, pulvillus post-analis; *g.c.*, genital cone; *l.d.*, dorsal lateral line; *l.v.*, ventral lateral line (the bursa is not shown).

(1) *Ovejector:* the specialized portion of the uterus before it joins the vagina; there may be a separate one for each uterus, or a common one for both uteri. (2) *Seminal receptacle:* at the other extremity of the uterus. (3) *Oviduct:* a narrow tube connecting the ovary with

the uterus proper. (For the explanation of the terms *convergent* and *divergent* uteri *vide* footnote p. 432.) Uterus and ovaries, which arise in the first place from a single cell, lie between the body wall and the gut and are surrounded by connective tissue. In some species (for instance, Trichinella) the ovary is single.

At the blind end of the ovary there is a mass of protoplasm with numerous nuclei that multiply continuously. Gradually the nuclei arrange themselves in longitudinal rows (fig. 265) and the protoplasm commences to leave the periphery and surround each nucleus. The nearer to the uterus the more progressive is this loosening process, until club-shaped cells each containing a nucleus are developed. The most pointed end of each, however, is still attached to an axial fibre of protoplasm, the *rhachis;* probably this has some connection with the nutrition of the ova. Finally the ova fall off and reach the uterus, where they are fertilized and enclosed in shells.

(*b*) *Male Sexual Organs*.—There is never more than one testis (fig. 266), which is a straight or sinuous tube of the same construction as an ovary, and in which the mother cells originate in the same manner as the ova. In the same way as the ovary passes into the uterus, so does the testis pass into the spermatic duct; the latter is often divided into the somewhat dilated seminal vesicle and into the muscular ductus ejaculatorius, which, running ventral to the intestine backward (fig. 267), finally opens into the cloaca. In many species, *e.g.*, *A. duodenale*, the ejaculatory duct is surrounded for a greater or less portion of its extent by the cement gland, the secretion of which (brownish or blackish in colour) serves for copulation. The ejaculatory duct of the large *Ascaridæ* is for the most of its course surrounded by a muscular network which takes its origin from the two dilator cells of the gut (fig. 268 *F.*). The spermatozoa of the Nematodes, it may be noted, only attain their full development after the sperm mother cells have been conveyed by copulation into the uteri of the female genitalia. In their form (sheathless, capable of amœboid motion) they differ from those of most other animals.

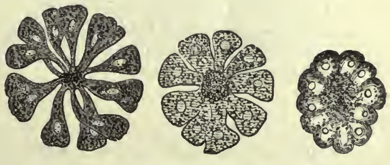


FIG. 265.—Transverse section through the ovarian tube of *Belascaris cati* of the cat at various levels. To demonstrate the development (right to left) of the ova and of the rhachis. Magnified.

SPICULES.—The male genital apparatus is also provided with one or two sacs, situated on the dorsal side of the intestine, and opening into the cloaca. In each sac there is a chitinous rod-like body, the spicule. Further, in many cases there exists, more or less fixed in the dorsal wall of the cloaca, a chitinous structure, the accessory piece or *gubernaculum*, the latter name implying its function of guiding the spicules during copulation (fig. 264A). A special muscular apparatus, consisting of protractors and retractors, moves the spicules. The protractors or exsertors in the large Ascaridæ consist of four flat band-like muscles which surround the spicule sac. Two long muscle cells which arise proportionally far forward on the dorsal side of the lateral line and are inserted into the base of the spicules serve as retractors. The spicules can be projected from the cloacal orifice (anus) during copulation, and when they are introduced into the vagina they serve as prehensile organs, perhaps also as stimulatory organs.

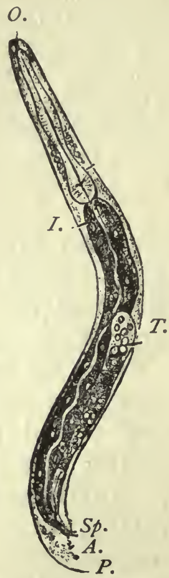


FIG. 266.—Male of the rhabditic form of *Angiostomum nigrovenosum*. *A.*, anus; *I.*, mid-gut; *T.*, testicular tube; *O.*, oral orifice; *P.*, papillæ; *Sp.*, spicule. Magnified.

FIG. 267.—Transverse section through the posterior extremity of the body of *Ascaris lumbricoides* (male). The intestine is in the middle, and the lateral lines are subjoined thereto; above the intestine the two spicule sacs are seen; below is the ductus ejaculatorius. The muscular fibres are between the lateral and median lines. Magnified.

BURSA COPULATRIX.—The males in many genera possess epidermal wing-like appendages at their posterior extremity. These are supported by elongated tactile papillæ called ribs. In the most highly developed bursæ, *e.g.*, in the *Strongylidæ*, the ribs are called rays, as they consist not only of nerve fibres but mainly of "pulp," *i.e.*, prolongations of the subcuticular layer. Bursæ are either open, *i.e.*, bilaterally symmetrical, or closed, when the posterior border is continuous all round. A *pseudo-bursa* is one unsupported by ribs or rays, *e.g.*, in Trichuris. The bursa serves as an organ of prehension during copulation. Some forms, moreover, carry a sucker at the posterior extremity (*e.g.*, Heterakis); in others the spicules and other prehensile organs are absent; they are then replaced by an evertible cloaca, *e.g.*, Trichinella.

Development of the Nematodes.

After impregnation, the ovum develops around itself a delicate membrane (vitelline membrane), and subsequently an egg-shell is formed. This is derived either as a secretion from the uterine wall or it is a further differentiation of the vitelline membrane, the original single membrane splitting into two, the outer becoming the egg-shell. Further the uterus often secretes a special albuminous covering around the egg-shell. The "yolk" granules of the ovum are secretions of the protoplasm of the ovum itself and first appear when the rhachis is formed. In certain cases ova lie in follicles or capsules

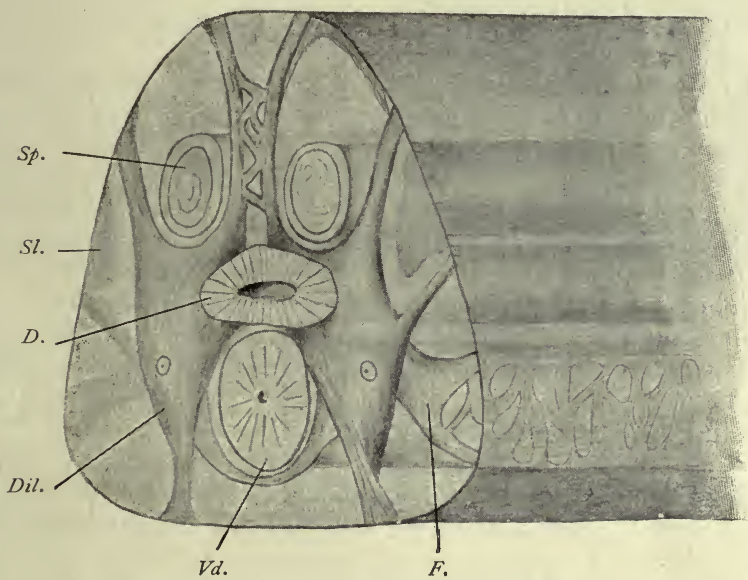


FIG. 268.—Hind end of a male *Ascaris lumbricoides* cut across at the level of the dilator cells of the gut. *D.*, gut; *Dil.*, dilator cells of the gut; *F.*, a process of the dilator cells forming a network over the vas deferens; *Sl.*, lateral line; *Sp.*, spicule; *Vd.*, vas deferens. The anterior end of the worm lies to the right. Magnified. (After Goldschmidt.)

formed of epithelium cells derived from the ovarian tubes. These cells subsequently fuse and form a membrane—the CHORION.

The shape of the completed eggs is characteristic of the different species, and therefore a single egg often suffices to diagnose the species. According to the species, the eggs may be deposited sooner or later, either before or during segmentation, or with the embryo perfectly developed. Only a few species are viviparous, *e.g.*, *Dracunculus medinensis*, *Trichinella spiralis*; in the other Nematodes the further development of the extruded eggs takes place after various lengths of time in the open, in moist earth, or in water. Thick-shelled eggs can maintain their developmental capacity for a long time, even after prolonged desiccation.

Finally, a nematode-like embryo develops, which usually lies somewhat coiled up within the shell, and varies in its further development according to the species to which it belongs.

In the simplest forms, as in the free-living Nematodes, the embryos, apart from their size, resemble their parents, and grow up into these after leaving the egg-shell. In many parasitical Nematodes, however, the young must be called *larvæ*, as they present characters which are subsequently lost.

The manner of conveyance of the eggs or the embryos contained in them after they have left the body into the definite host is very different in the various species.

(1) *Without Intermediate Host.*—(*a*) In many the conveyance into the definite host is effected directly after the larvæ have developed within the eggs; thus, for instance, the feeding of suitable animals with the embryo-containing eggs of species of Trichocephalus and Ascaris leads to an infection of the gut, for the young Trichocephali or Ascarides only leave the egg-shell when they have attained the intestine of the final host, in which they become adult.

In other cases (*b*) Ancylostoma, Necator, the larvæ hatch in the open, and live for a time free, changing their form; they grow, cast their skin, and finally gain the intestine of the host by means of water or through the skin, when they lose their larval characters and assume the structure of the adult worm.

(*c*) In a number of Nematodes, however, HETEROGONY occurs. This terms signifies a mode of development in which two structurally different sexual generations of the same species alternate with each other. To these appertains, for instance, *Angiostomum* (syn.: *Rhabdonema*) *nigrovenosum*, which lives in the lungs of frogs and toads; this Nematode measures about 1 cm. in length and is hermaphrodite (protanrdic). The eggs are deposited in the pulmonary cavity, and through the cilia of the same reach the oral cavity, where they are swallowed and thus conveyed into the intestine. They pass through the entire gut, and are finally evacuated with the fæces; often, indeed, the young themselves emerge from the egg-shell within the hind-gut of the frogs. These young forms become sexually differentiated, remain much smaller than the parent, their œsophagus is differently constructed (rhabditis form), and they are non-parasitic (fig. 266). After having grown in the open they copulate; the males die soon after copulation, and the females in their own bodies develop a few young, which, given the opportunity to get into frogs, infect them, and are transformed into the hermaphroditic Angiostomum.

The same manner of development occurs in other species of the same genus, and also in the case of *Strongyloides stercoralis*.

(2) *With Intermediate Host.*—(*a*) Frequently, however, the larvæ of Nematodes make use of one or even two intermediate hosts; their condition then resembles that of Cestodes or Trematodes, excepting that there is never a multiplication within the intermediate hosts. The larvæ become encapsuled amongst the tissues of the intermediate host, and wait till they are introduced with the latter into the final host. For instance, *Ollulanus tricuspis*, the adult form of which is found in cats, previously lives encysted in the muscular system of mice. *Cucullanus elegans*, which attains the adult stage in fishes (perch, etc.), is found encysted in species of Cyclops. Other examples of species that require an intermediate host are *Filaria bancrofti* and *Dracunculus medinensis.*

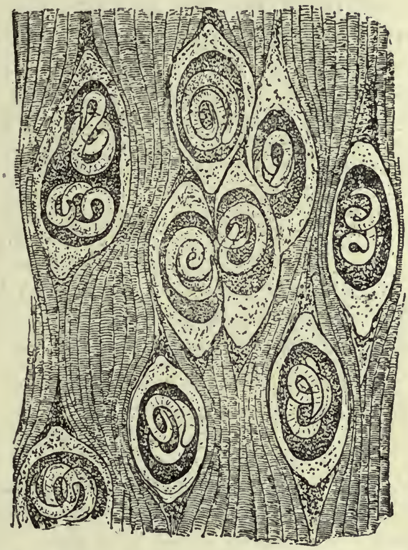


FIG. 269.—A piece of the trunk muscle of the pig with encapsuled embryonic Trichinæ. Magnified.

Peculiar conditions prevail in the case of (*b*) *Trichinella spiralis.* This species, which in its adult state lives in the intestine of man and of various mammals, is viviparous; the young Trichinæ, however, do not leave the intestine, but reach the intestinal wall (Cerfontaine, Askanazy) in the following way: the female intestinal Trichinæ bore into the intestinal wall, where they are found in the submucosa, or in the lumen of the dilated lacteal vessels. Here the young are born, in the intestinal wall, and leave this position with the lymph stream. Some of them, no doubt, actively bore through the intestinal wall, reaching the lymph or blood-stream, or even pass into the body cavity. What occurs during their further migrations is difficult to say at present. It has hitherto been maintained that the wandering is entirely active; for instance, the ligaturing of an artery would be no protection against the part of the body supplied by such artery being invaded by Trichinella. This observation cannot be otherwise explained than by the active progress of the young Trichinella. The question, however, may be mooted as to where and when the worms quit the blood-vessels, which they for the most part reach through the thoracic duct, the natural connection between the vascular system and the lymphatic system, to wander further independently, and ultimately reach the muscular system, in which they become encysted (fig. 269). Thus the progeny does not leave the body of the host inhabited by the parents, as is generally the case amongst helminthes, but uses it as an intermediate carrier to reach another host, which is then the final host. The latter may belong to another species, or may be another individual of the same species. This second migration is, of course, purely passive.

Classification of the Nematoda.

The Nematodes are usually divided into a number of families, some of which it is at present impossible to define accurately; moreover, the definition of many genera is also in an unsatisfactory state.

Family. **Anguillulidæ**, Gervais and van Beneden, 1859.

A "family" name not definable. They comprise a vast number of small forms, most of which live free in fresh water, in soil, or in macerating substances; amongst them there are some which live parasitically on plants, more rarely on animals. They do not exceed 8 mm. in length. The large majority are only 1 to 2 mm., or even 0·5 mm. The uterus is straight. Eggs in the uterus at one time, one to four. Genera very numerous, but many of them insufficiently defined (Anguillula, Anguillulina, Rhabditis, Heterodera, etc.).

Family. **Angiostomidæ**, Braun, 1895.

Small Nematodes undefined morphologically, but characterized by heterogony, *i.e.*, there is a free-living "rhabditic" generation and a parasitic "filariform" generation which succeed one another (*e.g.*, Angiostomum, Strongyloides, Probstmayria).

Family. **Gnathostomidæ.**

Cuticle covered totally or partly with cuticular laminæ fringed posteriorly with multiple points. Head subglobular, covered with simple spines. Two spicules. Vulva behind middle of body, parasitic in vertebrates, especially mammals (*e.g.*, Gnathostoma, Tanqua, Rictularia).

Family. **Dracunculidæ**, Leiper, 1912.

Males very small in proportion to females. Anus absent. Vulva absent (?). Genera: Dracunculus, Icthyonema (in body cavity of eel and other fish).

Family. **Filariidæ**, Claus, 1885.

Long thread-like Nematodes. Anus present. Œsophagus without bulb. Vulva usually in anterior half of body. Two ovaries. Generally ovoviviparous.

Development often requires an intermediate host. This family is at present ill-defined, but has been already subdivided into several sub-families, *Filariinæ*, *Onchocercinæ*, *Arduenninæ*.

Family. **Trichinellidæ**, Stiles and Crane, 1910.

Œsophagus consisting of a chain of single cells, the lumen of the œsophagus passing through their centre. Ovary single. Vulva at junction of anterior and posterior portions. Sub-families: (1) *Trichurinæ*, (2) *Trichinellinæ*.

Family. **Dioctophymidæ**.

Body anteriorly armed with spines or unarmed; mouth without lips, with six, twelve, or eighteen papillæ in one or two circles; œsophagus very long without a bulb; anus terminal in female; one ovary; vagina very long; spicule in male very long; bursa cup-shaped without rays (Dioctophyme, Hystrichis, Eustrongylides).

Family. **Strongylidæ**, Cobbold, 1864.

Bursa, supported by rays, always present. Oviparous.

Family. **Physalopteridæ**.

Mouth with two large lips. Bursa with supporting papillæ in form of a lanceolate cuticular expansion, with genus Physaloptera.

Family. **Ascaridæ**, Cobbold, 1864.

Rather thick Nematodes. Mouth with three lips—one dorsal, two latero-ventral. Sub-families: (1) *Ascarinæ*, (2) *Heterakinæ*, etc.

Family. **Oxyuridæ**.

Smallish forms, 4 to 45 mm., with cuticle thickened on each side for the whole length of body in the form of a lateral flange or wing. Œsophagus long with a well-marked bulb containing a valvular apparatus. Tail end of female drawn out into a long point. Eggs asymmetrical. Males very small (about 2 mm.). One spicule. Genera: Oxyuris, Passalurus, Ozolaimus, Atractis, etc.

Mermithidæ, greatly elongated "Nematodes," which, in the larval stage, are parasitic in insects, but in their adult condition are free living. Cuticle with diagonal striation. Without an open mouth or anus. Oral papillæ present. Characteristic eggs with two processes, ending in a tuft of filaments. Larvæ with a movable boring spine at the head end.

Gordiidæ.—Long, thread-like "Nematodes." Mouth and anterior portion of gut atrophied in adult. Oral papillæ absent.

The Nematodes Observed in Man.

Family	Sub-family	Genus	Species
Anguillulidæ ...	— ...	*Rhabditis*	*R. pellio.*
			R. niellyi.
			Rhabditis sp.
		Anguillula ...	*A. aceti.*
		Anguillulina ...	*A. putrefaciens.*
Angiostomidæ ...	— ...	*Strongyloides* ...	*St. stercoralis.*
Gnathostomidæ ...	— ...	*Gnathostoma* ...	*Gn. siamense.*
			Gn. spinigerum.
Dracunculidæ ...	— ...	*Dracunculus* ...	*D. medinensis.*
Filariidæ ...	*Filariinæ*	*Filaria*	*F. bancrofti.*
			F. demarquayi.
			F. taniguchi.
			F. (?) *conjunctivæ.*
	Group. *Agamofilaria* ...	— ...	*Ag. georgiana.*
			Ag. palpebralis.
			Ag. oculi humani.
			Ag. labialis.
			F. (?) *romanorum-orientalis.*
			F. (?) *kilimaræ.*
			F. (?) *sp.* ?
		(*Mikrofilaria*) ...	*Mf. powelli.*
			Mf. philippinensis.
		Setaria	*S. equina.*
		Loa	*L. loa.*
		Acanthocheilonema	*Ac. perstans.*
		Dirofilaria ...	*Di. magalhãesi.*
	Onchocercinæ ...	*Onchocerca* ...	*O. volvulus.*
Trichinellidæ ...	*Trichurinæ* ...	*Trichuris*	*T. trichiura.*
	Trichinellinæ ...	*Trichinella*... ...	*T. spiralis.*
Dioctophymidæ ...	— ...	*Dioctophyme* ...	*D. gigas.*
Strongylidæ ...	*Metastrongylinæ* ...	*Metastrongylus* ...	*M. apri.*
	Trichostrongylinæ	*Trichostrongylus* ...	*T. instabilis.*
			T. probolurus.
			T. vitrinus.
		Hæmonchus ...	*H. contortus.*
		Mecistocirrus (*Nematodirus*)	*M. fordi.*
	Ancylostominæ		
	Group. *Œsophagostomeæ*	*Ternidens*	*T. deminutus.*
		Œsophagostomum...	*Œ. brumpti.*
			Œ. stephanostomum var. *thomasi.*
			Œ. apiostomum.
	Group. *Ancylostomeæ* ...	*Ancylostoma* ...	*A. duodenale.*
			A. ceylanicum.
			A. braziliense.
	Group. *Bunostomeæ* ...	*Necator*	*N. americanus.*
			N. exilidens.
	Group. *Syngameæ* ...	*Syngamus*	*S. kingi.*

Family	Sub-family	Genus	Species
Physalopteridæ ...	—	... *Physaloptera*	... *P. caucasica.*
			P. mordens.
Ascaridæ ...	*Ascarinæ* ...	... *Ascaris* ...	... *A. lumbricoides.*
			A. sp.
			A. texana.
			A. maritima.
		Toxascaris	... *T. limbata.*
		Belascaris ...	... *B. cati.*
			B. marginata.
		Lagocheilascaris	... *L. minor.*
Oxyuridæ ...	—	... *Oxyuris* ...	... *O. vermicularis.*
Mermithidæ ...	—	... *Mermis* ...	... *M. hominis oris.*
		(*Agamomermis*)	... *Ag. restiformis.*

Family. **Anguillulidæ.**

Genus. **Rhabditis,** Dujardin, 1845.

Buccal cavity elongated, with lips. Its chitinous wall uniformly thick. Lateral lines absent. Males with bursa.

Rhabditis pellio, Schneider, 1866.

Syn.: *Pelodera pellio*, Schn., 1866; *Rhabditis genitalis*, Scheiber, 1880; *Rhabditis pellio*, Schn., 1866.

Males 0·8 to 1·05 mm. in length; females, 0·9 to 1·3 mm. in length. The posterior extremity of the body of the male has a heart-shaped bursa, and seven to ten ribs on each side; the bursa may, however, be lacking. The spicules measure 0·027 to 0·033 mm. in length, but are never quite alike. The posterior extremity of the female is long and pointed; the vulva lies somewhat behind the middle of the body, the ovary is single, the eggs are oval, 60 μ by 35 μ.

This species was found in Stuhlweissenburg by Scheiber in the acid urine (containing albumin, pus and blood) of a woman suffering from pyelonephritis, pneumonia and acute intestinal catarrh; the observer was able to convince himself that the Nematodes which were found during the whole period of the illness lived in the vagina, and were evacuated with the urine.

Oerley proved that this species had long been known; during its larval stage (*Anguillula mucronata*, Grube, 1849) it lives in earthworms; in its adult stage it lives in decomposing matter in the soil. By introducing individuals of this species into the vagina of mice, Oerley succeeded in obtaining infection and multiplication (facultative parasitism). These Nematodes must in some such way have got into the vagina of Scheiber's patient.

Two other cases described by Baginsky and Peiper probably belonged to the same or a nearly related species.

Rhabditis niellyi, Blanchard, 1885.

Syn.: *Leptodera niellyi*, Blanchard, 1885.

In 1882 Nielly had a cabin-boy, aged 14, under observation in Brest. The lad had never left the neighbourhood of Brest, and had suffered from itching papules on the skin for five or six weeks; in the papules the observer found one or several rhabdites, measuring 0·33 mm. in length by 0·30 mm. in breadth. Their cuticle presented a delicate transverse striation; the intestine was the only internal organ recognizable, and it opened somewhat in front of the posterior extremity. Therefore, it must have belonged to the rhabditis-like larva of a Nematode, the adult stage of which is unknown.

The manner of infection was established almost certainly by a further observation of Nielly's: at the commencement of the illness small Nematodes were found in the blood of the patient; later on, however, they disappeared, neither were Nematodes found in the fæces, urine or sputum. Therefore it must be concluded that the cabin-boy, who was in the habit of drinking water from brooks, had thus ingested embryo-containing eggs of a Nematode; the young hatched out in the intestine, perforated it, reached the blood and then settled in the skin; but, on the other hand, the entry may have been direct through the skin.

In connection with the foregoing, reference should be made to a communication by Whittles, insufficient from a zoological point of view. In a case of hypertrophic gingivitis occurring in a female patient, aged 19, who had never left Birmingham, he found Nematode larvæ in the periosteum of the upper jaw, which was excised after extraction of the right premolar; the genital rudiment could be recognized in them. Similar larvæ were found in the same patient in abscesses in various regions of the skin, and in the case of her mother in the blood. The author considers that the infection took place through a dog, and refers to the case of O'Neil (1875), who found Filariæ in the skin (in the condition known as "craw-craw"), referred by Manson to *Filaria perstans*. O'Neil's case was quoted, and attributed to *Filaria sanguinis hominis*. In conclusion, the author states that he has repeatedly found Nematode larvæ in the blood of persons who suffered from pruritus; in his opinion the parasite had been imported through the agency of troops returned from South Africa. Glatzel found true Filaria larvæ in a pustule of a cutaneous eruption of the trunk and extremities in a patient at Dar-es-Salam.

Skin diseases which are caused by young Nematodes are also observed in dogs (Siedamgrotzky, Möller, J. G. Schneider, Künnemann), foxes (Leuckart), and horses (Semmer). Zürn found young Nematodes (*Anguillulidæ*) also in pig's flesh. In Künnemann's case it was shown that the adult Rhabdites lived in the straw upon which the dog lay.

Rhabditis, sp.

In the fluid obtained by lavage from the stomach of a female patient, aged 16, suffering from ozæna, O. Frese found during two consecutive months Rhabdites of various ages, 0·275 to 0·64 mm. in length, the adults all with eggs; males were not found; transmission into rabbit's stomach failed, but they could be kept alive in much diluted hydrochloric acid (2 : 1,000) for several weeks. Neither eggs nor larvæ appeared in the fæces of the patient. The nature of the infection, which was perhaps of unique occurrence, remained doubtful.

Genus. **Anguillula**, Ehrenberg, 1826.

Buccal cavity very small, without lips. Males without bursa, but with a series of papillæ. Lateral lines absent.

Anguillula aceti, Müller, 1783.

Cuticule unstriped, body cylindrical, anterior end tapering but little, posterior end long, pointed. Male up to 1·45 mm. long, 0·024 to 0·028 mm. wide; two pre-anal papillæ, one post-anal; spicules equal, curved, 0·038 mm. long; gubernaculum present; testis extending in front of mid-line of body. Female up to 2·4 mm. long, 0·040 to 0·072 mm. wide; anterior uterus reaching to near the œsophagus, posterior to hind gut. Viviparous; embryos in both or only in one uterine horn, 0·22 mm. long, 0·012 mm. broad.

The species is a frequent inhabitant of vinegar (prepared by older methods), and was once observed for some time by Stiles and Frankland in the urine of a woman; the urine had an acid reaction, and once had a distinct odour of vinegar. It was assumed that the patient, who was hysterical and suffered from chronic nephritis, employed vaginal douches with diluted vinegar, perhaps to deceive her physician or to protect herself against conception. According to Ward, Billings and Miller are said to have reported on two other cases. Ill-effects which might be connected with the vinegar eel (*Anguillula aceti*) were not present.

Genus. **Anguillulina**, Gervais and Beneden, 1859.

Syn.: *Tylenchus*, Bastian, 1864.

Characterized by the possession in the buccal cavity of a spine knobbed posteriorly; bursa present; uterus asymmetrical. Numerous species parasitic in plants.

Anguillulina putrefaciens, Kühn, 1879.

Syn.: *Tylenchus putrefaciens*, Kühn; *Trichina contorta*, Botkin, 1883.

In 1883 Botkin (*Pet. klin. Wochenschr.*, 1883) found a small Nematode, which was, however, entirely mistaken, in the material vomited by a Russian; this was not a species of Trichinella, but an *Anguillulina* living in onions which had already, in 1879, been described by Kühn as *Tylenchus putrefaciens*; the Nematodes got into the stomach with the onions, causing nausea and vomiting.

Family. **Angiostomidæ**, Braun, 1895.

Genus. **Strongyloides**, Grassi, 1879.

Syn.: *Pseudorhabditis*, Perroncito, 1881; *Rhabdonema*, Leuckart, 1882, *p.p.*

The genus is insufficiently defined. The parasitic form possesses a simple mouth opening directly into the long cylindrical œsophagus which occupies the anterior third of the body. The free-living forms possess a small buccal cavity; the œsophagus is short, with a double bulb, in the hinder one there is a Y-shaped chitinous valve; two spicules of equal size.

Strongyloides stercoralis, Bavay, 1877.

Syn.: *Anguillula intestinalis* et *stercoralis*, Bavay, 1877; *Leptodera intestinalis* et *stercoralis*, Cobb.; *Pseudorhabditis stercoralis*, Perroncito, 1881; *Rhabdonema strongyloides*, Leuckart, 1883; *Strongyloides intestinalis*, Grassi, 1883; *Rhabdonema intestinale*, Blanchard, 1886.

In 1876, a number of French soldiers returned to Toulon from Cochin China suffering from severe diarrhœa. Dr. Normand, under whose treatment they were, discovered a large number of Nematodes in the evacuated fæces, and Bavay described

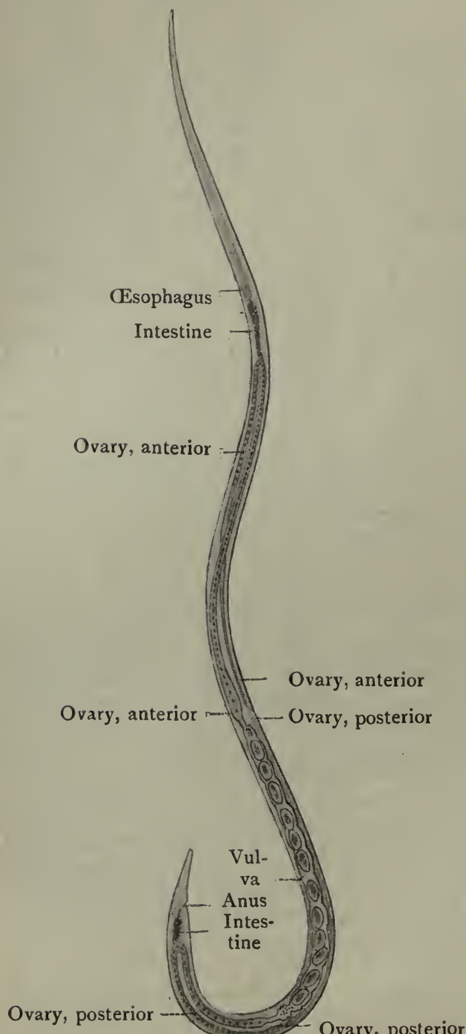


FIG. 270.—*Strongyloides stercoralis*, female: parasitic generation from gut of man. × 70. (After Looss.)

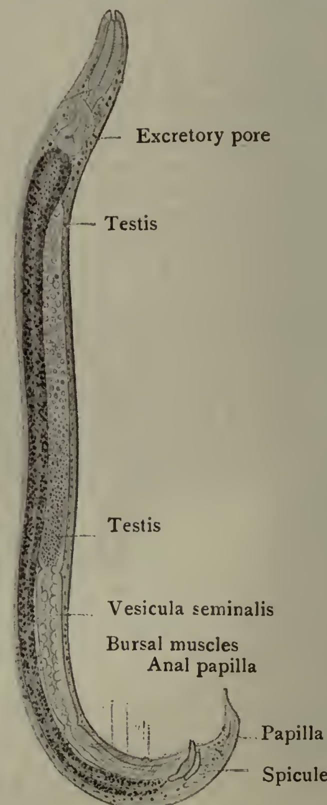


FIG. 271.—*Strongyloides stercoralis*, male: free-living generation. × 170. (After Looss.)

them as *Anguillula stercoralis*. Soon after Normand, at the *post-mortem* of five patients who had died of Cochin China diarrhœa, found numerous other Nematodes in the intestine, from the stomach to the rectum, in the bile-ducts and in the pancreas, and these he handed over to Bavay. The latter diagnosed another species, and described them as *A. intestinalis.* Both forms were then regarded as the cause of Cochin China diarrhœa until, in 1882, Leuckart was able to demonstrate that the two forms are only two succeeding generations of the same species, of which the one (*A. intestinalis*) lives parasitically in the intestine, whereas its young (*A. stercoralis*) attain the open, where they come to maturity and propagate. The young of these again live parasitically. There thus exists the same heterogony as was discovered by Leuckart in *Angiostomum nigrovenosum* of frogs, which heterogony, indeed, according to v. Linstow, appertains to the entire family of the *Angiostomidæ.*

(1) The parasitic generation (strongyloid or filariform ♀) is quite colourless and cannot be seen *in situ* even with a lens. To detect them it is necessary to scrape the mucosa of the jejunum and examine the scrapings microscopically. It measures 2·2 mm. in length, and 34 μ to 70 μ in breadth; the cuticle is finely transversely striated; the mouth is surrounded by four lips; the œsophagus is almost cylindrical and a third the length of the entire body. The anus opens shortly in front of the pointed posterior extremity; the vulva is situated at junction of middle and posterior thirds of the body; the uterus has no special ovejector; the eggs measure 50 μ to 58 μ in length, and 30 μ to 34 μ in breadth, and lie in a chain one behind the other (fig. 270). As in the case of *Angiostomum nigrovenosum,* Leuckart considers this stage to be hermaphroditic, the testes degenerating after having functioned; other authors (Rovelli) regard it as a female reproducing by parthenogenesis.

(2) The free-living generation (♂ and ♀) has a smooth body, cylindrical, somewhat more slender at the anterior extremity and pointed at the tail end. The mouth has four indistinct lips; the œsophagus is short with a double (rhabditis-like) bulb; there is a **Y**-shaped valve in the posterior bulb; the anus opens in front of the tail end. The males measure 0·7 mm. in length, 0·035 mm. in breadth. Their posterior end is rolled up; the two brown spicules are small (38 μ) and much curved. There is also a gubernaculum. The females measure 1 mm. in length or a little over; 0·05 mm. in breadth. The tail end is straight and pointed; the vulva lies somewhat behind the middle of the body. The yellowish, thin-shelled ova measure 70 μ in length and 45 μ in breadth.

As Askanazy has shown, the parasitic form bores deeply into the mucous membrane of the intestine, and frequently into the epithelium of Lieberkühn's glands, both for nourishment and oviposition. The eggs then develop in the intestinal wall. The eggs which are found in scrapings from the mucosa occur, at least in the case of Strongyloides of the sheep, in chains enclosed in a thin tube or sheath, the origin of which is doubtful; possibly it is the uterus. The eggs themselves are only rarely found in stools, *e.g.*, after a strong purge. The larvæ, which are hatched out, and measure 0·2 to 0·25 mm. long by

0·016 mm. broad, again reach the lumen of the intestine,[1] and grow to double or three times that size, until they are passed out with the fæces. They already differ from the parent (♀) in the shape (rhabditiform) of the œsophagus. When the external temperature is sufficiently high (26° to 35° C.), they become sexually mature after moulting. In about thirty hours they are completely developed and copulate, now forming the free-living rhabditiform generation. At lower temperatures the larvæ only moult, but do not escape from the old cuticle and do not develop further. At a temperature of about 25° C. only some of the larvæ attain maturity.

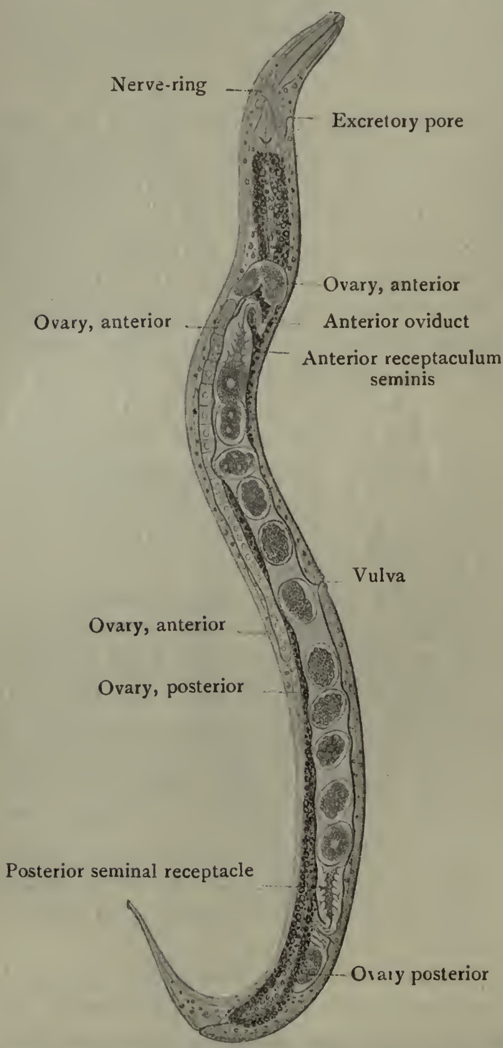


FIG. 272.—*Strongyloides stercoralis*, female; free-living generation. × 170. (After Looss.)

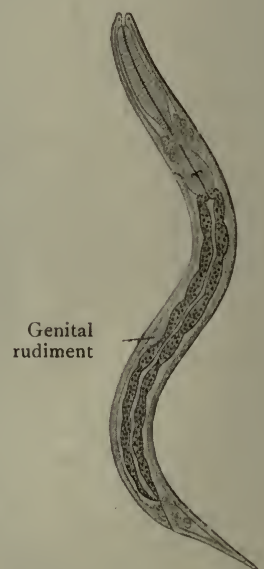


FIG. 273.—*Strongyloides stercoralis*: larva from fresh human fæces. × 310. (After Looss.)

[1] As a case published by Teissier shows, they may also abnormally appear in the blood (*Arch. méd. expér. et d'An. path.*, 1895, vii, p. 675).

The females of the free-living generation (rhabditiform) deposit from thirty to forty eggs, which develop rapidly, sometimes even within the uterus in the case of old females. After the larvæ have emerged from the egg-shell, they measure 0·22 mm. in length, and possess the characteristics of the parents (rhabditiform larvæ). When they have grown to 0·55 mm. they moult, and while losing their own characteristics they acquire the characteristics of their parasitic grand-parents (strongyloid or filariform). After about eight days the free-living adult generation in the cultures have disappeared, and all the rhabditiform larvæ have been transformed into strongyloid or filariform larvæ ; they then die off unless they reach the intestine.

This cycle of development holds good for *Strongyloides stercoralis* of tropical origin (Bavay, Leuckart, Leichtenstern, Zinn). In the European Strongyloides the free-living generation, as a rule, is absent (Grassi, Sonsino, Leichtenstern, Braun) ; the rhabditis-like larvæ evacuated with the fæces are transformed into the strongyloid or filariform type of larva (in cultures which are easily made) which will only become adult if introduced into man.

So that we have these two cycles : (*A*) (1) ♀ parasitic, (2) eggs, the rhabditiform larvæ in fæces, (3) free-living strongyloid or filariform larva, (4) ♀ parasitic. (*B*) (1) (2) (3) as before, then (4) adult ♀ and ♂, free living, (5) eggs, (6) rhabditiform larva, (7) strongyloid or filariform larva, (8) ♀ parasitic.

Infection of man results not only

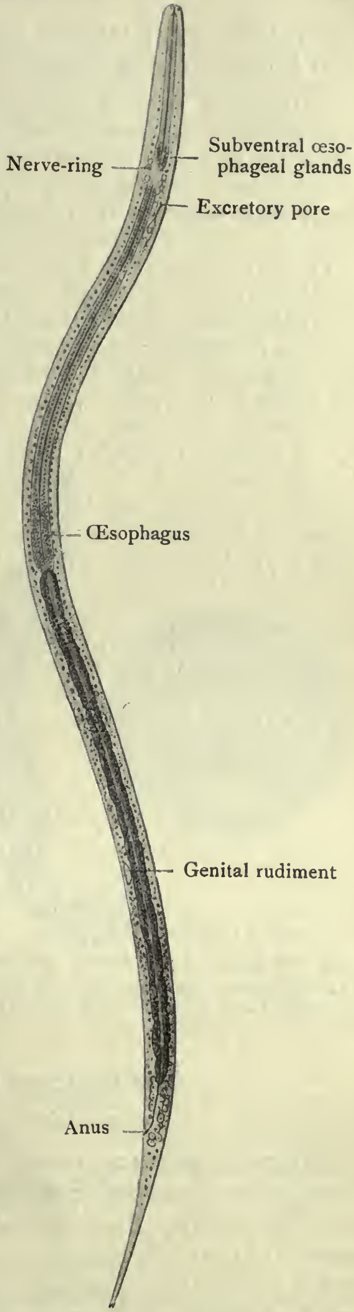


FIG. 274.—*Strongyloides stercoralis* : mature filariform larva showing long transparent œsophagus, slender granular intestine and characteristic tip to the tail ending in two small points. × 620. (After Looss).

from direct entry into the stomach but also, according to van Durme and Looss, through the skin.

Occurrence in Man.—As already mentioned, *Strongyloides stercoralis* was first observed in persons suffering from so-called Cochin China diarrhœa. From the enormous numbers of parasites evacuated with the fæces, the cause of the disease was apparently evident. It appeared, however, that only some of the soldiers returning from Cochin China and Martinique, and suffering from diarrhœa, harboured Strongyloides (Chauvin). Breton made the same observations in Cochin China and found that only 10·4 per cent. of cases of chronic dysentery, and 8·8 per cent. of chronic diarrhœa, show Strongyloides. Normand, moreover, found that only a few of the Europeans residing in Cochin China are exempt from *S. intestinalis*, yet the people exhibit no intestinal symptoms ; if, however, from any cause a catarrhal condition of the intestine supervenes the condition is changed, the parasites appear in larger numbers, and the disorder is considerably intensified.

S. intestinalis, besides being present in the Indo-China region, also occurs in the Antilles, in Brazil, Africa, and Europe ; in 1878 it was discovered in Italy by Grassi and C. and E. Parona ; in 1880 it was also found in the labourers working at the St. Gothard tunnel. It was imported into Germany, Belgium, and the Netherlands by Italian labourers. One sporadic case has been observed in East Prussia, and the worm has also been reported from Siberia.

In mammals the following species are found : *Probstmayria* (*Strongyloides*) *vivipara*, Ransom, 1907, in *Equus caballus ; Strongyloides fülleborni*, v. Linst., in *Anthropopithecus troglodytes* and *Cynocephalus babuin.*

Their development is, so far as is known, the same as that of *Strongyloides stercoralis* (v. Linstow, *Centralbl. f. Bakt.*, *Path. u. Infektionsk.*, 1905, Orig. xxxviii, p. 532).

Family. **Gnathostomidæ.**

Genus. **Gnathostoma,** Owen, 1836.

Syn. : *Cheiracanthus*, Diesing, 1839.

Easily recognizable by the numerous spines which cover the entire body or only the anterior extremity, and terminate in several points ; head globular and beset with bristles ; mouth with two lips ; two spicules ; vulva situated behind the middle of the body.

Gnathostoma siamense, Levinsen, 1889.

Syn. : *Cheiracanthus siamense*, Lev., 1889.

Female measures 9 mm. in length, 1 mm. in breadth. There are eight rows of simple spines on the head ; the armature of spines extends over the anterior third of the body only ; each spine on the anterior region of the body spreads into three points, of which the middle one is the longest ; the posterior spines are simple ; they gradually become smaller and then disappear entirely. The vulva is situated behind the middle of the body.

Male.—10·5 mm. long by 0·6 mm. broad. Head terminates in a globular swelling with two large lips. Neck 3 mm. broad. In front of neck eight rows of simple spines directed backwards. Anterior half of body with cuticular laminæ, posterior unarmed. Two pre-anal and two post-anal papillæ. Bursa wanting.

Spicules 1·1 and 0·4 mm. respectively.

Leiper considers *Gnathostoma siamense* to be identical with *Gnathostoma spinigerum.*

The single specimen described by Levinsen was found by Deuntzer in Bangkok (Siam), and was obtained from a young Siamese woman who suffered from a small tumour of the breast which had developed in the course of a few days. After the disappearance of the tumour, nodules the size of beans were found in the skin; out of one of these the worm was obtained. The same observer saw this affection in two other persons.

A closely related species, *Gnathostoma spinigerum*, Ow., lives in the stomach of wild cat (*Felis catus*), puma (*Felis concolor*), tiger (*Felis tigris*), and domestic cat (India); another species, *Gnathostoma hispidum*, Fedsch., 1839, in the stomach of pigs in Turkestan, Annam, Hungary, Congo, and by Collin in the stomach of an ox (Berlin).

Gnathostoma sp. in pariah dogs, Calcutta. *Gnathostoma* sp. in monkeys, French Guiana. They produce large fibrous thickenings in the stomach wall.

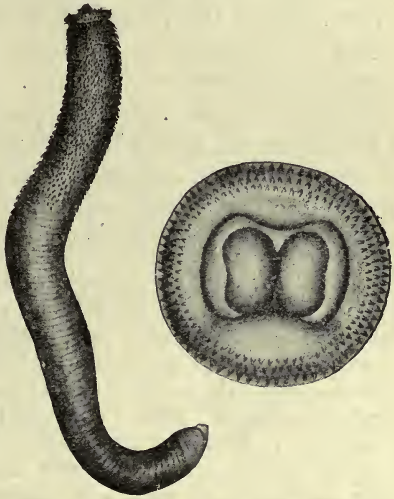


FIG. 275.—*Gnathostoma siamense*: to the left, the entire worm (8/1); to the right the head seen from above, with two fleshy lips (about 40/1). (After Levinsen.)

Gnathostoma spinigerum, Owen, 1836.

Cuticle of bulb with eight rows of chitinous laminæ with their posterior edges notched into spines. The laminæ on the anterior portion of the body are similar trident laminæ. In the middle of the body, the laminæ are simple and conical, cuticle posteriorly is unarmed. Mouth with two fleshy lips.

Male 5 mm. long by 0·5 mm. broad; tail spiral, four pairs of papillæ. Female about twice as long; tail straight, trilobed.

Family. Dracunculidæ, Leiper, 1912.

Genus. Dracunculus, Kniphoff, 1759.

Anterior end rounded with a cuticular thickening or shield. Mouth triangular with two lips. Alimentary canal atrophied.

Dracunculus medinensis, Velsch, 1674.

Syn.: *Vena medinensis*, Velsch, 1674; *Dracunculus persarum*, Kämpfer, 1694; *Gordius medinensis*, Linné, 1758; *Filaria dracunculus*, Bremser, 1819; *Filaria æthiopica*, Valenciennes, 1856; *Dracunculus medinensis*, Cobbold, 1864; *Guinea worm*, *Medina worm*.

The females attain a length of 50 to 80 cm., or even more, and average 1·5 to 1·7 mm. in diameter. They are whitish or yellowish in colour. The anterior extremity is roundish and bears a cuticular thickening or shield. The triangular mouth opening is surrounded by two projections or lips, behind which on the shield there are two lateral and four sub-median papillæ; the posterior end terminates in a spine, ventrally directed, and about 1 mm. in length; the alimentary canal below the œsophagus is atrophied, but not entirely obliterated; anus absent; the lateral lines are very flat. The greater part of the body is occupied by the long uterus, in which a great number of young larvæ are always found. The ovaries probably lie at the ends of the uterus; the vulva lies just behind the cephalic shield. During parturition the uterus is prolapsed through this opening.

The male is almost unknown. Leiper in an experimentally infected monkey found two males 22 mm. long, one from the psoas muscle, the other from the connective tissue behind the œsophagus.

Occurrence.—*Filaria medinensis* has been known since the most remote period. The "fiery serpents" that molested the Israelites by the Red Sea, and which Moses mentioned, were probably filariæ. The term Δρακόντιον occurs in Agatharchides (140 B.C.). Galen called the disorder dracontiasis; the Arabian authors were well acquainted with the worm. It is found not only in Medina or Arabia, but also in Persia, Turkestan, Hindustan. The Guinea worm is also widely distributed in Africa, on the coasts as well as in the interior. It occurs in the Fiji Islands. It was carried to South America by negro slaves, but is said at the present time to exist in only quite a few places (British Guiana, Brazil [Bahia]); it is also observed in mammals (ox, horse, dog, leopard, jackal [*Canis lapuster*], etc.).

Dracunculus medinensis in its adult stage lives in superficial ulcers on the body surface; it is seen most frequently on the lower extremities, more especially in the region of the ankle, but it also occurs in other parts of the body—on the trunk, scrotum, perineum, on the upper extremities, and in the eyelids and tongue. Sometimes there is only one ulcer and one worm, but more commonly several. It attacks man without distinction of race, age or sex. It is observed most frequently during the months of June to August.

Life history.[1]—When about a year old the worm seeks the surface

[1] The larvæ resemble those of *Cucullanus elegans* parasitic in the perch (*Perca fluviatilis*). The larvæ of this species develop in Cyclops sp. Fedschenko in 1870, at Leuckart's suggestion, succeeded in observing the invasion of Cyclops by Guinea worm larvæ. They penetrate not *per os* but through the exoskeleton. Newly hatched larvæ (in bananas) will cause infection of monkeys.

FIG. 276. — Guinea worm (*Dracunculus medinensis*. (After Leuckart.)

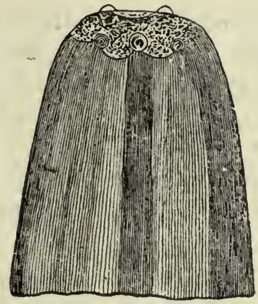


FIG. 277. — Anterior extremity of Guinea worm, showing dorsal and ventral lips, one lateral and two submedian papillæ and the lateral line. (After Leuckart.)

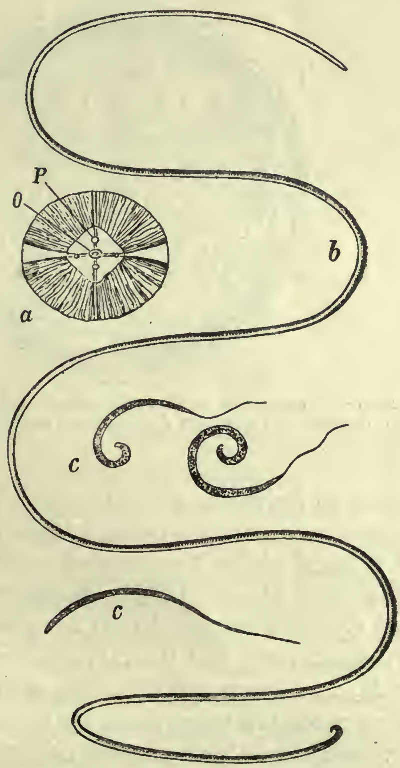


FIG. 278.—*Dracunculus medinensis*. *a*, anterior extremity seen end on ; O, mouth ; P, papillæ ; *b*, female reduced more than half ; *c*, larvæ enlarged. (After Claus.)

of the body and produces there a thickening as big as a florin. Over this a vesicle forms which eventually ruptures, and at the bottom of the ulcer can be seen a hole from which a part of the worm may project. On bathing the sides of the ulcer with water, a drop of fluid, at first clear then milky, exudes. This contains numerous larvæ. In other cases a thin tube an inch long is prolapsed (through the vulva). This is probably the uterus, but the mechanism of parturition is not clearly known. It lasts for about a fortnight. An abundant supply of larvæ can be got by placing wet compresses on a *fresh* ulcer. In a few hours a mass of larvæ is obtained.

The larvæ are 500 μ to 750 μ by 15 μ to 25 μ, with a long slender tail about one-third of the total length. The cuticle is transversely striated. The body is flattened. They possess an œsophagus and gut. At the anus there are apparently glandular structures.

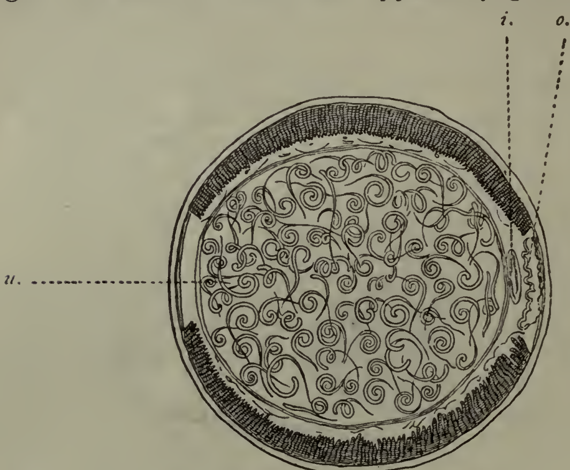


Fig. 279. — Transverse section of female Guinea worm; *u.*, uterus containing embryos; *i.*, intestinal canal; *o.*, ovary. (After Leuckart.)

The larvæ live and move actively in water for about two days, the majority dying on the third (Leiper). If a number of Cyclops sp. have been collected and isolated in clean water, and the larvæ are now added, the further development can be traced.

The larvæ enter the Cyclops, according to most authorities, by penetrating the exoskeleton, but according to Leiper this is impossible; they must enter by the mouth and penetrate the gut in order to reach the body cavity. In eight days moult 1 takes place, the striated cuticle being cast off. In ten days moult 2 takes place. In five weeks the larva is mature. If now the infected Cyclops is placed in 0·2 per cent. HCl solution the Cyclops is killed immediately, but the larvæ are stirred into activity, escape from the body, and swim about in the acid. This suggests that infection in nature probably takes place by the swallowing of infected Cyclops; Leiper, by feeding Cyclops containing mature larvæ to a monkey, found in it, *post mortem* six months later, two immature females 30 cm. long and two males 22 mm. long.

In certain areas the new cases occur principally in June. Five weeks later the larvæ will become mature in Cyclops, so that infection of Cyclops is taking place in July or August, and from then to June about ten months elapse, giving the period of development in man.

Pathology.—The initial induration is accompanied by itching. Urticarial eruptions are described in Dahomey and Mauretania accompanied by fever, rigors, blood-shot conjunctiva, and prostration resembling fungus poisoning. Symptoms last for one to two days, later the worms appear on the surface.

If the worm is ruptured in an attempt to extract it, disastrous results may occur through the escape of the larvæ into the tissues:

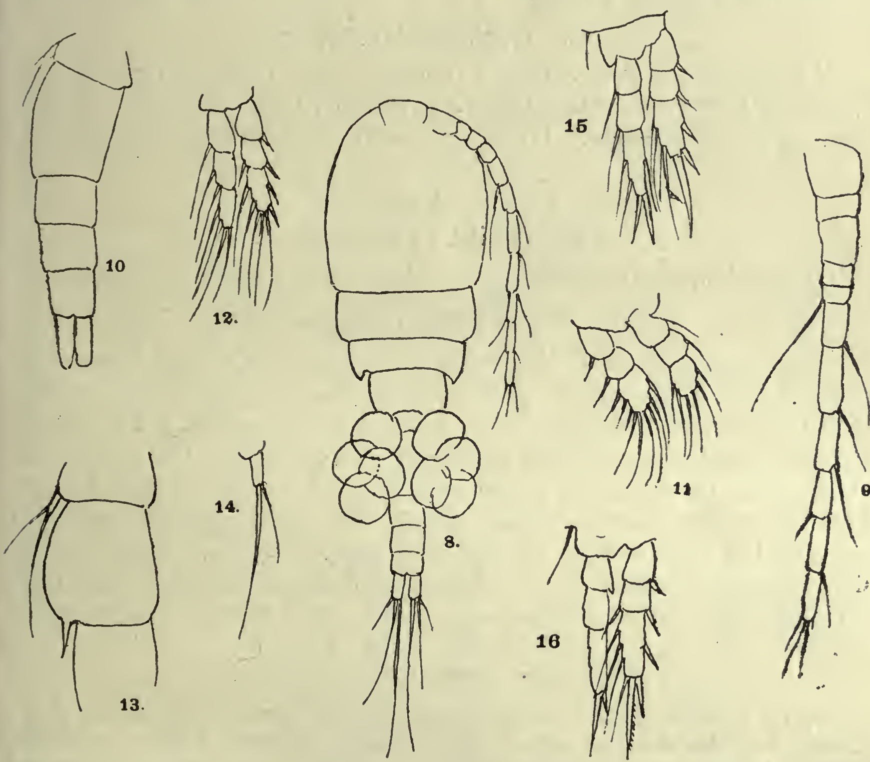


FIG. 280.—*Cyclops virescens*, ♀. 8, Female, ventral view, × 120; 9, anterior antennæ × 240; 10, urosome and last thoracic segment, × 240; 11, foot of first pair, × 320; 12, 15, 16, foot of second, third and fourth pairs, × 240; 14, foot of fifth pair, × 440; 13, last thoracic segment and first segment of urosome of male, × 240.

fever, inflammation, abscess, sloughing, ankylosis, even death from sepsis. Eosinophilia is often marked, 11 to 13 or even 50 per cent.

Extraction.—(1) The native method consists in rolling the worm round a stick; 1 in. to 2 in. are extracted each day, the process taking about a fortnight; (2) Emily used injections of 1 in 1,000 sublimate into the swelling or into the worm itself fixed by a ligature.

(3) Béclère chloroforms the worm ; (4) the worm can be more easily removed when all the embryos have been deposited (two to three weeks).

Cyclopidæ.—Cephalothorax ovate, clearly separated from abdomen. Anterior antennæ of female when bent back scarcely ever stretch beyond the cephalothorax. The second antennæ are unbranched. First four pairs of feet two-branched, outer branches three-jointed. The fifth pair of limbs are rudimentary alike in both sexes, usually one-jointed. There is no heart. The female has two egg sacs containing about fifty eggs.

Genus. **Cyclops**, Müller, 1776.

Mandible palp rudimentary, reduced to a tubercle bearing two branchial filaments. Maxillary palp rudimentary (obsolete). Lower foot-jaw non-prehensile. Head ankylosed to first thoracic segment.

Family. **Filariidæ.**

Sub-family. **Filariinæ.**

The residue after exclusion of the *Arduenninæ* and *Onchocercinæ*.

Genus. **Filaria**, O. Fr. Müller, 1787.

Very long, slender Nematodes, without excretory vessels or excretory pore, the males of which are usually considerably smaller than the females. Mouth round, without lips, unarmed. The lateral lines occupy one-sixth of the circumference of body. The tails of the males are bent or spirally rolled, and bear little wing-like appendages. The two spicules are unequal; almost always there are four pre-anal papillæ, but the number of post-anal papillæ varies. The vulva is always situated at the anterior extremity. Parasitic chiefly in the serous cavities and in the subcutaneous connective tissue. Insufficiently defined.

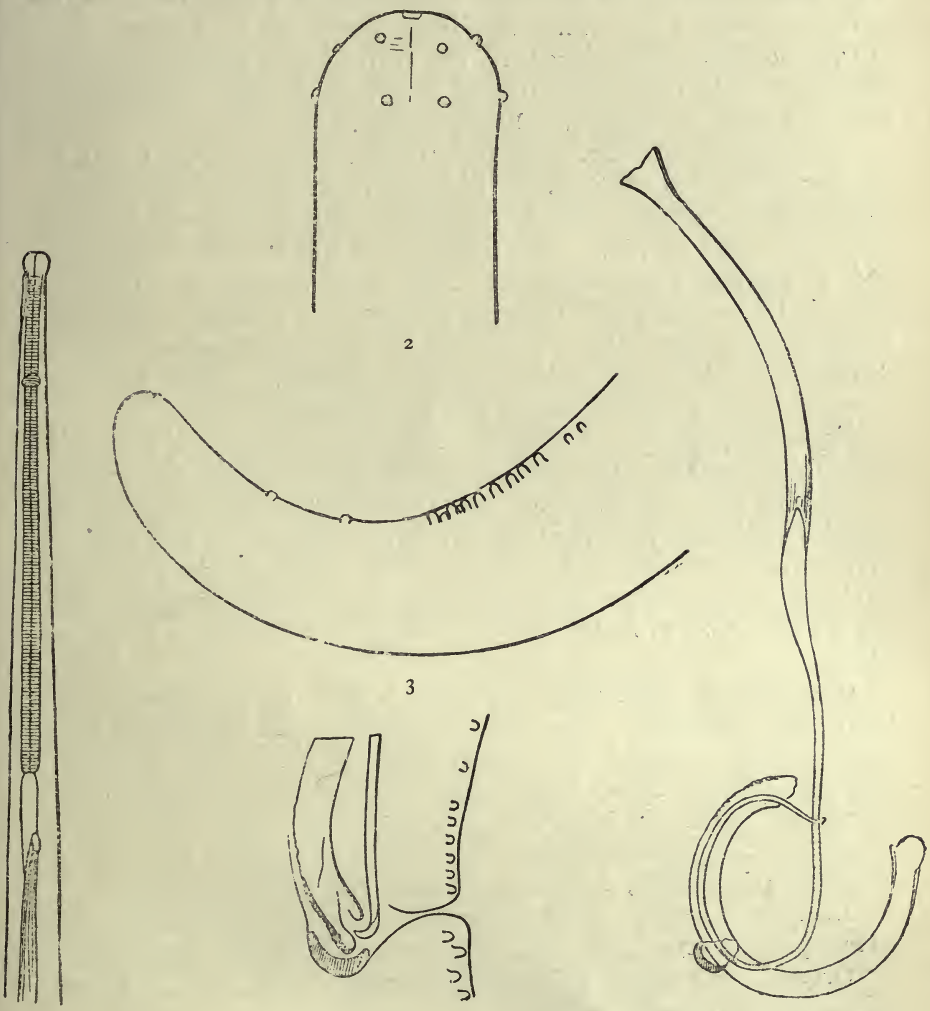
Filaria bancrofti, Cobbold, 1877.

Syn. : *Trichina cystica*, Salisbury,[1] 1868 (*nec Filaria cystica*, Rud., 1819) ; *Filaria sanguinis hominis*, Lewis, 1872 ; *Filaria sanguinis hominis ægyptiaca*, Sonsino, 1875 ; *Filaria wüchereri*, da Silva Lima ; *Filaria sanguinis hominum*, Hall, 1885 ; *Filaria sanguinis hominis nocturna*, Manson, 1891 ; *Filaria nocturna*, Manson, 1891.

These parasites of man were for a long time only known in their larval stage. They were discovered in 1863 in Paris by Demarquay, in the hydrocele fluid of a Havanese emptied by puncture ; they were next observed by Wücherer, in Bahia, in the urine of twenty-eight cases of tropical chyluria ; they were likewise observed in North America by Salisbury, who gave them the name of *Trichina cystica*. The next discoveries (in Calcutta, Guadeloupe, and Port Natal) related to chyluria patients, until Lewis discovered the larvæ in the blood of man (India), and

[1] C. W. S iles ("American Medicine," 1905, ix, p. 682) is of the opinion that Salisbury's *Trichina cystica* is identical with *Oxyuris vermicularis*.

found they were almost always present in persons suffering from chyluria, elephantiasis, and lymphatic enlargements; he also, in exceptional cases, found them in apparently healthy persons (*Filaria sanguinis hominis*). Lewis and Manson studied the disease and the filariæ of the blood very minutely, and became aware that the filariæ were sucked up by mosquitoes with the blood. Manson described the



1 2 3 4 5

FIG. 281.—*Filaria bancrofti*. 1, Anterior portion of male; 2, two rows of papillæ on head; 3, papillæ of tail of male; 4, cloaca of male showing tips of spicules and gubernaculum; 5, the spicules and gubernaculum of male. (After Leiper.)

metamorphoses that take place within the body of the mosquito. The adult female was discovered in Queensland by Bancroft, and soon after Lewis found it in Calcutta; it was described by Cobbold as *F. bancrofti*. The male was first seen by Bourne in 1888.

Head bougie-like, *i.e.*, separated by a narrowing from the neck, having two rows of minute papillæ. Cuticle has extremely fine striations.

Female.—50 to 65 mm. long by 1·5 to 2 mm. broad. Vulva 0·4 to 0·7 mm. behind the head. Anus about $\frac{1}{4}$ mm. from the tip of the tail (vulva 1 to 1·3 mm. from head, and anus 0·17 to 28 mm. from tail according to other authors). The vagina is a muscular tube forming three bold loops, and has terminally a pyriform enlargement. Uterus double (or single). Ovoviviparous.

Male.—25 to 30 mm. long by 0·1 mm. thick (40 by 0·1 mm. according to various authors). Probably two pairs of pre-anal papillæ, eight pairs of peri-anal, two pairs of post-anal papillæ, and one pair terminal. Tail curved. Two spicules, 0·2 and 0·6 mm. respectively, and a cup-like gubernaculum. The long spicule is cylindrical, expanded proximally and tapering distally to a filament with wings. At the tip it is spoon-like. The short spicule is of the same diameter throughout. It is gutter-like, coarsely marked. Testis uncoiled, terminating in a snowdrop-like process (Leiper).

Eggs.—40 μ by 25 μ. They do not appear to possess a true shell, but only an embryonal or vitelline membrane secreted by the ovum.

Embryos.—In the posterior part of the uterus eggs occur, in the anterior part embryos; the larvæ at birth measure 127 μ to 200 μ by 8 μ to 10 μ. In the blood they measure in the fresh 260 μ by 7·5 μ to 8 μ. In stained films, owing to shrinkage, there is great variation in size, from 154 μ to 311 μ. Probably 260 μ to 285 μ is the average in stained films.

Geographical Distribution.—Europe: Two cases recorded, one from near Barcelona. The patient suffered from hæmato-chyluria and enlarged scrotum with mikrofilariæ in the blood. A second case from Siena. Africa: The filarial index has not been estimated for various parts. In Nigeria it is about 10 per cent.

Habitat.—Lymphatic glands: *e.g.*, inguinal, femoral, iliac, lumbar, mesenteric, bronchial, superficial cervical, epitrochlear.

Lymphatic vessels: *e.g.*, those draining into the receptaculum chyli of the spermatic cord, in the thoracic duct and in various different parts.

Organs, etc.: Testis, epididymis, spermatic cord, tunica vaginalis, mammary cyst, and in abscesses.

They may occur in masses, but usually only a few (one to eight). Females are commoner than males. Dead and calcified worms are common in the various sites.

Distribution of Larvæ in Body.—These are by no means uniformly distributed, but occur in greater number in the capillaries of the lungs. Besides the lungs they occur in the capillaries of other organs, as the following data of Rodenwaldt show:—

	Mikrofilariæ		Mikrofilariæ
Lungs	134,821[1]	Spleen	1,666
Liver	4,884	Brain	3,833
Kidneys	15,253	Glands	0
{ Glomeruli	8,008	Marrow	0
{ Parenchyma	7,245	Blood	3,000

The following data of Rodenwaldt refer to the larvæ of *Filaria immitis* in the dog. They are commoner in organs than in vessels, and especially in the *capillaries* of the organs, but in the lungs they appear to be equally distributed in capillaries, arteries and veins.

The length of life of larvæ is unknown, but they appear to be destroyed in the kidneys, as dead calcified specimens are fairly numerous in the capillaries of the vasa recta of the medullary substance.

Kidneys: mainly in the glomerular capillaries and those of the vasa recta.

Liver: in the capillaries of the portal system, especially in those between the interlobular and the central intralobular veins.

Periodicity of Larvæ.[2]—Roughly speaking, the larvæ of *Filaria bancrofti* are found in the peripheral blood only during the night, disappearing (but not entirely) during the daytime. Their periodicity and that of *Loa loa* larvæ is shown by the table on p. 394, based on that of Smith and Rivas (*Amer. Journ. Trop. Dis. and Prev. Med.*, 1914, vol. iii, p. 361).

It was discovered by Mackenzie that this periodicity could be reversed by making the patient sleep during the daytime, showing that the phenomenon was in some way dependent on sleep or its attendant phenomena. Rodenwaldt gives the following explanation of the phenomenon of periodicity:—

Mikrofilariæ come to rest in capillaries. After passing up the thoracic duct they would reach the capillaries of the lungs by the superior vena cava. Here they occur in immense numbers. In the case of *Loa loa* larvæ (which have a diurnal periodicity) some of these are forced out by the increased force and rapidity of the pulmonary circulation during the day, but are able to rest (owing to their sticky sheath ?) in the peripheral capillaries on their way to the capillaries of the organs. During the night the force of the current through the lungs is relaxed and consequently they are able

[1] These figures refer to 1 c.c. of each organ, and were estimated by cutting sections of definite thickness (30 μ to 40 μ) and counting the filariæ in a definite area of section, *e.g.*, ¼ cm.^{2} The organs before removal from the body have their vessels tied, and are then fixed in hot alcohol.

[2] For determining periodicity measured quantities of blood, *e.g*, 20 mm.^{3}, should be used. A thick film is made of the whole quantity. The numbers present in this quantity may vary from three or four to 300 or 400.

to remain in the pulmonary capillaries and do not appear in the capillaries of the systemic circulation. If it is true that the periodicity of *Loa loa* cannot be reversed by changing the hours of sleep, then the explanation is incomplete. In the case of the larvæ of *Filaria bancrofti* (which have a nocturnal periodicity), in order to apply the same explanation we must further assume that the mikrofilariæ have less power of resisting the force of the capillary current (*i.e.*, are less sticky). They are washed out of the pulmonary capillaries by day and by night, but it is only at night, when the blood-stream in systemic capillaries is less rapid, that they are able to rest there. In the daytime they are washed on until they reach the capillaries of the organs (possibly again the lungs). The reversal of the periodicity by sleeping

	Larvæ of *L. loa* in equal quantities of blood	Average 132. Deviations from average	CASE 1. *F. bancrofti* larvæ in 1 c.c. of blood	Average 1,000 (about). Deviations from average	CASE 2. *F. bancrofti* larvæ in 1 c.c. of blood	Average 1,570 (about). Deviations from average
2 a.m. ...	9	− 123	3,500	+ 2,500	6,500	+ 3,930
4 a.m. ...	11	− 121	3,200	+ 2,200	5,200	+ 3,630
6 a.m. ...	41	− 91	2,800	+ 1,800	2,000	+ 430
8 a.m. ...	168	+ 36	900	− 100	1,100	− 470
10 a.m. ...	298	+ 166	210	− 790	350	− 1,220
12 noon ...	531	+ 389	30	− 970	50	− 1,520
2 p.m. ...	252	+ 120	20	− 980	40	− 1,530
4 p.m. ...	146	+ 14	10	− 990	30	− 1,540
6 p.m. ...	91	− 41	40	− 960	40	− 1,530
8 p.m. ...	23	− 99	60	− 940	100	− 1,470
10 p.m. ...	5	− 127	600	− 400	800	− 770
12 midnight	5	− 127	750	− 250	2,600	+ 1,030
Total ...	1,580	—	12,120	—	18,810	—

during the daytime admits of a similar explanation. If this explanation be true, then a prolongation of the day conditions, *e.g.*, by continued exercise, should result in still keeping the larvæ out of the circulation, but this does not appear to be the case.

In certain countries, *e.g.*, Fiji, Samoa, Philippines, West Africa, larvæ, apparently those of *Filaria bancrofti*, show no periodicity. In Fiji the usual intermediate host is *Stegomyia pseudoscutellaris*, a day-biting mosquito, so that possibly, as Bahr suggests, the mikrofilariæ have partly adapted themselves to the habits of their intermediate host, as the nocturnal mikrofilariæ are adapted for transmission by a nocturnal feeding mosquito, *e.g.*, *Culex fatigans*, but how this could come about is a mystery. It is not certain in all cases whether the non-periodic mikrofilariæ really belong to *Filaria bancrofti*; some may be *L. loa* larvæ, or possibly unknown larvæ. An exact morphological description of these larvæ is therefore always necessary.

Preservation of Living Larvæ.—Blood from the vein (or finger puncture) is shaken up with twenty times its volume of sterile 0·9 per cent. salt solution, and kept in an ice cupboard (Fülleborn).

Concentration of Larvæ.—(*a*) The above mixture is hæmolysed with water and then sufficient salt solution added to make up to 0·9 per cent. The solution is allowed to stand or can be centrifugalized. (*b*) The blood is mixed with sodium citrate and centrifugalized; the larvæ are found in the leucocytic layer (Bahr). (*c*) Allow blood to clot in a small tube; the larvæ appear on the surface of the clot and are so got in pure serum. A drop of blood may also be allowed to clot on the slide; the larvæ are found in the clear areas of serum. (*d*) Hæmolyse blood with water or acetic acid. Centrifugalize, make smears from, or examine the sediment.

Removal of Red Corpuscles.—The blood film is allowed to stand for some minutes in a moist atmosphere. The staining solution is sucked through with blotting paper: the larvæ stick to the slide, while the corpuscles are washed out.

Morphology of Larvæ.—Wet staining: Azur II one part, 0·9 per cent., salt solution 3,000, or very dilute Giemsa or ripened methylene blue or neutral red solutions. Place a drop on the slide and add a drop of blood to this. The larvæ remain alive for one or more days; it sometimes takes twenty-four hours to stain some particular structure. Differentiation by drawing through weak eosin solution is often useful. This method is the best for finest details. The excretory pore, anal pore, excretory cell, and chief "genital" cell stain first, then the matrix cells and finally the column of nuclei.

Wet fixation and staining: The blood is spread on a large cover-glass—floated on the surface of 70 per cent. alcohol heated to about 70° C. Wash in water, (1) overstain with 1 in 1,000 azur II solution, warming slightly; (2) differentiate with (*a*) absolute alcohol (containing, if necessary, a trace of HCl), or (*b*) with absolute alcohol 96 per cent. ninety parts, anilin oil ten parts; (3) clear in origanum, bergamot or cajeput oil; (4) mount in balsam. Or stain with hæmatoxylin, *e.g.*, Mayer's glycerine alumhæmatein, heating till slightly steaming. Differentiate with acid (2 per cent. HCl) alcohol if overstained. Clear and mount as above.

Dry fixation and staining: (1) With azur II as above, or (2) with hæmatein (warm). Examine the dried films in the usual way without a cover-glass. The azur stains the excretory and genital cells clearly.

Thick films: (1) The blood is smeared out fairly thickly over an area as big as a sixpence.

(2) Dry *quickly* to prevent shrinking, using carefully a spirit lamp in a moist climate.

(3) Place films downwards in water for a few minutes.

(4) Fix in alcohol.

(5) Stain with azur II, 1 in 1,000. Differentiate as above. Examine as a dry film. This method suffices for showing the excretory cell and the G1 cell; or

(6) Stain with hæmatein (slightly steaming), especially for the column of nuclei and the sheath. The fixation in alcohol in this case may be omitted.

(7) The removal of the hæmoglobin and the fixation may be combined by using Ruge's mixture (formalin 2 per cent., containing 1 per cent. acetic acid) or acetic alcohol (glacial acetic 1, alcohol 3).[1]

Structure of Larvæ.—(1) Subcuticular cells: By vital staining, at intervals underneath the cuticle are seen a series of spindle-shaped cells—the *subcuticular matrix cells* of Rodenwaldt, the *muscle cells* of Fülleborn. There are thirty or forty or more of these.

(2) Nerve ring: Appears as a break in the nuclear column about 20 per cent. of total length from the head.

(3) Excretory system: Consists of a lateral spherical hollow excretory pore which shows a radial striation. Connected with the pore is an excretory cell which appears to be canalized. *Excretory pore,* 29·6 per cent. of length from head. *Excretory cell,* 30·6 per cent. of length from head.

(4) "Genital" cells and anal pore: Consists of a pore opening ventrally on a very fine papilla with which are connected four other cells in series, the chief "genital" cell (G1) being some distance from the three others, which lie close to the pore. G1, 70·6 per cent., anal pore, 82·4 per cent. of length from head.

(5) Internal body, viscus, or reserve material: Best shown by vital staining with neutral red. This is a granular strand-like body extending from 52·7 per cent. to 65 per cent. of length from head.

(6) Tail end: (i) Rod-like structures resembling those in the head, 90 per cent. of length. (ii) The column of nuclei extends to 95 per cent. of length, so that the terminal portion is free from nuclei.

(7) Mouth: Terminal according to some authors, lateral according to others. Some describe a fang on the head, others not. By vital staining and eosin differentiation two rod-like structures with mushroom-like caps can be seen behind the head.

(8) Cuticle: Transversely striated. There is a longitudinal break in the striation on each side corresponding to the lateral lines. The striation is best shown by vital staining with azur II and eosin differentiation.

(9) Column of nuclei: These nuclei of the gut cells form the main feature in ordinary dry films stained with hæmatoxylin. They are separated by a space from the subcuticular cells.

---

[1] [Acetic alcohol does well for detecting crescents in thick films of malaria blood.—J. W. W. S.]

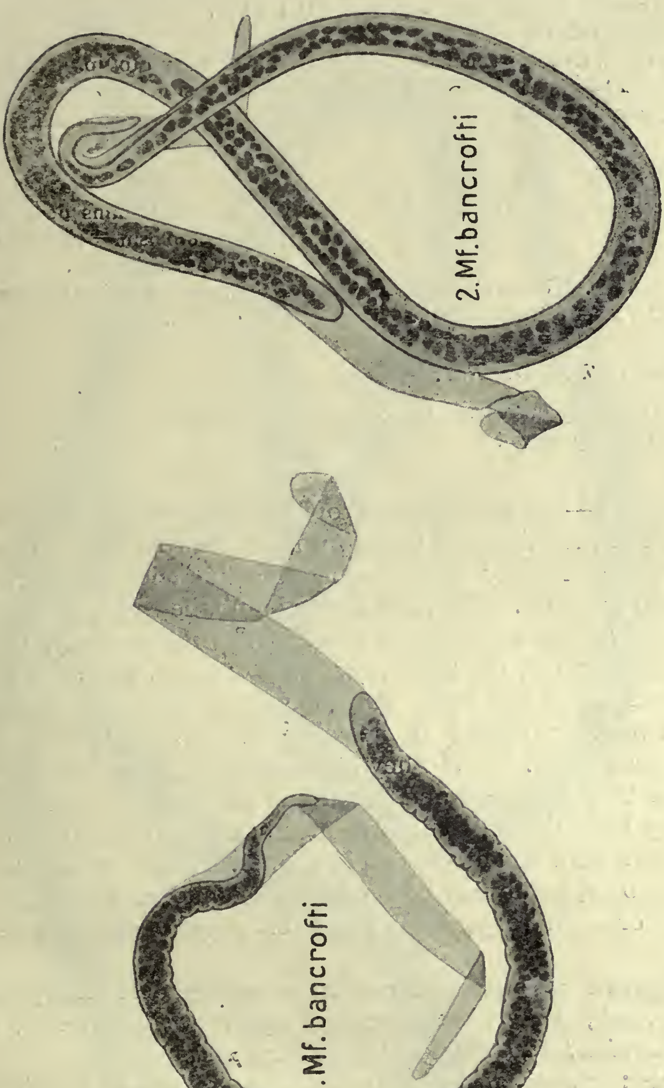


FIG. 282.—*Mf. bancrofti* in thick film, dried and stained with hæmatoxylin: 1, shrunken; 2, unshrunken. × 1,000. (After Fülleborn.

DISTINCTION BETWEEN *Mikrofilaria bancrofti* AND *Mikroloa loa.*

Dry Films, Hæmatoxylin Staining:—

Mf. bancrofti.	*Ml. loa.*
(1) In graceful curves (but only if quickly dried).	(1) Kinked.
(2) Tip of tail free from nuclei.	(2) Nuclei extend to tip.
(3) Column of nuclei separated by a space from the cuticle.	(3) Not so distinctly.

Azur Staining:—

(4) G1 cell small, easily overlooked.	(4) G1 cell large, stains deep blue, cell protoplasm = twice width of larva, easily seen.
(5) Excretory cell close to excretory pore, 2 per cent. of length.	(5) Excretory cell farther from pore, 4 per cent. of length.

Vital Staining with Neutral Red:—

(6) Internal body or reserve material clearly shown.	(6) Not shown.

Life History.—In the stomach of the mosquito the larvæ cast their sheath in the thickened blood in one to two hours. In twenty-four hours the majority have reached the thoracic muscles, where development proceeds. They are at first immobile and of a "sausage" form (110 μ by 13 μ), with a short spiky tail. In three to five days the œsophagus is formed, the larva now being 0·5 mm. long. The larva appears to moult at this time. After the gut is formed papillæ, three or four in number, appear at the tail end. In two to three weeks the larvæ are 1·5 mm. long. They now leave the thorax and reach the labium, but they may be found in various parts of the body, *e.g.*, the legs. They bore through Dutton's membrane and so arrive on the surface of the skin, which they rapidly enter. Their development in man is unknown, but it may be very long, as children are not infected till 4 to 5, or even 10 years old, but this may be due to unknown causes.

Development takes place in numerous mosquitoes. Anophelines: *Myzomyia rossii, Pyretophorus costalis, Myzorhynchus sinensis, Myzorhynchus barbirostris, Myzorhynchus peditæniatus.*

Culicines: *Culex pipiens, Culex fatigans, Culex skusei, Culex gelidus, Culex sitiens, Culex albopictus, Stegomyia fasciata, Stegomyia pseudoscutellaris, Stegomyia gracilis, Stegomyia perplexa, Mansonioides uniformis, Mansonioides annulipes, Scutomyia albolineata, Tæniorhynchus domesticus.*

Partial development takes place in other species.

Pathology.—Among the conditions which *Filaria bancrofti* is

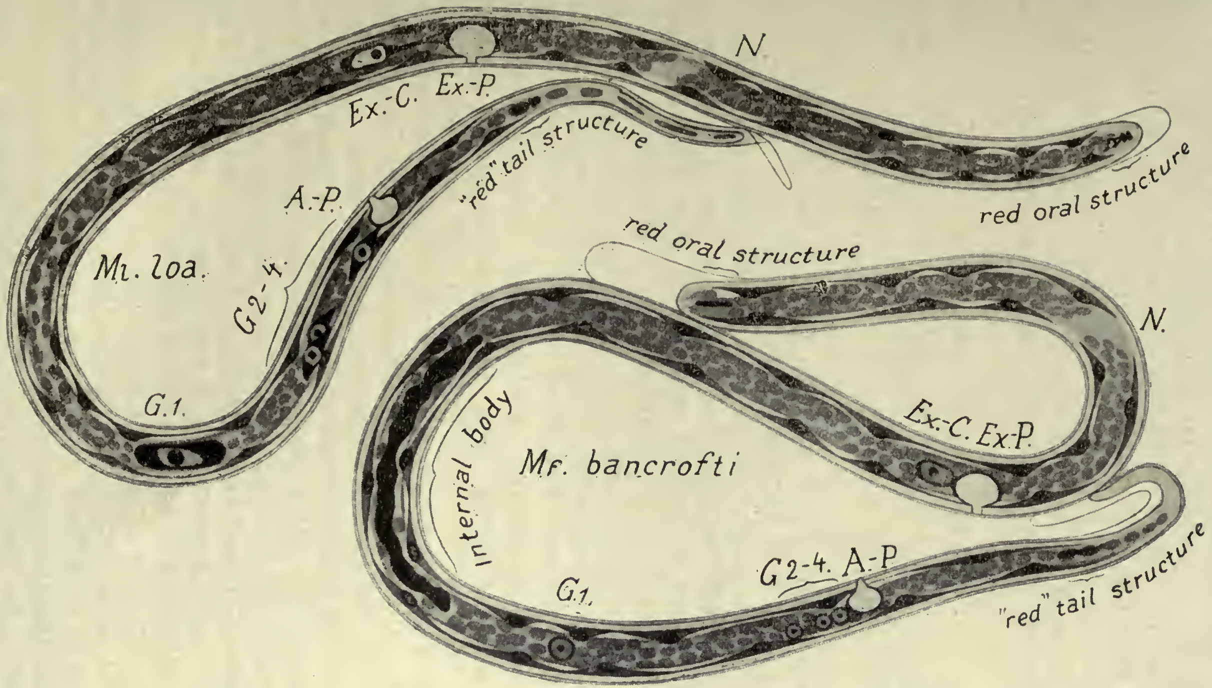


FIG. 283.—Schematic drawings of the anatomy of *Mi. loa* and *Mf. bancrofti* combined from specimens stained in different ways. The position of the organs has not been based on the average values of a large series of specimens, but on that of a single specimen. G1, chief genital cell; G2-4, other genital cells; Ex.-C., excretory cell; Ex.-P., excretory pore; A-P., anal pore; N., nerve ring. Magnification circa 1,000. (After Fülleborn).

believed to produce are lymphangitis, varicose glands, especially inguinal and epitrochlear, chyluria, chylocele, lymph scrotum, orchitis, abscess, and elephantiasis. The evidence that these so-called "filarial diseases" are produced by *F. bancrofti* is (1) geographical and statistical; (2) pathological. Bahr has contributed evidence of the former kind from his researches in Fiji, on which we may base the following statements:—

(1) The prevalence of filarial diseases is proportional to the prevalence of *Mikrofilaria bancrofti* in the blood. Thus in four villages examined by him he got the following figures:—

	Village A	Village B	Village C	Village D
Mf. bancrofti ...	12·5 per cent. ...	25 per cent. ...	31 per cent. ...	33 per cent.
Filarial diseases ...	29 " ...	39 " ...	58 " ...	34 "
Total population ...	168	114	425	222

(2) Out of 257 people with *Mf. bancrofti* in the blood, 153 were suffering from filarial diseases, *i.e.*, 59 per cent.

(3) Whereas of 672 people without *Mf. bancrofti* in the blood, only 263 were suffering from filarial diseases, *i.e.*, 37·6 per cent.

(4) Again out of 416 people suffering from filarial disease, 153 showed *Mf. bancrofti* in their blood, *i.e.*, 36·7 per cent.

It is generally assumed that all people suffering from filarial disease show at some (presumably early) stage larvæ in the blood; but we do not consider that this must necessarily be so. It appears to us quite possible that living adult filariæ may be present in the body, producing disease, without their larvæ appearing in the blood. The absence of larvæ from the blood in 63·3 per cent. of persons suffering from filarial disease is, however, generally explained otherwise. The adults which occur in enlarged glands, etc., get eventually destroyed by inflammatory reaction, so that larvæ are no longer being produced, while the enlarged gland, etc., which the adults have produced remains. This explanation assumes that the larvæ of the original worm die in the circulation or elsewhere, *e.g.*, kidney, but we have no evidence as to the duration of life of larvæ in the human body; but also it assumes that a person cannot be reinfected with filaria, for otherwise there is no reason why the diseased should not be infected in the same proportion as the non-diseased. But assuming the explanation to be true, it would explain why a diseased population show larvæ in only about one-third of the cases. It must be borne in mind also that the figures are rather small.

Pathology.—In order to explain the effects which do or may be expected to occur from obstruction of lymphatics, it is necessary to have an accurate knowledge of the distribution and connections of lymphatic vessels (and glands) and the anastomoses of these vessels. We can only briefly summarize our knowledge here.

We should recall also that considerable destruction or obstruction of lymphatics or glands may occur without necessarily producing any lymphatic obstruction, at least, of a permanent nature, *e.g.*, when a mass of lymphatic glands is destroyed by a bubo in the groin or, again, when a carcinomatous mass of glands is removed from the axilla. Again, to take the case of chyluria—where it is generally assumed that obstruction must occur higher up than the point at which the intestinal lacteals enter the juxta-aortic glands—this disease may occur, *e.g.*, in temperate regions, quite apart from such obstruction. It is true that some of these cases of chyluria are not cases of chyle in the urine, but, as little or no fat is present, lymphuria. These do not require the above assumption, but seeing that true chyluria may apparently occur without such obstruction, we should be cautious about explaining this and other symptoms on the basis of obstructions which theory may demand, for only too often there are no *post-mortem* facts at our disposal.

Lymphangitis: What this is due to is unknown. There is no actual evidence of the occurrence of adults in the inflamed vessel. Complete disappearance, not to reappear, of (non-periodic) mikrofilariæ from the blood has been shown by Bahr and others to occur within twenty-four hours after an attack of lymphangitis, orchitis adenitis or simply a high temperature. This mysterious phenomenon requires explanation. If the mikrofilariæ were being killed by the attack, their dead bodies should still be found in the blood; or if the adults were being killed, for all we know to the contrary, the larvæ might well survive. We consider there is no evidence that either are affected, but that for some reason, as little understood as in periodicity, the larvæ now remain in the organs.

Abscess: In Fiji, by Bahr, they have been found in the substance of various muscles, *e.g.*, quadriceps extensor, latissimus dorsi, serratus magnus, in the popliteal space, groin, axilla, and over the internal condyle of the humerus, and in the upper extremity they are frequently infected with cocci. They not infrequently contain fragments of dead adult filariæ. Their mode of origin is not clear. They form nearly 30 per cent. of cases of filariasis in Fiji. Of 95 cases, 41 showed mikrofilariæ in blood, 54 did not.

Hydrocele and enlarged testis: In Fiji they form about 10 per cent. (36 out of 343) of cases of filariasis. The fluid is usually sterile; mikrofilariæ were present in the fluid in 1 out of 11 cases. In the wall numerous calcified adult filariæ may be found. The walls consist chiefly of hypertrophied muscle with fibrous tissue, dilated blood-vessels and lymphatics, the lining epithelium of which appears to be absent; of 38 cases 14 had mikrofilariæ in the blood, 24 had not. Most of the cases are associated with elephantiasis of the scrotum (11 out of 12 cases).

Enlarged glands form over 40 per cent. (153 out of 343) of cases of filariasis, so that they are the commonest expression of filariasis met with in Fiji. The glands are enlarged, fibrotic, and the trabeculæ are thickened. The lymphatics are thickened or represented merely by fibrous tissue. The gland also shows dilated blood-vessels and numerous spaces filled with lymph. Giant-cells are common in those glands which contain remnants of filariæ. Masses of lymphocytes enclosed by inflammatory or fibrous tissue are common. Eosinophile cells are also extremely common, not only in the fibrous tissue of the glands, but in other inflammatory or fibrotic conditions: in other organs living or calcified filariæ are "usually" present. Only about 33 per cent. show mikrofilariæ in the blood. The epitrochlear gland is frequently enlarged in Fiji.

Breinl has examined enlarged glands and finds loose vascular fibrous tissue with lymphocytic invasion. In parts, the lymphocytes collect into areas 200 μ to 800 μ in diameter. The lymph tissue surrounding the spermatic cord showed abundance of vessels—(1) large, (2) small. The large had thick walls and wide lumina. In other cases the lumina were nearly filled by a thrombus of newly formed, fine, loose connective tissue.

Varicose glands: In about 7 per cent. (24 out of 343 cases) of filariasis, mikrofilariæ are found in the blood in 50 per cent. (12 out of 24).

Elephantiasis.—Elephantiasis scroti is associated with hydrocele in 50 per cent. of cases (12 out of 23); in 65 per cent. of cases (15 out of 23) there are associated enlarged glands in one or both groins, though also hydrocele and enlarged glands occur without elephantiasis scroti. In 13 out of 27, *i.e.*, about 50 per cent., cases of elephantiasis in various regions, no associated enlargement of glands is found. Elephantiasis forms in Fiji less than 10 per cent. of cases of filariasis. Mikrofilariæ are present in the blood in 36 per cent. (12 out of 33) of cases.

Chyluria.—Exceedingly rare in Fiji. Theory would demand an obstruction above the point of entry of the lacteals, *viz.*, the pre-aortic lymphatic glands, but in cases in temperate regions it may occur without any such lesion. In some of these cases the fluid is not chyle (fat absent), but presumably lymph. A discussion of the mode of production of chyluria, lymph scrotum, elephantiasis, etc., is at present premature; theory has far outrun fact. Too much stress had been laid on the mechanical action of the worms to the almost total exclusion of their (or possibly their larval) toxic action. The above analysis has been made in the hope of acquiring more extended observations similar to those made by Bahr.

Geographical Distribution.—Filaria bancrofti is known in nearly all tropical countries. It occurs in India, China, Indo-China, Japan, Australia, Queensland, the Islands of Polynesia (with the exception of the Sandwich Islands), Egypt, Algeria, Tunis, Madagascar, Zanzibar, Sudan, etc., the south of the United States of America, Brazil, the Antilles, etc. Whether it is the same species in all cases is questionable.

Filaria demarquayi, Manson, 1895.

Syn.: *F. ozzardi*, Manson, 1897.

The adult female *F. demarquayi* measures from 65 to 80 mm. in length by 0·21 to 0·25 mm. in breadth. The head has a diameter of from 0·09 to 0·1 mm. The mouth is terminal. The genital pore opens at 0·76 mm. from the head. The alimentary canal is nearly straight and terminates in an anus, which is subterminal. The opening of the anus is marked by a slight papilla. The tail is curved. It rapidly diminishes in size just below the anal papilla. A characteristic pair of fleshy papillæ project from the tip of the tail. The diameter near the tip of the tail before its termination is 0·03 mm. *F. demarquayi* is a thicker worm than *Ac. perstans*. It differs from *F. bancrofti* in the greater size of the head, in the smaller tail, and particularly in the marked fleshy papillæ at the tip of the tail. These papillæ are knobby, and not simply cuticular as in *Ac. perstans*.

FIG. 284.—*F. demarquayi*: tail, showing paired large fleshy papillæ. (After Leiper.)

The male of *Filaria demarquayi* has still to be found.

The adult female form of *F. demarquayi* was found by Dr. Galgey in the body of a native of St. Lucia in whose blood the larvæ had been found during life. Five adult females were found in the connective tissue of the mesentery.

The larva measures 200 μ in length by 5 μ in breadth; it is sharp-tailed, and has no sheath. Its movements are very active, and the absence of a sheath enables it to glide along freely all over the slide. It observes no periodicity, being present in the peripheral circulation both by day and by night. As a rule, some eight or ten parasites are found in an ordinary preparation. Sometimes hundreds of these larval filariæ may be counted on every slide.

The intermediate host has not been discovered.

Geographical Distribution.—St. Vincent, Dominica, Trinidad, and St. Lucia (West Indies), British Guiana, New Guinea (?).

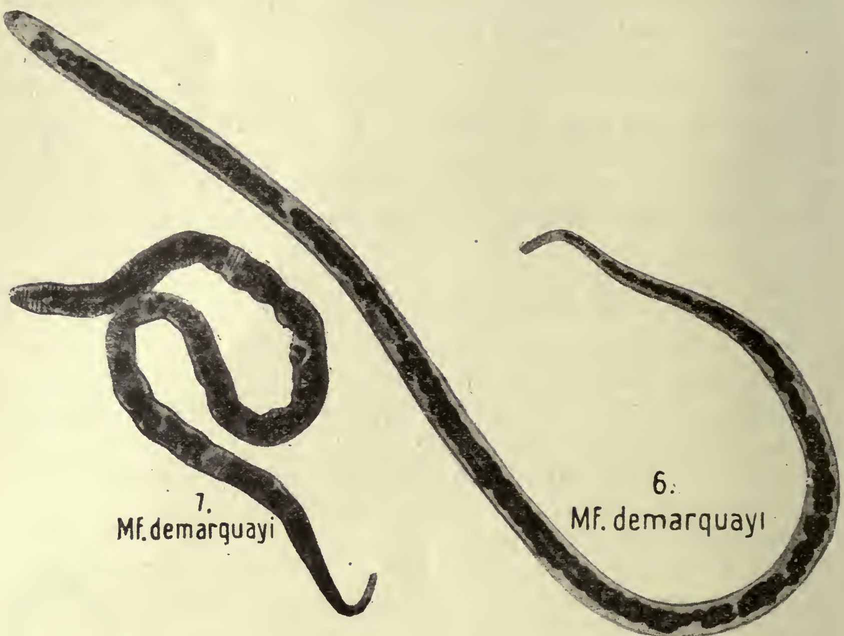


FIG. 285.—*Mf. demarquayi* in thick film, dried and stained with hæmatoxylin. 6, unshrunken; 7, shrunken. × 1,000. (After Fülleborn.)

Filaria taniguchi, Penel, 1905.

Female 68 by 0·2 mm. in breadth. Cuticle non-striated. Mouth two pairs of papillæ. Anus 23 mm. from extremity. Vulva 1·3 mm. from mouth. Larva 164 μ by 8 μ, sheathed. Tail truncated. Periodicity nocturnal.

Habitat.—Lymphatic glands of man. Japan.

Filaria (?) conjunctivæ, Addario, 1885.

Syn.: *Filaria peritonei hominis*, Babes, 1880; *Filaria inermis*, Grassi, 1887; *Filaria apapillocephata*, Condorelli-Francaviglia, 1892.

The female only of this species is known. It measures 16 to 20 cm. in length and 0·5 mm. in breadth, and is of a whitish or brownish tint. The cuticle is striated with fine transverse and more marked longitudinal striæ with the exception of a small field surrounding the mouth, which is terminal and has neither papillæ nor lips. The œsophagus measures 0·6 mm. in length. The anus is 3 mm. in front of the rounded posterior extremity, and behind it there are two (glandular ?) sacs. The vulva is close behind the oral aperture; the vagina soon divides into two convoluted uteri, which are filled with eggs and embryos. Embryos 350 μ by 5·5 μ.

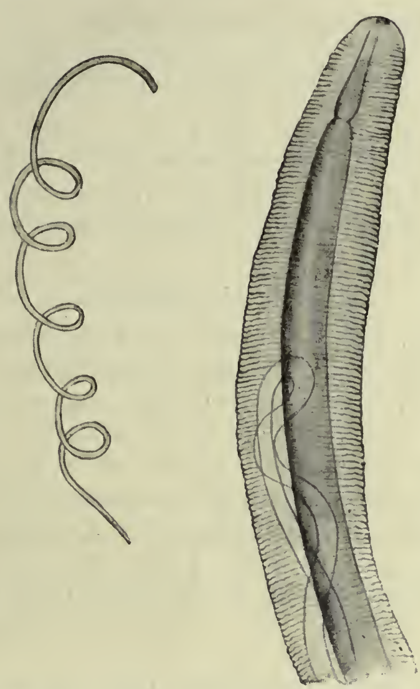


FIG. 286.—*Filaria* (?) *conjunctivæ* : to the left, life size; to the right, the anterior extremity magnified. (After Addario.)

This species (115 mm. long) was first observed in Milan by Dubini in the eye of a man; subsequently it was observed, encysted and calcified (190 mm. long), by Babes in the gastro-splenic omentum of a woman in Budapest, and finally one (95 mm. long) was extracted by Vadela from a tumour the size of a pea in the ocular conjunctiva of a woman in Catania (Sicily), which case has been described by Addario. Possibly *Agamofilaria palpebralis*, Pace, 1867 (*nec* Wilson, 1844), and *A. oculi humani*, v. Nordm., 1832, are the same species.

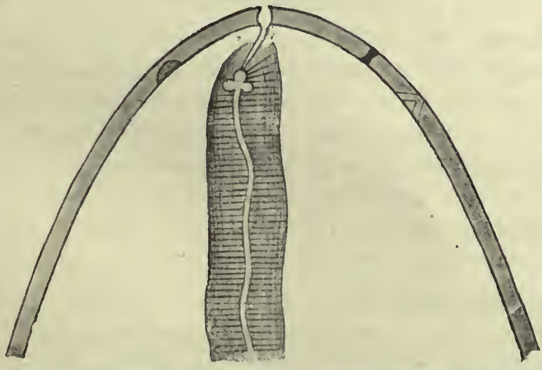


FIG. 287.—*Filaria* (?) *conjunctivæ* : anterior end greatly magnified; the mouth with the pharynx in the middle; in the cuticle on the right side the opening of the vagina, and behind it the excretory pore. (After Grassi.)

Filaria (?) *conjunctivæ* is certainly only an incidental parasite of man; the horse and ass are its normal hosts, but it is not common in these animals, or is frequently confused with *Hamularia equi*, Gmelin, 1789.

Group. **Agamofilaria,** Stiles, 1906.

Not a generic but a group name for immature *Filariidæ* the development of which does not admit of generic determination.

Agamofilaria georgiana.

Adult unknown, length from 32 to 53 mm. Maximum diameter 560 μ to 640 μ. Head no cephalic cone. Mouth small, circular, surrounded by six papillæ (two small latero-median and four sub-median). The larger papillæ are 24 μ from base to tip. Excretory pore about 0·5 mm. from head. Anus 64 μ to 128 μ from tip. Cuticle fine striæ near anus, occasionally elsewhere. Lateral lines clearly marked. Œsophagus 2·5 to 2·9 mm. Rectum 200 μ long.

Habitat.—Superficial sores on the ankle of a negress, Georgia, U.S.A.

Agamofilaria palpebralis, Pace, 1867 (*nec* Wilson, 1844).

100 by 1·5 mm., removed from a cyst in the left upper eyelid of a boy by Pace, in Palermo.

Agamofilaria oculi humani, v. Nordmann, 1832.

Syn.: *Filaria lentis*, Diesing, 1851.

The sexless Nematodes observed in the lens of the human eye were termed *Filaria oculi humani*. Only three cases are known. v. Nordmann observed very small round worms in the lens of a man and woman with cataract, and Gescheidt once found three specimens in the lens of a woman similarly affected.

The demonstration of nematode-like formations in the vitreous remains uncertain even when movements are observed, and when they cannot be extracted and examined microscopically the doubt may occur that one may have mistaken the remains of the hyaloid artery for a worm, which it resembles in form, size and colour; the slightest movement of the eye also causes it to move so that it simulates a living organism.

Accordingly it would be more correct to exclude all the cases known only ophthalmoscopically (Quadri, 1857; Fano, 1868; Schoeler, 1875; Eversbusch, 1891). There then remains only one positive case, described by Kühnt in 1891. In this case it was possible to follow the gradual growth of the parasite for some time, and the worm, which measured only 0·38 mm. in length, was finally extracted.

Agamofilaria labialis, Pane, 1864.

The parasite measures 30 mm. in length; the anterior extremity is pointed; the terminal oral aperture is surrounded by four papillæ; the anus opens 0·5 mm. in front of the posterior extremity; the vulva is 2·5 mm. in front of the anus; the uterus is double; the anterior one passes with convolutions forward to the cephalic end; the posterior one is directed backwards and remains rudimentary.

Extracted from a small pustule on the inner surface of the upper lip. Also found in Naples by Pierantoni in 1908.

The position of many of these worms is doubtful, and still more so is that of many other imperfectly described "Filariæ," which are hardly more than useless and confusing names. These include the following:—

Filaria (?) romanorum-orientalis, Sarcani, 1888.

Observed in the blood of a Roumanian woman; 1 mm. in length, 0·03 mm. in breadth; tail end pointed, a tongue-like appendage on the head. Eggs the size of a red cell with developed embryo, apparently viviparous.

Filaria (?) kilimaræ, Kolb, 1898.

Several female specimens, 10 to 20 cm. long by 0·5 to 1 mm. broad, were once found free in the abdomen of a fallen Kitú warrior; according to Spengel, who examined them, the oral papillæ of these worms were similar to those of *Dracunculus medinensis*. Moreover, Kolb classifies together Nematodes that probably have no connection with each other.

Filaria (?) sp. ?

Cholodkowsky calls attention to Filariæ that are still unknown which cause tumours resembling whitlows on the fingers of peasants of the Twer Government.

Mikrofilaria powelli, Penel, 1905. In Bombay.

Mikrofilaria philippinensis, Ashburn and Craig, 1906. In the Philippines.

Genus. Setaria, Viborg, 1795.

Syn.: *Hamularia*, Treutler, 1793; *Tentacularia*, Zeder, 1800 (*nec* Bosc, 1797).

Mouth with projecting peribuccal armature deeply notched on the lateral margins, less so dorsally and ventrally. Tail in both sexes with peculiar caudal appendages.

Parasitic in serous cavities, especially of ruminants.

Setaria equina, Abildg., 1789.

Syn.: *Gordius equinus*, Abildg., 1789; *Filaria equi*, Gmelin, 1789; *Hamularia lymphatica*, Treutler, 1793; *Tentacularia subcompressa*, Zedder, 1800; *Filaria papillosa*, Rud., 1802; *Filaria hominis bronchialis*, Rud., 1819; *Filaria hominis*, Dies., 1851; *Strongylus bronchialis*, Cobb., 1879.

The body is whitish, filiform, pointed posteriorly. The cuticle presents a delicate transverse striation. The mouth is small, round, and surrounded by a chitinous ring, the border of which carries, at the sides, two semilunar lips, and there is on the dorsal as well as on the ventral surface a papilliform process; on the tail, corresponding with each sub-median line, is a conical papilla. The male measures 6 to 8 cm. in length; the posterior extremity ends in a corkscrew spiral; there are on each side four pairs of pre-anal and four or five post-anal papillæ; the spicules are unequal. The female measures 9 to 12 cm. in length and is viviparous; the embryos measure 0·28 mm. in length and 0·007 mm. in breadth.

FIG. 288.—*Setaria equina:* left, male; right, female. Natural size. (After Railliet.

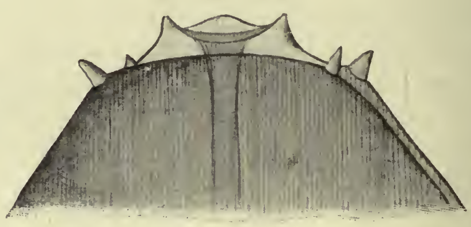


FIG. 289.—*Setaria equina:* anterior end, magnified. (After Railliet.)

Setaria equina is a frequent parasite of horses and asses; it inhabits the peritoneal cavity, and from there occasionally invades the female genitalia or even the liver; it is found more rarely in the pleural cavity or in the cranium. The statement that it also occurs in the subcutaneous connective tissue is probably due to confusion with *Setaria* (*Filaria*) *hæmorrhagica*, Raill., 1885 (*Filaria multipapillosa*, Cond. et Drouilly, 1878). *Setaria labiata papillosa* (immature form) occurs in the eye of the horse, adults in the peritoneal cavity.

Treutler, in 1790, found a filaria in the enlarged bronchial lymphatic gland of a patient suffering from phthisis. It measured 26 mm. in length and had two spicules, which Treutler mistook for mouth hooks, hence the name *Hamularia*. Blanchard mentions another case from Geneva, Brera a third and v. Linstow a fourth. As shown by the synonyms, a few authors consider this form to be a distinct species, which is hardly probable.

Genus. **Loa**, Stiles, 1905.

Characterized by the possession of cuticular bosses in both sexes (fig. 294).

Loa loa, Guyot, 1778.

Syn.: *Filaria oculi*, Gerv. et v. Ben., 1859; *Dracunculus oculi*, Diesing, 1860; *Dracunculus loa*, Cobbold, 1864; *Filaria subconjunctivalis*, Guyon, 1864.

The male measures 25 to 35 mm. in length, and 0·3 to 0·4 mm. in breadth; the cuticle is not striated, but, with the exception of the anterior and posterior extremities (1·5 mm.), is beset with numerous irregularly distributed bosses (4 μ to 12 μ high by 12 μ to 27 μ broad). The anterior extremity is somewhat attenuated, and in front is conical and transversely truncated. At the anterior limit of the conical part is a small papilla corresponding with the dorsal and ventral median lines, and a little in front six non-projecting sensory papillæ (two lateral, four sub-median). Excretory pore 0·65 mm. from the anterior end. The posterior extremity is attenuated and somewhat curved ventrally; the anus is 0·082 mm. distant from the rounded posterior border. In front of the anus on each side are three globular and pedunculated papillæ of different sizes, set close one behind the other but asymmetrically; behind the anus on either side are two smaller papillæ of a different shape; the anterior one resembles the pre-anal papillæ in form, but is smaller; the posterior one is conical, and rests with a broad base on the cuticle. The spicules are 0·113 and 0·176 mm. long.

The female measures 45 to 63 mm. in length by 0·5 mm. in breadth. It is also beset with irregularly distributed bosses, which in places lie close to each other, and extend to the anterior extremity; posteriorly they become less frequent, but are not entirely absent. The anterior extremity is conical, the posterior one straight, attenuated, rounded off, 0·17 mm. from the anus. The uteri contain eggs in the most various stages of development, as well as hatched-out larvæ, 253 μ to 262 μ in length and 4·7 μ to 5 μ in breadth. The vulva lies about 2 mm. from the head end. The vagina, 9 mm. long, divides into two branches, which at first run posteriorly and parallel to one another for about 18 mm. One then bends forward, runs as far as the œsophagus, bends here again and runs backward to end at the point of its first bending. The other branch at first runs straight backward and then bends forward, but before reaching the point of the first bend of the anterior tube bends backward again, forms again a loop and ends at the level of the anus. The tubes consist in

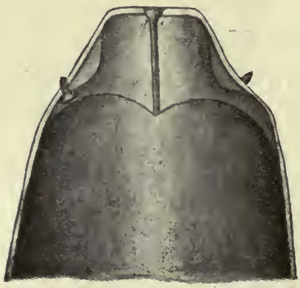


FIG. 290. — *Loa loa:* the anterior end of the male, magnified. (After R. Blanchard.)

FIG. 291.—*Loa loa:* anterior portion of the female as far as vulva. (After Looss.)

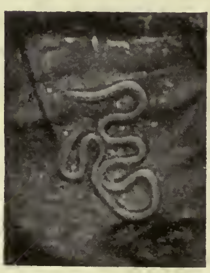


FIG. 292.—*Loa loa* in situ. Natural size. (After Fülleborn and Rodenwaldt.)

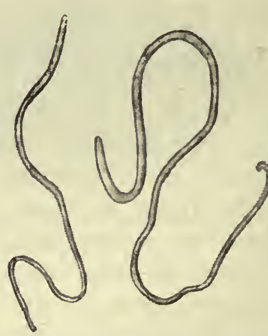


FIG. 293.—*Loa loa:* male on the left, female on the right. ×2. (After Looss.)

the main of the uterus, then a club-shaped swelling, the receptaculum seminis, then the oviduct 2 mm. long, and finally the ovary.

Unsegmented eggs measure 32 μ by 17 μ, in the morula stage 40 μ by 25 μ, and when containing embryos 50 μ by 25 μ. The vitelline "shell" of the egg is, according to most authors, stretched by the embryo and becomes the sheath of the hatched larva. While

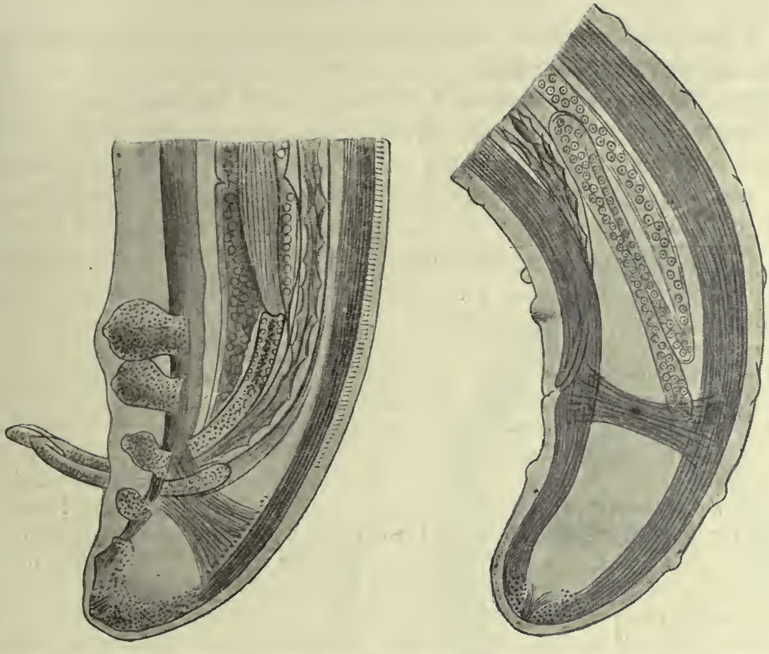


FIG. 294.—*Loa loa:* on the left, the hind end of a male; on the right, of a female. Note the cuticular bosses shown in the figure of the female. × 285. (After Looss.)

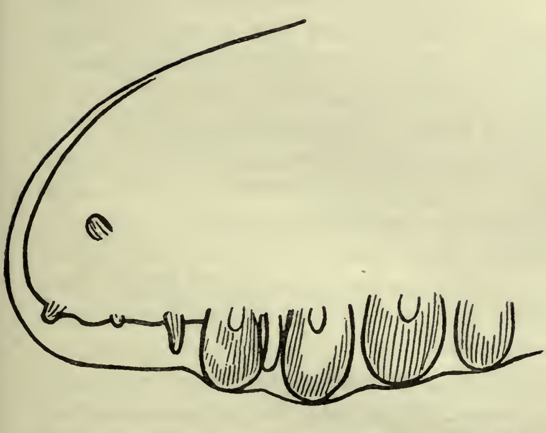


FIG. 295.—*Loa loa:* lateral view of tail of male showing papillæ. (After Lane and Leiper.)

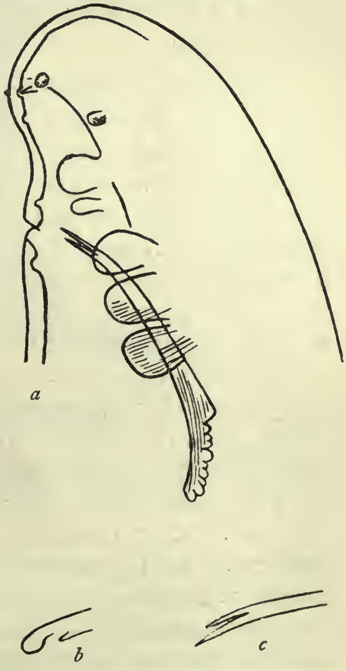


FIG. 296.—*Loa loa.* *a*, ventro-lateral aspect of tail showing papillæ and one spicule; *b* and *c*, terminations of the two spicules. (After Leiper.)

still in the vulva, the larva measures 217 μ to 274 μ (average 246 μ) in fresh, 146 to 226 μ (average 192 μ) stained.

Site of Worms.—In various localities; under the muscular aponeuroses on extensor surfaces of arms and legs, fingers, trunk, eyelid, conjunctiva, frænum linguæ, penis, pericardium, anterior chamber of eye, and, according to some authorities, in lymphatic vessels, *e.g.*, those of spermatic cord. As many as thirty adults may be found. The worms appear to be frequently immature, and it has been stated that worms in superficial parts are immature, those situated deeply are mature, but the data are few.

The first accounts of *Loa loa*—long since forgotten—were reported by Pigafetta, and are contained in a book of travels on the Congo printed in 1598. In an accompanying illustration is depicted, not only the ancient method of extraction of the Medina worm, but also the operative removal of the filaria from the conjunctiva. Subsequently the presence of the worm in negroes was confirmed by Bajon in Guiana (1768) and by Mongin in Mariborou (San Domingo), likewise in a negro (1770). At about this time a French ship's doctor, Guyot, was cruising on the West Coast of Africa; he observed the parasite termed "loa" by the natives, and learned that it was frequent in the negroes of the Congo district. Since that time numerous observations have been reported. It was formerly common in South America, where the parasite was imported by slaves, but it disappeared when the traffic ceased; it was particularly prevalent in the Congo, where it occurs not only in natives, but also in Europeans. During recent times it has repeatedly been observed in Europe in negroes as well as in white men who have lived on the West Coast of Africa.

Nematodes of different size have been repeatedly observed in the eye of man, in the anterior chamber, lens and vitreous. For example, Mercier, in 1771 and 1774, removed a filaria out of the anterior chamber of two negroes in St. Domingo. One was 36 mm. long. Barkan, in 1876, in San Francisco, removed one from the eye of an Australian. Again, Cappez and Lacompte, in Brussels, in 1894, observed for some weeks immature Nematodes in the eye of a negro girl, aged 2½ years, and then removed them. What these Nematodes actually were in these cases it is impossible to say.

Structure of Larvæ.—In dried films the larva varies in size from 140·5 μ to 166·5 μ, average, 152·5 μ; while another set of measurements gave the values 131 μ to 150 μ, average, 143·6. In films fixed with hot alcohol the dimensions were 208 μ to 254 μ, average, 231 μ.

The nerve ring 21·4 to 21·8 per cent. Excretory pore 30·4 to 31·8 per cent. Excretory cel 34·8 to 37·3 per cent. G1 cell 68·2 to 68·5 per cent. Anal pore 81·6 to 82·4 per cent of total length. For other details *cf. Filaria bancrofti.*

Larvæ in Blood.—These from their diurnal periodicity are known as *Mikrofilaria diurna.* The evidence that these larvæ are the young of the adult worm *Loa loa* is: (1) They are identical in structure with larvæ taken from the uterus of *L. loa;* (2) their geographical distribution is the same as that of *L. loa;* (3) they eventually occur in the blood of patients suffering from Calabar swellings, a condition due to *L. loa.* Their occurrence in the blood in this latter condition and in *L. loa* infections we shall consider later.

Periodicity.—Here, as in the case of the larvæ of *Filaria bancrofti*, the larvæ that appear in the blood are probably the overflow simply of the larvæ which we assume, on analogy, to have their principal site in the lungs. They appear in the blood about the time of getting up, 6 to 8 a.m. (10 in 20 $mm.^3$), at 12 noon there are twenty-four, at 8 p.m. the number has fallen to eighteen, and at midnight to one, while from 2 a.m. to 6 a.m. none, or one only, may be found. This periodicity is, as a rule, a very constant one, but there are exceptions, and in certain cases more have been found at midnight than at 9 a.m. The periodicity is also lost in pathological conditions, *e.g.*, sleeping sickness (*vide* also under *Filaria bancrofti*). The possibility of non-periodic *Loa loa* larvæ should also be considered.

FIG. 297.—*Mf. loa:* in thick film, dried and stained with hæmatoxylin. × 1,000. (After Fülleborn.)

Pathology.—The parasite wanders about the body, and may be seen under the skin in thin parts. Their advance is in some cases at the rate of an inch in two minutes. During their progress they give rise to creeping sensations and to a condition of transient œdematous areas known as Calabar swellings on various parts of the body, *e.g.*, arm. These vary in diameter from 1 to 10 cm., and often shift their position an inch or so a day. They give rise to a certain amount of redness, tension and heat, and their development is promoted by muscular action of the part. They disappear to reappear elsewhere. The condition is associated with a high eosinophilia, 50 per cent. being not uncommon. Patients known to harbour

L. loa, e.g., native children, frequently show no larvæ in their blood, but they may do so after years of infection. Again, in patients having an infection of *Mikrofilaria diurna*, there is frequently at the time no evidence of the presence of *Loa loa* adults. Here again they may appear later, but the conditions which determine whether persons infected with *L. loa* show larvæ in the blood, or persons infected with *Mikrofilaria diurna* also show *L. loa*, are unknown, though explanations unsupported by facts abound. Likewise also the mode of production of the swellings is unknown.

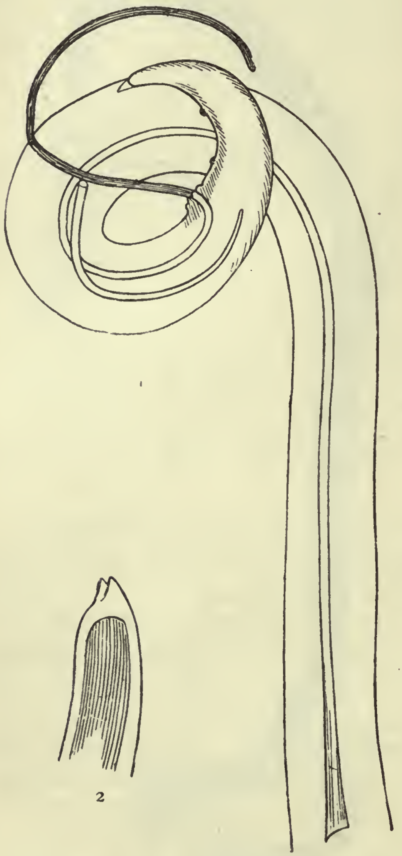


FIG. 298. — *Acanthocheilonema perstans*. 1, tail of male; 2, tail showing cuticular flaps devoid of fleshy contents. (After Leiper.)

Not uncommonly *Mikrofilaria perstans* occurs in the blood together with *M. diurna*.

Duration of Life.—This is long, as some cases have been observed five to six years after leaving Africa. The incubation period is about a year.

Life-history.—Development of the larvæ takes place in the salivary glands of Chrysops sp. as shown by Leiper.

Geographical Distribution. — West Africa, especially in Congo.

Genus. **Acanthocheilonema**, Cobbold, 1870.

Cuticle striated *longitudinally*. Œsophagus divided into two portions. Tail in both sexes with short lateral conical cuticular appendages. Spicules unequal, the larger membranous distally, the smaller hooked. Vulva in œsophageal region.

Acanthocheilonema perstans, Manson, 1891.

Syn.: *Filaria perstans*, P. Manson, 1891; *Filaria sanguinis hominis* var. *minor*, Manson, 1891.

The adult female *Ac. perstans* measures 70 to 80 mm. in length by 120 μ to 140 μ in breadth. The head is club-shaped and measures 0·07 mm. in diameter. The vulva opens at 0·6 to 1·0 mm. from the head. The tail is curved and presents a cuticular thickening which forms two triangular appendages. The anus opens at the apex of a papilla situated in the concavity of the curve formed by the tail 150 μ from the end. The diameter of the tail just before termination is 0·02 mm.

FIG. 299.—*Mf. perstans* in thick film, dried and stained with hæmatoxylin; 4, unshrunken; 5, shrunken. × 1,000. (After Fülleborn.)

The adult male measures 45 mm. in length by 60 μ to 80 μ in breadth. The diameter of the head is 0·04 mm. The tail is much curved. There are four pairs of pre-anal papillæ and two pairs of post-anal papillæ. Spicules very unequal in size. Cloaca 121 μ from the tail end. At the tail end two triangular cuticular appendages.

The adult worms inhabit the connective tissue at the base of the mesentery, especially in the region of the pancreas, abdominal aorta and suprarenals. To find them the mesentery should be removed, placed in a 2 per cent. solution of formalin, and then carefully examined at leisure.

Mikrofilaria perstans.—160 μ to 210 μ by 5 μ to 6 μ broad. Has no sheath. Cuticle transversely striated. Tail rounded off, not pointed. Nerve ring at 34 μ. Excretory pore 49 μ, genital pore 125 μ from head. Smaller larvæ 90 μ to 110 μ by 4 μ broad. A "fang" is also described on the head.

Mf. perstans.	*Mf. demarquayi.*
(1) Tail stumpy.	(1) Tail pointed.
(2) Column of nuclei extends to tip of tail.	(2) Does not extend to tip.

Periodicity.—None.

Life-history.—Unknown.

Geographical Distribution.—Very common in many parts of Africa: Sierra Leone, Dahomey, Northern Nigeria, Southern Nigeria, Cameroons, Ivory Coast, Gold Coast, Old Calabar, Congo, Uganda. Absent from Zululand, Basutoland. On the East Coast of Africa it is not found in the towns of Zanzibar and Mombasa, neither is it found in the country of the Masi, nor amongst the Kavirondo, who dwell along the north-east shores of Lake Victoria.

In South America, *Ac. perstans* is very common amongst the aboriginal Indians in the interior of British Guiana. However, it is not found in Georgetown and in New Amsterdam, neither is it found in the cultivated strip of coast lying between these two towns, but it is common on the coast farther north near the Venezuelan boundary, where the forests stretch to the sea. The Waran Indians, who live at the mouth of the Waini river, harbour this parasite. It is absent in the West Indies.

Topographically, *Ac. perstans* is found only in areas covered by dense forest growth and abounding in swamps. In Kavirondo, where the forest disappears and the land is covered with scrub and short grass, it is not found; likewise it is not found on the grassy plains of the highlands of British East Africa. Towns and cultivated areas are free from it.

Genus. **Dirofilaria.** Railliet and Henry, 1911.

Body very long, thread-like, cuticle transversely striated. Mouth with six papillæ. Male tail spiral with voluminous pre-anal and some large post-anal papillæ; spicules unequal. Vulva near the anterior hundredth of body; viviparous. Parasitic in heart or blood-vessels and subcutaneous tissue.

Dirofilaria magalhãesi, R. Blanchard, 1895.

Syn.: *Filaria bancrofti*, v. Linstow, 1892; *Filaria bancrofti*, P. S. de Magalhães, 1892 (*nec* Cobbold, 1877).

The male measures 83 mm. in length by 0·28 to 0·40 mm. in breadth. The anterior extremity is rounded, and has no papillæ (? 6); the posterior extremity exhibits a double curve, with four pre-anal and four post-anal papillæ on each side. These are large and have a villous appearance. The mouth is round and unarmed, the pharynx measures 1 mm. in length, is cylindrical, very muscular, and its hinder part is dilated. The anus is situated 0·11 mm. in fron of the hind end. There are probably two unequal spicules; one only, however, is known —apparently the shorter one—the length of which is given as 0·17 to 0·23 mm.

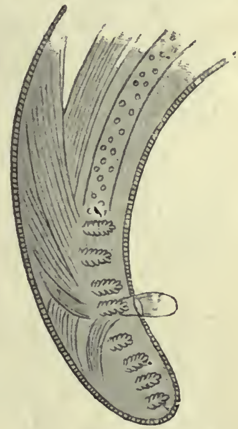


FIG. 300.—*Dirofilaria magalhäesi*: posterior extremity. (After v. Linstow.)

The female measures 155 mm. in length and 0·6 to 0·8 mm. in breadth; the rings of the cuticle are 0·005 mm. apart (in the male 0·003 mm. apart); the anterior extremity is slightly thickened and club-like, the posterior extremity is slender, and terminates obtusely; the lateral line is 0·127 mm. in breadth (that of the male 0·007 to 0·008 mm.); the anus opens 0·13 mm. in front of the hind end, the vulva is 2·5 mm. distant from the mouth, the ovaries are two much convoluted tubes. The eggs measure 38 μ by 11 μ.

This species was first discovered at a *post-mortem*, in the left ventricle, by J. P. Figueira de Saboia in Rio de Janeiro, and has been described by P. S. de Magalhães.

D. immitis occurs in the right ventricle of the heart of the dog in Europe and the Tropics.

D. repens is also a common subcutaneous Nematode in dogs in Annam.

Sub-family. Onchocercinæ, Leiper, 1911.

Cuticle with spiral thickenings.

Genus. Onchocerca, Diesing, 1841.

Male with four pre-anal papillæ. Female with vulva situated anteriorly.

Onchocerca volvulus, R. Leuckart, 1893.

Syn.: *Filaria volvulus*, R. Leuckart, 1893.

The adult male measures 30 to 35 mm. in length by 0·14 mm. in breadth. The body is white, filiform, attenuated at both ends. The head is rounded and has a diameter of 0·048 mm. The cuticle is distinctly transversely striated. The mouth is unarmed. The alimentary canal is straight, the anus opening 0·07 mm. from the tip of the tail. The tail is strongly curved and somewhat flattened on the concave surface. There are three papillæ, one large and two small, on each side of the cloaca and one large and two post-anal small papillæ. Two curved spicules, 0·166 and 0·08 mm. respectively.

The adult female is of uncertain length, but much longer than the male, probably about 10 to 12 cm. The head is rounded and truncated; it measures 0·065 mm. in diameter. The tail is curved. The vulva opens 0·55 mm. from the head. The hand-like cuticular thickenings are well marked. Eggs ovoid with a prolongation at each pole "like an orange wrapped in tissue paper." The larva measures about 300 μ by 7 μ to 8 μ; it has no "sheath." The body tapers from about the last fifth of its length, and terminates in a sharply pointed tail. At about the anterior fifth of the body there is a **V** spot.

O. volvulus is found in peculiar subcutaneous tumours, the size of a pea to that of a pigeon's egg. The same patient may present one or several of these tumours. The regions of the body most frequently affected are those in which the peripheral lymphatics converge. Thus they are usually found in the axilla, in the popliteal space, about the elbow, in the sub-occipital region and in the intercostal spaces. The tumours are never adherent to the surrounding structures, and can be easily enucleated. They are formed of a dense connective tissue wall and internally a looser fibrous meshwork. This is traversed by a series of canals in which the worms lie, but they are also partly embedded in the denser wall. The canals apparently dilate into cavities filled with slimy pus-like fluid consisting largely of larvæ. According to Brumpt the posterior extremity of the male, and the anterior extremity of the female with its vaginal opening, are free in one of the spaces for the purpose of copulation and parturition. If a tumour be cut into and placed in salt solution, Rodenwaldt states that the undamaged males wander out into the solution.

The formation of the tumours is elucidated by Labadie-Lagrave and Deguy's case. The authors found an immature female *Onchocerca volvulus* in a lymphatic vessel partly obstructed by an infiltration of fibrin and leucocytes. It appears, therefore, that the presence of the parasites within the lymphatics gives rise to an inflammatory process, and that the consequent fibrinous deposit envelops the parasites, obliterates the lumen of the vessel, and ultimately isolates the affected tract. At any rate, in young tumours the worms appear to lie in a structureless substance permeated by leucocytes in which connective tissue is gradually organized from the periphery, thus isolating the worms.

In cases of infection with *O. volvulus* larvæ have been found by Ouizilleau, Fülleborn, and Simon in lymph glands, and in the finger blood if considerable pressure is used so as to squeeze lymph out of the tissues. They are *sheathless*, and the following are the dimensions in ordinary dried films: Length, 274 μ; nerve ring, 23·7 per cent.; G1 cell, 69·6 per cent.; end of last tail cell, 96·3 per cent. The dimensions of larvæ of *O. volvulus* taken from the uterus and prepared in the same way are: Length, 224·5 μ; nerve ring, 24·3 per cent.; G1 cell, 68·9 per cent.; end of the last tail cell, 95·5 per cent. In all probability the larvæ in the glands and blood are those of *O. volvulus.*

According to the natives, the tumours may last indefinitely and never ulcerate. Some old patients told Brumpt that their tumours had been present since childhood. Probably *Onchocerca volvulus,* like some other *Filariidæ,* may live for many years.

O. volvulus occurs in various parts of West Africa: Gold Coast, Sierra Leone, Dahomey, Lagos, Cameroons. Brumpt, on the banks of the Welle between Dongon and M'Binia (Belgian Congo), found about 5 per cent. of the riverine population affected.

Family. **Trichinellidæ**, Stiles and Crane, 1910.

Sub-family. **Trichurinæ**, Ransom, 1911.

Male with a single long spicule, with sleeve-like sheath. One ovary. Eggs with an opening at each pole closed by a plug-like operculum. Eggs hatch on being swallowed by a new host. Genera: Trichuris, Capillaria.

Genus. **Trichuris**, Röderer and Wagler, 1761.

Syn.: *Trichocephalus*, Goeze, 1782 (*nec Trichiurus*, L., 1758); *Mastigodes*, Zeder, 1803.

The anterior part of the body is very long and thread-like; the posterior, much shorter part, is thicker, rounded posteriorly, and the anus is terminal. The males have the posterior extremity spirally rolled; the vulva is situated at the commencement of the posterior part of the body. The Trichocephali live in the large intestine of mammals, the cæcum by predilection; their development is direct, infection occurs through the ingestion of embryo-containing eggs.

Trichuris trichiura, Linnæus, 1761.

Syn.: *Trichocephalus trichiurus*, L., 1771; *Ascaris trichiura*, L., 1771; *Trichocephalus hominis*, Schrank, 1788; *Trichocephalus dispar*, Rud., 1801.

The male measures 40 to 45 mm. in length, the spicule is 2·5 mm. long, its retractile sheath is beset with spines. The female measures 45 to 50 mm. in length, of which two-fifths appertain to the posterior part of the body. The ova are barrel-shaped and have a thick brownish shell which is perforated at the poles. Each opening is closed by a light-coloured plug. The eggs measure 50 μ to 54 μ in length and 23 μ in breadth; they are deposited before segmentation. *Trichuris trichiura* usually lives in the cæcum of man, and is also occasionally found in the vermiform appendix and in the colon, exceptionally also in the small intestine; usually only a few specimens are present, and these do not cause any particular disturbance, although, as Askanazy found, they feed on blood; in other cases cerebral symptoms of more or less severity are observed when Trichocephali are present in large numbers. At *post-mortems* performed soon after death the filiform anterior extremity of the worm is frequently found embedded in the mucous membrane (Askanazy).

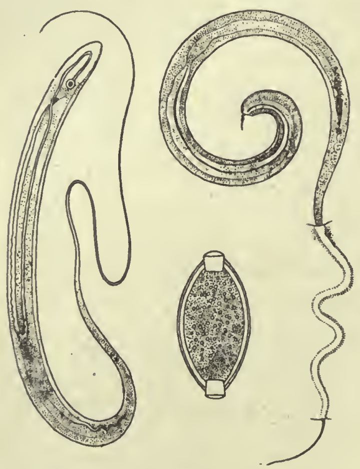


FIG. 301.—*Trichuris trichiura*: on the left, male; on the right, female with the anterior extremity embedded in the mucous membrane of the intestine; below, egg.

The whip worm is one of the most common parasites of man and appears to be distributed over the entire surface of the globe; it is, however, more frequent in the warmer regions. It is found in persons of both sexes and all ages with the exception of infants. In autopsies it is found in the following numbers: In Dresden in 2·5 per cent., in Erlangen in 11·1 per cent., in Kiel in 31·8 per cent., in Munich in 9·3 per cent., in Petrograd in 0·18 per cent., in Göttingen in 46·1 per cent., in Basle in 23·7 per cent., in Greenwich in 68 per cent., in Dublin in 89 per cent., in Paris in about 50 per cent., and in Southern Italy in almost 100 per cent. On examining the fæces the eggs of the whip worm were found as follows: In Munich in 8·26 per cent., in Kiel in 45·2 per cent., in Greifswald in 45 per cent., in North Holland in 7 per cent., in Novgorod in 26·4 per cent., in Petrograd in 5 per cent., in Moscow in 5·3 per cent.

The development of the eggs is completed in water or in moist soil, and occupies a longer or shorter time according to the season; the eggs possess great powers of resistance, as do the larvæ, which, according to Davaine, may remain as long as five years in the egg-shell without losing their vitality. Leuckart proved by experiment that direct infection with *Trichuris ovis* (*Ovis aries*) and *T. crenata* (*Sus scrofa dom.*) was produced by embryo-containing eggs; Railliet obtained the same results with *T. depressiuscula* of dogs, and Grassi subsequently, by means of two experiments, demonstrated the direct development of *Trichuris trichiura*. In one case embryo-containing eggs were swallowed on June 27, 1884, and on July 24 the ova of Trichocephali were found in the fæces for the first time.

Trichuris trichiura is found not only in man, but also in various monkeys (*T. palæformis*, Rud.), as well as in lemurs (*T. lemuris*, Rud.).

Other species are *T. crenata* in pig; *T. ovis* in cattle, sheep, goat, and pig (?); *T. depressiuscula* in dog; *T. campanula* in cat; *T. unguiculata* in rabbit and hare; *T. cameli* in camel; *T. discolor* in humped cattle; *T. nodosus* in mouse; *T. alcocki* in the thamin (India); *T. globulosa* in camel; *T. giraffæ* in giraffe.

Sub-family. **Trichinellinæ**, Ransom, 1911.

Male without spicule; females ovoviviparous. Larvæ penetrate muscles of host and become encysted. Genus: Trichinella.

Genus. **Trichinella**, Railliet, 1895.

Syn.: *Trichina*, Owen, 1835 (*nec* Meigen, 1830).

Very small *Trichinellinæ*, the males of which have two conical appendages at the caudal extremity; the vulva is situated at the border of the anterior fifth of the body. There is only one species.

Trichinella spiralis, Owen, 1835.

Syn.: *Trichina spiralis*, Owen, 1835.

The male measures 1·4 to 1·6 mm. in length and 0·04 mm. in diameter. The anterior part of the body is narrowed, the orifice of the cloaca is terminal and lies between the two caudal appendages; internal to these are two pairs of papillæ, dorsal one behind the other. The cloaca is evertible for copulation. The females measure 3 to 4 mm. in length and 0·06 mm. in diameter; anus terminal.

Trichinella spiralis in its adult stage inhabits the small intestine of man, pig, wild boar, rat. The young do not leave the body of the host but become encysted in the muscles. Experimentally it develops in the black rat (*Mus rattus*), the sewer rat (*M. decumanus*), the domestic pig (*Sus scrofa dom.*), the wild boar (*Sus scrofa ferox*), the domestic dog (*Canis familiaris*), the fox (*C. vulpes*) the badger (*Meles taxus*), the polecat (*Putorius fœtidus*), the marten (*Mustela foina*), the raccoon (*Procyon lotor*), the hippopotamus and the cat, and many other mammals (rodents and carnivora); Trichinellæ have been artificially introduced, by administering the encysted stage, into the dog, the mole (*Talpa europæa*), the mouse (*Mus musculus*), the hare (*Lepus timidus*), the rabbit (*L. cuniculus*), the hedgehog (*Erinaceus europæus*), the marmot (*Cricetus vulgaris*), the vole, the dormouse, the sheep, the calf, the horse, etc. Human beings and the pig, rat, mouse, guinea-pig and rabbit are most easily infected; less easily the sheep, calf and horse; with difficulty the cat, dog and badger. Trichinella can also be reared in birds (fowl, pigeon and duck), but the young do not encyst in the muscular system, but are expelled with the fæces. By cold-blooded animals as well as by insects (*Calliphora vomitaria*)

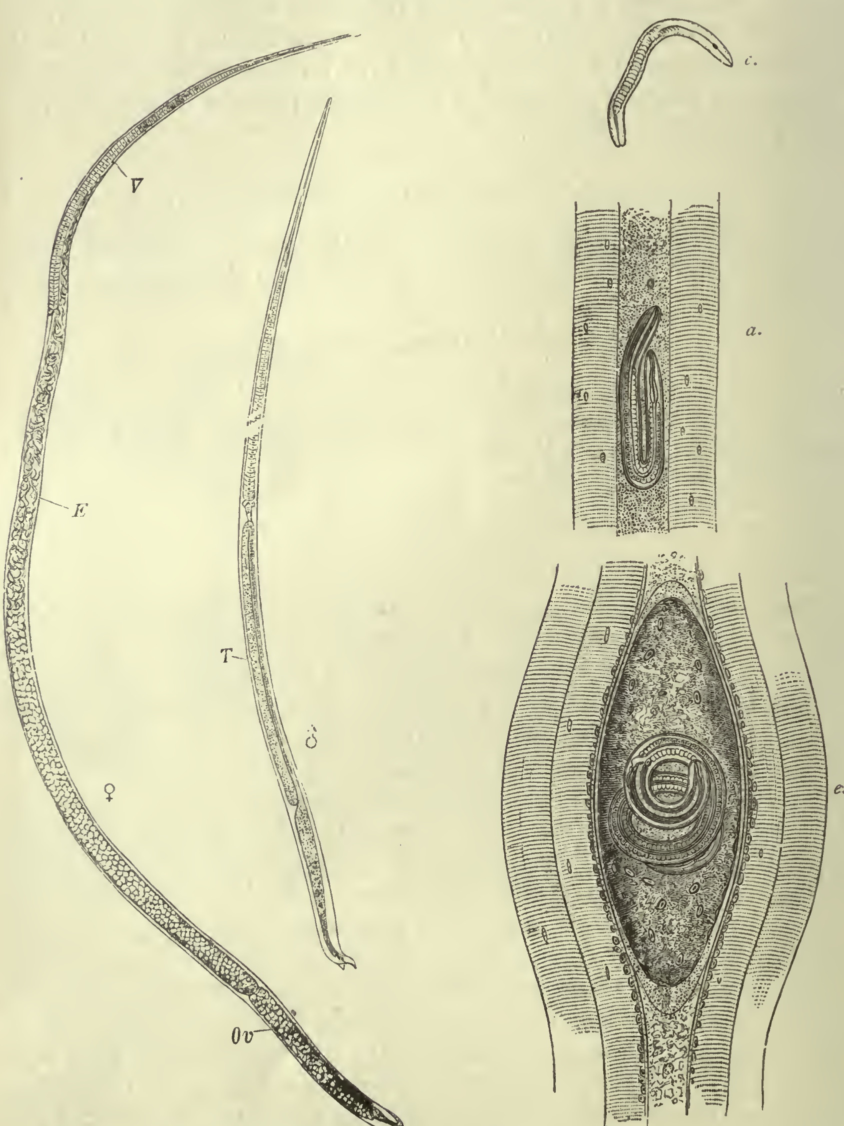


FIG. 302.—*Trichinella spiralis*. ♀, mature female : *E*, embryos ; *V*, vulva ; *Ov*, ovary. ♂, mature male : *T*, testes. *c.*, newly born larva. *d.*, larva in the muscles. *e.*, encapsuled larva in the muscles. Magnified. (After Claus.)

encysted Trichinellæ are evacuated without undergoing any change, but they will still develop if subsequently ingested, say, by rabbits. According to Gujon, however, Trichinella can develop in salamanders, because he has found Trichinella of the muscles in these animals after they had been fed on encysted specimens. A high temperature (30° C.) must be provided in which to keep the experimental animals to ensure the success of the infection.

History.—Encapsuled Trichinellæ had been observed in London by Peacock (1828) and by J. Hilton (1833) in the muscular system of man; soon after (1835), Paget found them in London in an Italian who had died of tuberculosis, and recognized them to be encysted entozoa, which R. Owen described as *Trichina spiralis.* Soon after, some further observations were reported on the occurrence of encysted Trichinellæ, in man, in England, Berlin, Heidelberg, Denmark, North America; they were also found in the pig (Leidy, Philadelphia) and the cat (Herbst, Göttingen, and Gurlt, Berlin). Herbst even succeeded in infecting a badger with encysted Trichinellæ, and subsequently infected two dogs with the flesh of this badger (1850). In 1855 R. Leuckart (Giessen) also commenced feeding experiments, and, like Küchenmeister and Virchow (1859), first went on the wrong track because it was believed at that time that Trichinellæ were the larvæ either of Trichocephalus or Strongylus. Nevertheless, these experiments yielded some important results; they showed that Trichinellæ become adult in the intestine within a few days, and that the females are viviparous (Leuckart). Until that time Trichinellæ had been regarded as fairly harmless guests of man, but opinions soon changed when Zenker in Dresden (January, 1860), in performing the autopsy of a girl, aged 10, who had entered the hospital with typhoid symptoms and there died, found Trichinellæ (not yet encysted) in the muscles; the intestinal lesions characteristic of typhoid were lacking, but numerous adult Trichinellæ were found in the intestine. Inquiries elicited the fact that at about Christmas time the girl had been taken ill after eating pork, and at the same time the butcher from whom the meat was brought as well as several of his customers fell sick: the pickled pieces of the same meat were full of Trichinellæ. In the face of this information it was not difficult to ascertain the cause of the disease and the manner of infection in Zenker's case, and it was not long before Leuckart, Virchow and Zenker were able by renewed experiments to demonstrate the cycle of development of *Trichinella spiralis.* Similar investigations followed by Claus in Würzburg, Davaine in Paris, Fuchs and Pagenstecher in Heidelberg, etc.

Hardly had Zenker's case been published than numerous observations on trichinosis in man appeared, some referring to isolated cases, others to small or great epidemics, and nearly all from North Germany. The worst epidemic was that of Hadersleben (1865), in which place, numbering hardly 2,000 inhabitants, 337 persons were taken ill within a short time, and of these 101 died. The source of infection proved to be a single pig, the flesh of which had been mixed with that of three other pigs; 200 of the badly infected persons had exclusively eaten raw pork.

Moreover, it soon became clear that epidemics of trichinosis had been observed in Germany prior to 1860, but that their nature had not been recognized, although in a few cases Trichinellæ had been found in the muscles of those who had succumbed.

History of the Development of *Trichinella spiralis.*

Shortly after their introduction into the intestine of experimental animals the encysted Trichinellæ escape from their capsules, which are destroyed by the gastric juices, and they then enter the duodenum and jejunum, where they become adult. During this period they do not grow much, the males from 0·8 to 1·0 to 1·2 to 1·5 mm.; the females to 1·5 to 1·8 mm. Soon after copulation, which takes place in the course of two days, the males die; the females, which during the following days attain a length of 3 to 3·5 mm., either bore more or less deeply into the villi or, by means of Lieberkühn's glands, into the mucous membrane (Askanazy, Cerfontaine, Geisse), and thus usually attain the lymph spaces. A few also pierce the intestinal wall and are then found in the mesentery and glands. The females deposit their young, the number of which, according to Leuckart, averages at least 1,500, in the lymph spaces; the newly born larvæ measure 90 μ to 100 μ in length, 6 μ in diameter, and they do not appear to increase in size during their migrations. The migrations are mostly passive, that is to say, the larvæ are carried along mainly by the lymph stream to the heart, but sometimes they are active, as may be inferred from the fact that young Trichinellæ are found in various parts of the intestinal wall beyond the chyle and lymph spaces, as well as in abundance in the abdominal cavity. Trichinellæ occur in the heart's blood of artificially infected animals seven to twenty-three days after infection. If scanty, dilute the blood with about ten times the amount of 3 per cent. acetic acid and centrifugalize.

The young brood is distributed from the heart throughout the entire body, but the conditions necessary to its further development are found only in striated muscle; the young Nematodes penetrate the capillaries, attain the intramuscular connective tissue and then invade the fibres (Virchow, Leuckart, Graham[1]). On the ninth or tenth day after infection the first Trichinellæ have reached their destination; but further invasions are constantly taking place because the intestinal Trichinellæ live from five to seven weeks, and continue to produce their young.

Symptoms.—(1) Period of invasion: Gastro-intestinal symptoms—nausea, vomiting, watery diarrhœa, colic. Muscular pains may occur even at this period. Recurrent abdominal pains about the eighth day, a *temporary* œdema. Embryos are abundant in the serous cavities.

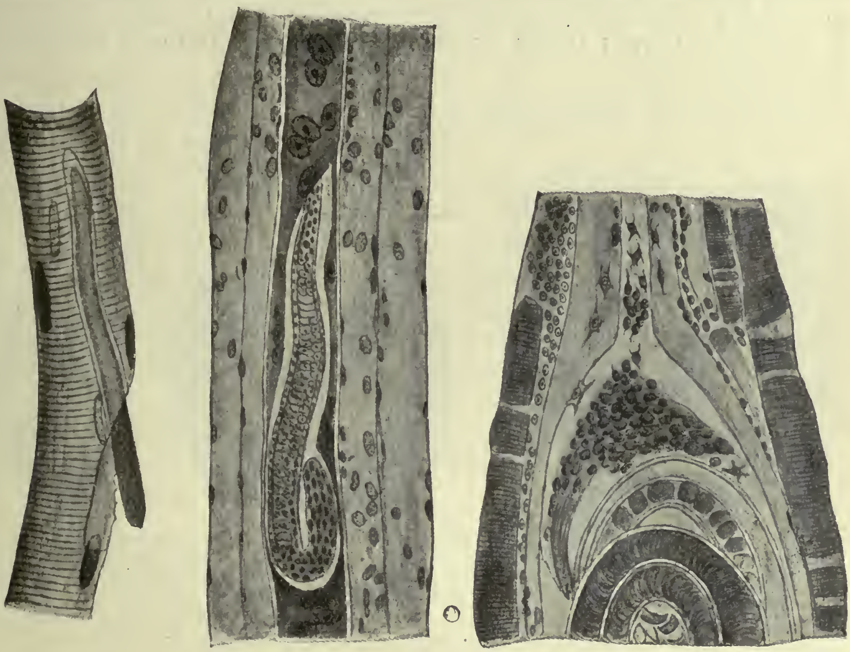
(2) Period of dissemination: Second week. Myositis, variable in amount, is the predominant symptom. The biceps and calf may be hard and tender. Mastication, speech, respiration, etc., may be difficult and painful. Dyspnœa may be intense. Temperature 104° to 105° F.

[1] Trichinellæ that are unable to penetrate into muscular fibres invariably die, no matter where else they settle; their occurrence in the adipose tissue is disputed, but is still possibly correct, as bundles of muscles are present in the fat of bacon. The Trichinellæ do not settle in heart muscle, although they may reach it in cases of heavy infection; they then die or wander into the pericardium, and eventually into the heart cavities.

(3) Period of encystment: Symptoms of marked cachexia. Third week: Second period of œdema, especially of face. Delirium, somnolence, lung affections. Death or gradual subsidence of symptoms in mild cases.

Eosinophilia (50 per cent. or more) is present.

In consequence of the new batches of young produced during several weeks, the above-mentioned symptoms of disease are often considerably aggravated; the fever increases, delirium may arise, and infiltration of the lungs, fatty degeneration of the liver and inflammation of the kidneys may ensue; the initial slight œdema



A. B. C.

FIG. 303.—*A.*, isolated muscular fibre of a rat, invaded by Trichinella. 510/1. *B.*, section through the muscle of a rat; the infected fibre has lost its transverse striation; its nuclei are enlarged and multiplied. 310/1. *C.*, portion of a Trichinella capsule, at the pole of which connective tissue cells are penetrating the thickened sarcolemma. (After Hertwig-Graham.)

may extend, the strength dwindles, and in many cases the patients succumb to the trichinosis. In severe cases improvement of the condition is only apt to occur in the fourth or fifth week; the convalescence is always protracted.

The muscular fibres attacked degenerate, the transverse striation at first disappearing; the fibres then assume a granular appearance, the nuclei multiply and become enlarged, and are surrounded by an area of granular material, which stains more deeply than the remaining contents of the sarcolemma. Two or three weeks after infection, the spirally rolled-up Trichinellæ have grown to 0·8 to 1·0 mm., and in their vicinity the muscular fibre is swollen, spindle-shaped, and the sarcolemma is glassy and thickened. The inflammation also extends to contiguous fibres, especially to the intramuscular tissue, which proliferates greatly, especially in the vicinity of the degenerated fibres. While the latter become more and more absorbed, the capsule is formed by the inflamed connective tissue, which, penetrating into the glassy and thickened sarcolemma from the poles of the spindle, forms the cystic membrane. According to other authorities, the larvæ settle in the *inter*muscular connective tissue which forms the cyst and not in the muscular fibres within the sarcolemma. The cysts are lemon-shaped and usually lie with their longitudinal axis in the direction of the muscular fibres; on an average they measure 400 μ in length by 250 μ in breadth.

Later on fat cells appear at their poles, and after about six or nine months they commence to calcify, the process starting at the

FIG. 304.—Calcified Trichinella in the muscular system of a pig; the capsules are not calcified. (After Ostertag.)

FIG. 305.—Various phases of the calcification of Trichinella of the muscles, which starts at the poles of the capsule.

poles (fig. 305). Finally, sometimes after the lapse of years, the captive Trichinellæ themselves become calcified.

According to experience, Trichinellæ are not evenly distributed in the muscular system of pigs; the diaphragm, the muscles of the larynx, tongue, abdomen and intercostal spaces are their favourite positions; this predilection for the respiratory muscles is explained by their regular contractions, owing to which regular narrowings of the capillaries take place, thus favouring the settling of the circulating Trichinellæ. The same circumstance probably explains the frequency of the parasites in the tongue.

Possibly also the Trichinellæ that bore direct through the intestine may, from the abdominal cavity, penetrate the muscles in the vicinity. Frequently also encysted Trichinellæ are found in remarkable numbers in the vicinity of the points of insertion of the tendons, this proclivity being probably connected with the fact that the Trichinellæ first of all wander into the muscular fibres and find a natural barrier at the points of insertion of the tendons.

The Trichinellæ, in their encysted condition, may remain alive and capable of development for many years—in the pig eleven years and in man as much as twenty-five to thirty-one years. Encystment, however, is not a necessary condition for the development of the brood, that is to say, Trichinellæ which reach the gut of suitable animals become sexually mature and multiply provided that they have developed so far as to possess a rudimentary genital spot, which occurs when the body is 0·5 to 0·75 mm. long, but all the same a great part of non-encapsuled Trichinæ perish on their passage through the stomach.

The black rat (*Mus rattus*), and more particularly the sewer rat (*Mus decumanus*[1]), are the normal hosts of *Trichinella spiralis*. These animals, especially the last-named species, infect themselves very easily, as they are cannibalistic, and they also transmit trichinosis to other species by which they are devoured, such as pigs, dogs, cats, foxes, bears and martens. Rats are infected also by the ingestion of fæcal matter from infected animals which contains trichinæ (Höyberg). Man becomes infected with Trichinella by eating the flesh, insufficiently cooked, of infected pigs, also, but more rarely, by eating the infected flesh of wild boars, dogs, cats, bears and foxes.

The infection of pigs may likewise take place by their having access to the offal of trichinous pigs, or being actually fed on it. These are, however, exceptions, which, as a matter of course, are of great importance in certain places. As a matter of fact, the rats examined for Trichinella were always found to be severely infected. Thus Billings, in the knackers' yard at Boston, found that 76 per cent. of the rats were infected, and in an export slaughterhouse 100 per cent. were found to harbour the parasite; in the city of Boston 10 per cent. of the rats had trichinosis. Heller found that of 704 rats, from twenty-nine different places in Saxony, Bavaria, Würtemberg and Austria, 8·3 per cent. were infected with Trichinellæ; of the rats caught in the knackers' yards, 22·1 were diseased; of those taken in slaughterhouses, 2·3 were infected, and of rats from other localities only 0·3 per cent. harboured the parasite. Leisering found almost the same figures, but in rats from slaughterhouses 5·3 per cent were infected.

The geographical distribution of *T. spiralis* does not correspond with the occurrence of trichinosis in man; local customs are

[1] It is still a matter of dispute and can hardly be definitely settled whether Trichinellæ were brought to Europe by the sewer rats which invaded Europe at the end of the eighteenth century, or whether they were imported with the Chinese pig in 1820 or 1830, when it was introduced into England and Germany to cross with the native breeds, or whether finally Trichinellæ are also indigenous to Europe.

an important factor; for instance, the custom of eating pork in a condition that does not affect the life of the enclosed trichinella. In places where such customs do not prevail, epidemics do not occur—at the most there are isolated cases of the disease, although there be a great number of infected pigs. The following conditions prevail in North America: In Boston, Billings found that 4 to 5·7 per cent. of the pigs examined were trichinous; Belfield and Atwood found that 8 per cent. were infected in Chicago; Salmon found on an average that 2·7 per cent. were infected (but at various places the percentage fluctuated between 0·28 to 16·3 per cent.), yet epidemics of trichinosis hardly ever occur in North America, and only isolated cases of the disease are met with in German immigrants, who keep to their native customs.

This report, according to the researches of H. U. Williams, must be considerably modified. This author has examined the muscular system of human cadavers according to the method employed by inspectors of meat for pigs. The investigations were conducted in the Pathological Institute of the University of Buffalo, and the observer has examined 505 bodies since 1894, of which 27 (= 5·34 per cent.) were invaded by Trichinella. The cases, according to the nationality, are divided as follows:—

	Examined	Trichinella		Percentage of positive results
		Absent	Present	
Americans:—				
(*a*) Whites	207	201	6	2·89
(*b*) Negroes	70	65	5	7·14
British and Irish	62	57	5	8·06
Canadians	12	10	2	16·66
Germans	49	43	6	12·24
Italians	12	10	2	16·66
Other nationalities ...	27	27	0	0
Nationality unknown ...	66	65	1	1·51
Total	505	478	27	5·34

It is worthy of remark that half of all the positive cases were mental patients, who were found to be affected with Trichinella to well-nigh 12 per cent. Trichinosis was not, however, the cause of death in any case. Very frequently the Trichinellæ were found calcified and dead.

Conditions are similar in most countries of Europe, where, of course, the number of infected pigs is considerably smaller, but the disease depends less on this than on the way in which the pork is prepared.

Cases of trichinosis have been known to occur in nearly all the countries of Europe; further, in Egypt, Algeria, East Africa, Syria, India, Australia, and America. North Germany, more especially the Saxe-Thüringian states, is the classical land for epidemics of trichinosis; the mortality varies, but it may be very high.[1]

Prophylaxis.—The grave nature of the disease and the comparatively high mortality relating to trichinosis led the authorities to adopt certain preventive measures, which are the more necessary as national customs cannot be altered in a short time. As the usual process of pickling and smoking, even when long continued, does not certainly ensure the death of the Trichinellæ contained in the meat, and also because in roasting and boiling large pieces of pork a considerable time is necessary to permit the temperature required to kill off the parasites (62° to 70° C.) to penetrate to the middle of the joint, it appeared to be most practical to have all pigs microscopically examined for Trichinellæ before they, or parts of them, were placed on the market, and all infected meat condemned, no matter whether the Trichinellæ were present in large or small numbers, still undeveloped or calcified. Since 1877 obligatory examination of pork has been introduced in Prussia, though as yet it is not thoroughly carried out; other states of North Germany as well as the larger towns of South Germany soon followed; a complete army of trichina inspectors, officially examined and periodically controlled by experts, and whose number in Prussia amounted to 27,602 in 1896, this being even increased to 28,224 in 1899, have the charge of examining pork on certain lines laid down. These are at the present time uniformly administered. The proceeding is usually that the trichina inspector himself goes to the slaughterhouses, or special samplers take pieces of the muscles that are known to be the favourite seats of the parasite (pillars of the diaphragm, the costal part of the diaphragm, muscles of the tongue and larynx, intercostal and abdominal muscles); six small portions are separated from each piece, pressed between slides or special compressors, and carefully gone through by examining them with a low power of the microscope. The pigs free from Trichinellæ are passed for commerce; trichinous pigs, on the other hand, in Prussia, are only allowed to be used for industrial purposes, *i.e.*, the hide and bristles are used, the fat is allowed to be melted down, or certain parts are used for the manufacture of soap or glue. In Saxony, however, it is still permitted to place trichinous flesh on the market, fully declaring its nature, and after having been heated to its deepest strata at a temperature of 100° C. in a suitable apparatus, and under the supervision of a veterinary surgeon.

AS TO THE PROPORTION OF TRICHINOUS PIGS to healthy ones, the following tables give the figures for Prussia:—

---

[1] For instance, extensive epidemics occurred in Hettstädt in 1863 (160 patients, 28 deaths); Hanover, 1864—1865 (more than 300 patients); Hadersleben, 1865 (337 patients, 101 deaths); Potsdam, 1866 (164 patients); Greifswald, 1866 (140 cases, 1 death); Magdeburg, 1866 (240 cases, 16 deaths); Halberstadt, 1867 (100 cases, 20 deaths); Stassfurt, 1869 (over 100 cases); Wernigerode, 1873 (100 cases, 1 death); Chemnitz (194 cases, 3 deaths); Linden, 1874 (400 cases, 140 deaths); Niederzwohren, near Cassel, 1877 (half the population); Diedenhofen, 1877 (99 cases, 10 deaths); Leipzig, 1877 (134 cases, 2 deaths); Ernsleben, 1883 (403 cases, 66 deaths); Strenz-Neuendorf, 1884 (86 cases, 12 deaths), etc. According to Johne, 109 epidemics, with 3,402 cases and 79 deaths, occurred in Saxony between 1860 and 1889. Stiles, in a work recently published, states that there were 8,491 cases of trichinosis with 513 deaths (6·04 per cent.) in Germany from 1860 to 1880; and 6,329 cases and 318 deaths (5·02 per cent.) between 1881—1898. Of these latter, 1881—1898, 3,822 (225 deaths) occurred in Prussia, 1,634 (76 deaths) in Saxony, and 873 (17 deaths) in the remaining states. There is, however, no doubt that many deaths from trichinosis were not recognized, as proved by experience at *post-mortems*.

Year	Number of pigs examined	Number of trichinous pigs	Proportion
1878	2,524,105	1,222	1 : 2,065
1879	3,164,656	1,938	1 : 1,632
1881	3,118,780	1,695	1 : 1,839
1882	3,808,142	1,852	1 : 2,056
1883	4,248,767	2,199	1 : 1,932
1884	4,611,689	2,624	1 : 1,741
1885	4,421,208	2,387	1 : 1,852
1886	4,834,898	2,114	1 : 2,287
1887	5,486,416	2,776	1 : 1,988
1888	6,051,249	3,111	1 : 1,945
1889	5,500,678	3,026	1 : 1,818
1890	5,590,510	1,756	1 : 3,183
1891	6,550,182	2,187	1 : 2,996
1892	6,234,559	2,085	1 : 2,992
1896	8,759,490	1,877	1 : 4,666
1899	9,230,353	1,021	1 : 9,040
1902	9,093,210	725	1 : 12,397

The proportion, however, is not only subject to variation in separate years, but differs according to the district; thus, in 1884, in the state district of Minden there was one trichinous pig to 30,146 healthy animals, in Erfurt 1 to 14,563, in the district of Gnesen 1 to 101, in Schrimm 1 to 86, and in Schroda 1 to 68.

In Germany Trichinella is becoming LESS COMMON in pigs (Ostertag):—

(*a*) *Prussia.*

Year	Pigs found to be trichinous
1878—1885	0·061—0·048 per cent.
1886—1892	0·033—0·043 ,,
1896	0·021 ,,
1899	0·014 ,,
1902	0·011 ,,

(*b*) Saxony.

Year	Number of pigs found to be trichinous
1891	0·014 per cent.
1892	0·011 ,,
1893	0·008 ,,
1894	0·007 ,,
1895	0·012 ,,
1896	0·0102 ,,
1899	0·004 ,,
1902	0·0056 ,,

(*c*) City of Berlin.

Year	Number of pigs found to be trichinous
1883—1893	0·035—0·064 per cent.
1893—1897	0·022—0·015 ,,
1902	0·006 ,,

There is no doubt that the excellent preventive measure of official inspection for Trichinella has led to the avoidance of grave disasters; its introduction has not yet caused an entire cessation of trichinosis in man, because inspection of pork is not obligatory everywhere, so that human beings may become infected by unexamined trichinous pigs from their own country or from abroad, and also because an infection may occasionally escape notice. For these reasons the meat imported into Berlin from abroad as free from Trichinæ is examined again and not always in vain; finally, also, gross negligence may at times occur, or fatal errors may be made.

In addition *private prophylaxis* must not be neglected, and its chief aim should be directed to the suitable preparation of pork.

Family. **Dioctophymidæ.**

Genus. **Dioctophyme,** Collet-Megret, 1802.

Syn.: *Eustrongylus*, Dies., 1851.

Large worms. Anterior extremity unarmed; the mouth is surrounded by six papillæ. One ovary. The vulva is in the anterior region of the body.

Dioctophyme gigas, Rudolphi, 1802.

Syn.: *Dioctophyme renale*, Goeze, 1782; *Ascaris canis* et *martis*, Schrank, 1788; *Ascaris visceralis* et *renalis*, Gmelin, 1789; *Strongylus gigas*, Rud., 1802; *Eustrongylus gigas*, Dies., 1851; *Strongylus renalis*, Moq. Tand., 1860; *Eustrongylus visceralis*, Raill., 1885.

Colour blood-red; the anterior extremity somewhat slender; there is a series of about 150 papillæ along the lateral lines; the sub-median lines are strongly developed, and from them spring the radial muscles for the intestine.

The males attain a length of 40 cm. and a diameter of 4 to 6 mm.; the posterior extremity is transversely truncated; the anal orifice is within the base of the collar-like bursa, the thickened edges of which are beset with papillæ; the spicule measures 5 to 6 mm. in length.

The females attain a length of 100 cm. and a breadth of 12 mm. The anus is crescent-shaped and terminal. The vulva is 50 to 70 mm. distant from the anterior extremity. The eggs are oval and have a thick shell presenting numerous depressions; the shell itself is brownish, but it is colourless at the somewhat thickened poles; it measures 60 μ in length by 40 μ in breadth. The larva measures 240 μ by 14 μ.

Dioctophyme gigas lives in the pelvis of the kidney, more rarely in the abdominal cavity of the seal, otter, dog, wolf, fox, horse, marten and polecat, exceptionally also in human beings. It also occurs in tumours of the mamma and perinæum. Most of the cases in which this parasite has been reported as occurring in man may be traced back to unrecognized *Ascaris lumbricoides* or to clots of fibrin; seven certain cases, eight more or less doubtful, however, remain.

The source of infection is unknown, but according to Balbiani the eggs develop an embryo in water or moist soil, and this embryo may remain alive several years without hatching; the infection of dogs with embryo-containing eggs did not succeed; an intermediate stage in fishes is conjectured, but still the infection of cattle and horses is unintelligible.

FIG. 306. — *Dioctophyme gigas*, male. Natural size. (After Railliet.)

Family. **Strongylidæ.**

Sub-family. **Metastrongylinæ**, Leiper, 1908.

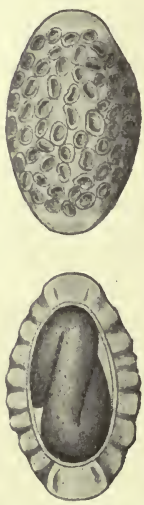


FIG. 307.—Eggs of *Dioctophyme gigas*; above seen from the flat, below in optical section. 400/1. (After Railliet.)

Buccal capsule absent or slightly developed, vagina elongate, uteri convergent [1] and have a simple musculature. Parasitic in the respiratory or circulatory system. Genera: Metastrongylus, Synthetocaulus.

Genus. **Metastrongylus**, Molin, 1861.

Mouth with six lips, of which the two lateral are the largest. Postero- and postero-external rays [2] of bursa thin, the rest thick. Only the median ray double. Spicules very long and slender, striated. Vulva immediately in front of anus. Eggs contain an embryo when laid.

Metastrongylus apri, Gmelin, 1789.

Syn.: *Gordius pulmonalis apri*, Ebel, 1777; *Ascaris apri*, Gmelin, 1789; *Strongylus suis*, Rud., 1809; *Strongylus paradoxus*, Mehlis, 1831; *Strongylus elongatus*, Duj., 1845; *Strongylus longevaginatus*, Dies., 1851.

The male measures 12 to 25 mm. in length; the bursa is bilobed; there are five rays in each lobe; the spicules are thin and up to 4 mm. in length. The females measure 20 to 50 mm. in length, the anus is close in front of the posterior extremity, which

[1] Convergent: *i.e.*, the uteri are parallel, converging from the anterior part of body to the vagina, which is near the anus, this position being associated with convergence of the uteri. Divergent: Uteri run anterior and posterior, diverging from the vagina, which in this case is near middle of body.

[2] For nomenclature of rays *vide* p. 449.

has a recurved, hook-like process; the vulva is close in front of the anus. The eggs are elliptical, 57 μ to 100 μ in length, 39 μ to 72 μ in breadth; when the eggs are deposited the embryo is already formed, 220 μ to 350 μ by 10 μ to 12 μ.

Metastrongylus apri frequently lives in the bronchial tubes—usually the smaller ones—of the pig[1] and wild boar; it is also found occasionally in sheep and in man; in young pigs it is apt to set up a bronchitis, which frequently causes death.

The first communication as to the occurrence of this species in man was that of Diesing, who, in 1845, in Klausenburg, had the opportunity of examining *Strongylidæ* found by Jortsits in the lung of a little boy, aged 6, in Transylvania; probably also the Nematodes found in the trachea and larynx of man, and described by Rainey and Bristowe as specimens of *Filaria trachealis*, belong to this group; according to Chatin, *Metastrongylus apri* may also occur in the intestine of man; this occurrence, however, may in all probability have been due to an accidental introduction of adult worms into the intestine, and should not be attributed to an infection by the larval stage.

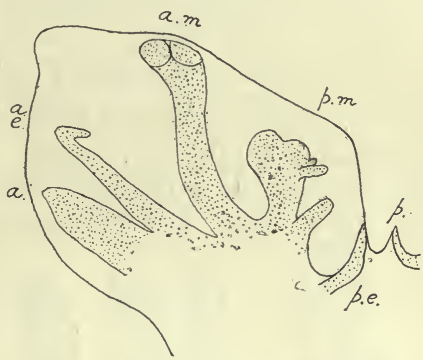


FIG. 308.—*Metastrongylus apri*: one side of bursa. *a.*, anterior; *a.e.*, antero-external; *a.m.*, antero-median; *p.m.*, postero-median; *p.e.*, postero-external; *p.*, one division of posterior ray. (Stephens.)

No experiments to induce infection have been made; it is probable, however, that infection is direct and without the aid of an intermediate host.

Sub-family. **Trichostrongylinæ**, Leiper, 1908.

Strongylidæ with buccal capsule absent or slightly developed, vagina short, uteri divergent (*i.e.*, anterior and posterior), ovejectors differentiated. Parasitic in the alimentary canal. Contains the genera Trichostrongylus, Hæmonchus, Ostertagia, Nematodirus, Cooperia, Dictyocaulus.[2]

[1] The reports of the city inspection of meat in Berlin state that *Strongylidæ* in the lungs of pigs are by no means rare; therefore the lungs of 1,941 pigs were condemned between 1885—1886, of 1,641 between 1886—1887, of 3,237 between 1887—1888, of 4,855 between 1888—1889, of 7,197 between 1889—1890, and of 5,574 pigs between 1890—1891, etc. Ostertag found *Strongylus apri* in 60 per cent. of the pigs examined in the Berlin abattoir; Meyer, in Leipzig, found the parasite in 15 per cent. of the native pigs and in 52 per cent. of the Hungarian pigs.

[2] *Dictyocaulus* is parasitic in the bronchi.

Genus. **Trichostrongylus**, Looss, 1905.

Very small *Strongylidæ*. Mouth with three small lips and nodular or punctiform papillæ. Cervical papillæ absent. Bursa entirely closed, with large lateral lobes, and median lobe not distinctly defined. Anterior[1] rays double, the branches widely divergent, one thin, the other thick, and close to the antero-median. The postero-median ray is thin and close to the postero-external. Posterior ray bifurcate, each branch bifid at the tip (fig. 311). Spicules short, spoon or spatula-like, with on the broad anterior end a lateral knob or disc and in front of the point an angular projection. Gubernaculum of a peculiar canoe or shoe shape in profile. Vulva in the hinder half of the body. Tail with two minute papillæ just in front of tip. Eggs thin shelled; when laid they show eight to thirty-two segments. Parasitic in duodenum, seldom in the stomach of herbivora.

Trichostrongylus instabilis,[2] Railliet, 1893.

Syn.: *Strongylus instabilis*, Railliet, 1893; *Strongylus subtilis*, Looss, 1895.

Male 4 to 5·5 mm. long, 0·08 mm. thick in front of bursa. Spicule 0·135 to 0·145 mm. long, accessory piece (gubernaculum) 0·07 mm. thick. Antero-external ray usually thickest of all, occasionally only as thick as the antero-median; postero-median far more slender than the antero-external and antero-median and

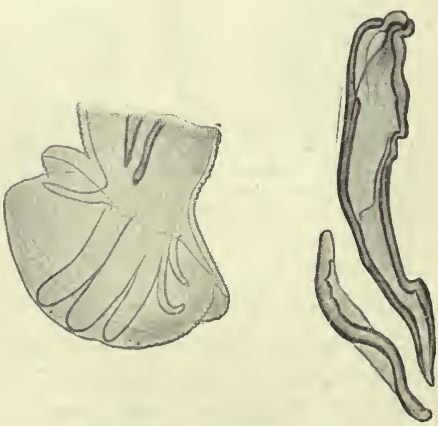


Fig. 309.—*Trichostrongylus instabilis*: left, posterior end of male; right, spicule and gubernaculum, side view. *Cf.* fig. 311. Magnified. (After Looss.)

Fig. 310.—*Trichostrongylus instabilis*: posterior end of female. Magnified. (After Looss.)

nearer to the postero-external than to the antero-median. Female 5 to 6 mm. long, vulva 1·05 to 1·2 mm. distant from the tip of the

[1] When the anterior ray is double, the branches of it are called antero-anterior and latero-anterior.

[2] Identical with *T. colubriformis* of the sheep according to Leiper. If so, this latter name has priority.

tail, placed *longitudinally*, 50 μ to 55 μ long, always shorter than the unpaired portion of the canal formed by the union of the two ovejectors; anus 0·055 to 0·07 mm. distant from tip of the tail; ova 73 μ to 80 μ by 40 μ to 43 μ.

This species lives in the duodenum, exceptionally also in the stomach of *Ovis aries*, *O. laticauda*, *Antilope dorcas*, *Camelus dromedarius* (Egypt), *Cynocephalus hamadryas* (North Africa), sheep and goats (France), and has been found by Looss in bodies of fellaheen at Alexandria and in the stomach of a Japanese female by Ijima.

Trichostrongylus probolurus, Railliet, 1896.

Syn.: *Strongylus probolurus*, Railliet, 1896.

Male 4·5 to 5·5 mm. long, in front of bursa 0·08 mm. thick; spicule 0·126 to 0·134 mm. long, gubernaculum 0·075 to 0·08 mm. long. Bursa: latero-anterior rib thickest; antero-external thicker than antero-median, postero-median and postero-external very short and close together. Female 4·5 to 6 mm. long, vulval opening 1·08 to 1·25 mm. from tip of tail, placed *longitudinally*, and slightly curved, 76 μ long, always longer than the unpaired portion of the ovejector; anus 0·040 to 0·05 mm. distant from tip of tail. Posterior end thick, point of tail short. Ova 76 μ to 80 μ by 43 μ to 46 μ.

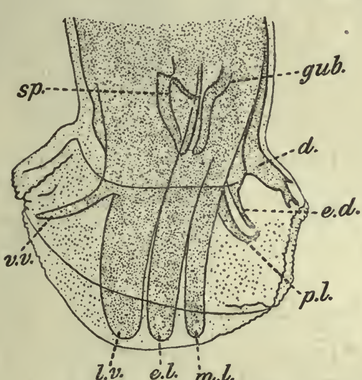


FIG. 311.—*Trichostrongylus probolurus*: tail of male from left side. *d.*, posterior; *e.d.*, postero-external; *p.l.*, postero-median; *m.l.*, antero-median; *e.l.*, antero-external; *l.v.*, latero-anterior; *v.v.*, antero-anterior; *gub.*, portion of gubernaculum; *sp.*, portion of spicules. × c. 300. (After Looss.)

FIG. 312.—*Trichostrongylus probolurus*: spicules and gubernaculum of male; on left, ventral view; on right, lateral view. × c. 300. (After Looss.)

Habitat.—In the duodenum of *Ovis aries*, *O. laticauda*, *Antilope dorcas*, *Camelus dromedarius* (Egypt) and occasionally also in man (Egypt).

Trichostrongylus vitrinus, Looss, 1905.

Male 4 to 5·5 mm. long, in front of bursa 0·085 mm. thick. Bursa larger than in the other two species, antero-external rib thickest, antero-anterior and postero-median equally thick, straight. Spicule 0·16 to 0·17 mm. long, gubernaculum 0·085 to 0·095 mm. long. Female 5 to 6·5 mm. long, vulval opening 1·15 to 1·25 mm. distant from tip of tail, crescent shaped, *oblique* to body axis, and around it irregular thickenings. Ova 84 μ to 90 μ by 46 μ to 50 μ.

In duodenum of *Ovis aries*, *O. laticauda*, occasionally in *Camelus dromedarius* and in man (Egypt).

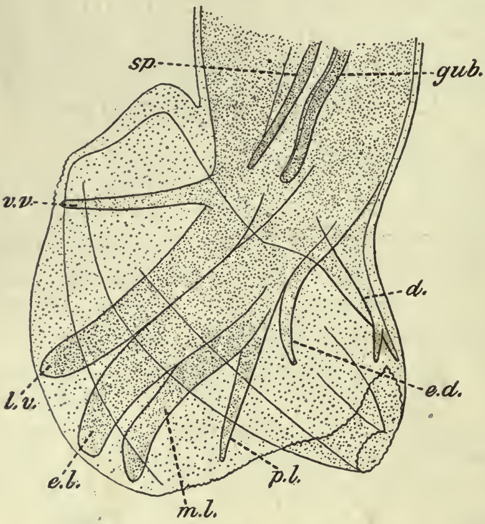


FIG. 313.—*Trichostrongylus vitrinus*: tail of male from left side. *d.*, posterior; *e.d.*, postero-external; *p.l.*, postero-median; *m.l.*, antero-median; *e.l.*, antero-external; *l.v.*, latero-anterior; *v.v.*, antero-anterior; *gub.*, portion of gubernaculum; *sp.*, portion of spicule. × c. 300. (After Looss.)

FIG. 314.—*Trichostrongylus vitrinus*: spicules and gubernaculum; on left, ventral view; on right, lateral view. × c. 300. (After Looss.)

Genus. **Hæmonchus**, Cobb., 1898.

Small mouth cavity contains a "tooth" or "lancet" arising from the dorsal side. Cuticle of head and neck not inflated. Cervical papillæ well marked. Bursa bilateral, with large lateral lobes and a small dorsal lobe *not median*, but lateral, attached to the base of one of the lateral lobes (fig. 316). Posterior ray bifurcate, each branch bifid apically. Each lateral lobe six rays. Anterior rays separated distally, curving forward. Antero-median and postero-median rays distally curve away from the antero-external. Postero-external ray long and slender. Spicules less than 1 mm. Gubernaculum present. Vulva in posterior part of body covered by a prominent tongue-like flap. Eggs ellipsoidal.

Hæmonchus contortus, Rudolphi, 1803; Cobb., 1898.

Dorsal "tooth" or "lancet" 10 μ to 15 μ long. Cervical papillæ 0·3 mm. from head.

Male 20 mm. long by 400 μ thick (maximum). Asymmetrical lobe of bursa 150 μ by 125 μ attached to left lateral lobe. Posterior ray bifurcate; each branch bifid. Stem of ray less than twice as long as its branches. Spicules 300 μ to 500 μ with knobbed tips, and the left spicule with a barb 20 μ from the tip, right spicule with a barb 40 μ from tip. Gubernaculum 200 μ by 25 μ to 35 μ, fusiform with thickened edges.

Female 18 to 30 mm. by 500 μ (maximum). Vulva 3 to 4·5 mm. from tip. Linguiform flap 0·5 mm. (a second one exists, according to Brumpt). Anus 400 μ to 630 μ from tip. Tail acutely pointed. Eggs 75 μ to 95 μ by 40 μ to 50 μ.

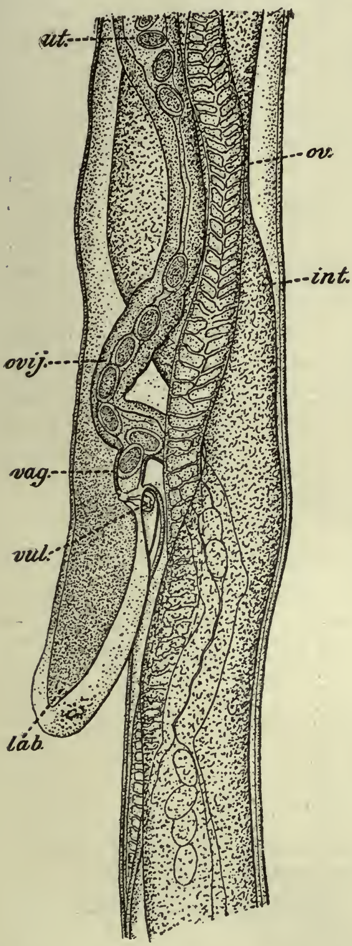


FIG. 315. — *Hæmonchus contortus:* vulval region of female viewed from left side. *int.*, intestine; *lab.*, linguiform process covering vulva; *ov.*, ovary; *ovij.*, ovejector; *ut.*, uterus; *vag.*, vagina; *vul.*, vulva. × 75. (After Ransom.)

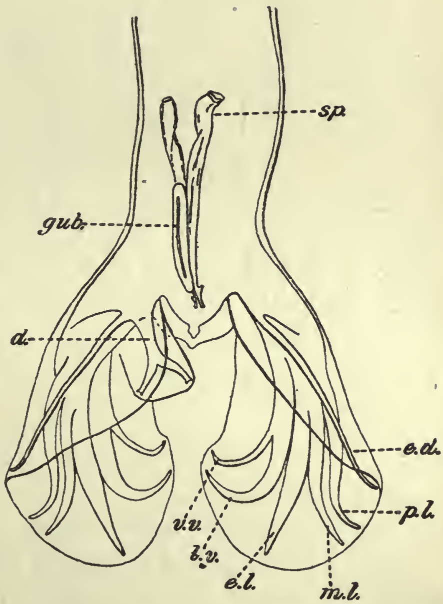


FIG. 316. — *Hæmonchus contortus:* tail of male, dorsal view. *d.*, posterior ray of the asymmetrically placed posterior lobe; *e.d.*, postero-external; *p.l.*, postero-median; *m.l.*, antero-median; *e.l.*, antero-external; *l.v.*, latero-anterior; *v.v.*, antero-anterior; *gub.*, gubernaculum; *sp.*, spicule. × 75. (After Ransom.)

Habitat.—Fourth stomach of cattle, sheep, antelope.

Distribution. — Europe, America, Africa, Asia, Australia, New Zealand. Once in man in South America by de Magalhães.

Pathology.—Produces anæmia, emaciation, dropsy in sheep; and in the human case the symptoms were mistaken for those of ancylostomiasis.

Life-history. — Rhabditic embryos easily hatch in water, then moult several times, becoming eventually "filariform" larvæ enclosed in the moulted skin. These crawl up blades of grass and are swallowed by sheep, etc.

Genus. **Nematodirus,** Ransom, 1907, emend. Railliet, 1912.

Head over 50 μ in diameter. Cuticle may be slightly inflated and often transversely striated. Cuticle with eighteen distinct longitudinal ridges. Cervical papillæ absent (?). Posterior lobe of bursa reduced to short lobules each with a dorsal ray. Antero-anterior + latero-anterior (= anterior double) rays close together, parallel; antero-external ray diverges widely from antero- and postero-median, which are close together and parallel. Postero-external ray slender. Spicules more than 0·5 mm. long, at most one-twelfth of body, united by a membrane throughout their length or only distally. Gubernaculum absent. Vulva behind middle of body. Eggs ellipsoidal, shell rather thick.

Habitat.—Duodenum of ruminants.

Sub-genus. **Mecistocirrus,** Railliet, 1912.

Head slightly inflated, with transverse striations. Skin with eighteen longitudinal ridges, but little apparent; cervical papillæ distinct. Bursa bilobed; median ray double (= postero-median + antero-median); very large antero-external at the edge, close to the anterior. Spicules very long, slender, one-sixth length of body (3·5 mm.); tail pointed. Vulva immediately in front of anus.

Habitat.—Stomach of ruminants.

Mecistocirrus fordi, Daniels, 1908.

Syn.: *Strongylus fordi*, Daniels, 1908; *Strongylus gibsoni*, Stephens, 1909; *Nematodirus fordi*, Leiper, 1911.

Male 21 mm. long by 0·4 mm. thick. Cervical papillæ 0·45 mm. behind the head. Spicules about 7 mm. long, *i.e.*, one-third of the body length. At the level of the postero-external rays of the bursa, the bursa has a projecting lobule.

Female 25 mm. long. Anus 0·2 mm., vulva 0·5 mm. from the tip of tail. Eggs 100 μ by 53 μ.

Sub-family. **Ancylostominæ,** Railliet, 1909.

Strongylidæ with buccal capsule, well developed. Uteri divergent. Parasitic in the alimentary canal, exceptionally in the respiratory system.

Group. **Œsophagostomeæ,** Railliet and Henry, 1909.

Bursa with anterior and median ray cleft (not double), postero- and postero-external arising from a common trunk, posterior bifurcated, each limb bidigitate.

Contains at present four genera : (1) Ternidens, (2) Chabertia, (3) Œsophagostomum, (4) Agriostomum.

FIG. 317.—*Mecistocirrus forai.* bursa of male, dorsal view. The rays are (1) postero-external, (2) median (= postero-median + antero-median), (3) antero-external, (4) latero-anterior, (5) antero-anterior. These two latter are parallel. The posterior ray is absent. (After Stephens.)

Genus. **Ternidens,** Railliet, 1909.

Buccal capsule sub-globular, opening obliquely in the dorsal surface, and having at the bottom three complex teeth resembling those of Triodontophorus.[1] Two crowns of leaflets ; peristomic collar moderate, edge of bursa slightly toothed.

Type.—T. deminutus, Railliet and Henry.

[1] Triodontophorus belongs to the group *Cylicostomeæ*, which has the following bursal formula : (1) anterior cleft, (2) median double, (3) postero-external and posterior arising *separately*, (4) posterior double, each branch giving off two lateral branches.

Ternidens deminutus, Raill. and Henry, 1905.

Syn. : *Triodontophorus deminutus*, Raill. and Henry, 1905.

Body relatively thick. Cervical papillæ 0·5 mm. behind the head. Buccal capsule 40 μ deep. Teeth 40 μ long.

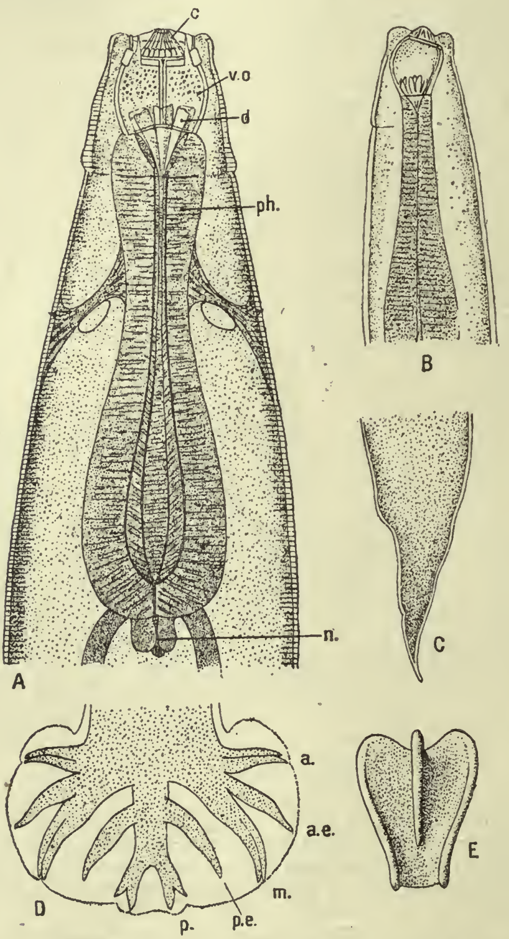


FIG. 318.—*Ternidens deminutus*. A, head end, ventral view : c, crown of leaflets ; v.o., buccal cavity ; d, pharyngeal plates ; ph., pharynx ; n., valve. B, lateral view. C, tail of female. D, bursa of male : a., anterior ray ; a.e., antero-external ; m., median ; p.e., postero-external ; p., posterior. E, pharyngeal plate. Enlarged. (After Railliet and Henry.)

Male 9·5 mm. long by 560 μ thick. Œsophagus 660 μ long. Bursa broader than long, the lateral lobes united by a small posterior lobe with slightly sinuous margin ; edge of bursa finely toothed. Spicules about 900 μ long.

Female 12 to 16 mm. long by 650 μ to 730 μ thick. Œsophagus 860 μ long. Vulva forms a distinct projection 480 μ from tip of tail. Anus 240 μ to 270 μ from tip. Eggs 60 μ to 80 μ by 40 μ.

Habitat.—Large intestine of a negro (Comoro Islands) and in the natives of Nyasaland and Portuguese East Africa. Also in large intestine of *Macacus sinensis* and *Macacus cynomolgus*.

Genus. **Œsophagostomum**, Molin, 1861.

No teeth. Cuticle around the mouth dilated to form a narrow cuticular "peristomic collar." Separated by a constriction from this is a much more extensive inflation, the "cephalic vesicle," bounded abruptly behind on the ventral side by a transverse groove, the "ventral cleft," which is always present even in absence of the vesicle. Buccal cavity of slight depth with a short dorsal tunnel. Internal margin of the mouth armed with chitinous leaflets ("external crown"); internal border of the buccal capsule armed with short tongue-like leaflets (internal crown). Lateral membranous wings may extend backwards from the ventral cleft. Cervical papillæ present. Bursa with two lateral lobes united by a smaller median lobe. Spicules over 5 mm. long, slender; gubernaculum inconspicuous. Vulva in front of anus. Adults usually in large intestine of ruminants, suidæ, tapirs, edentates and apes. Larvæ sometimes in nodules in intestinal wall.

Œsophagostomum brumpti, Railliet and Henry, 1905.

Female immature, 8·5 to 10·2 mm. long, 0·295 to 0·325 mm. thick. Cuticle transversely striated. The cephalic vesicle immediately behind the vestibulum oris, embracing the anterior two-fifths of the œsophagus, extending ventrally, however, towards its posterior end. Vestibulum oris formed by a cuticular band provided with a crown of twelve apical leaflets directed forward and inwards; six cephalic papillæ (two lateral, four submedian); buccal capsule in front of cervical swelling not delineated circularly behind, but provided with three wide incisions (one dorsal, two sub-ventral). Œsophagus, 0·470 to 0·500 mm. long, two cervical papillæ at five-eighths of its length. Vulva 0·350 to 0·475 mm., anus 0·170 to 0·200 mm., before tip of tail.

Habitat.—Found by Brumpt in tumours of the cæcum and colon of a native of the River Omo (Lake Rudolph), East Africa. Immature forms only were present. Adults have been found in similar tumours in monkeys.

Pathology.—They occur in hæmorrhagic cysts in the submucosa or

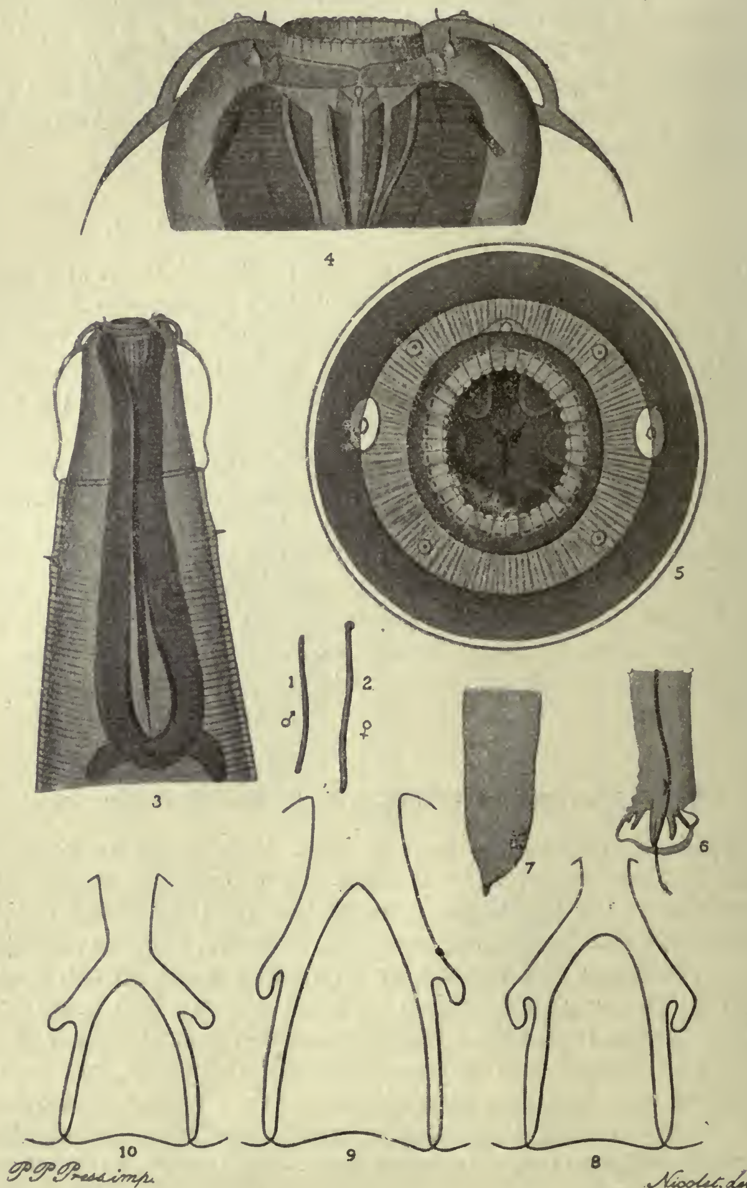


FIG. 319.—*Œsophagostomum stephanostomum* var. *thomasi*. 1, male, natural size; 2, female, natural size; 3, head of female, ventral view, showing cephalic vesicle and ventral cleft limiting it behind, × 55; 4, head of female, dorsal view, × 225; 5, head of male, end view, showing external and internal leaf crowns, × 225; 6, tail of male, lateral view (*cf.* fig. 318, D), × 20; 7, tail of female, lateral view, × 20; 8, *Œs. thomasi*, posterior ray of bursa, × 150; 9, *Œs. dentigerum*, from chimpanzee, posterior ray of bursa, × 150; 10, *Œs. stephanostomum*, from gorilla, posterior ray of bursa, × 150.

muscularis mucosæ of the gut wall. The cysts project internally and externally, and contain inmature adults, which eventually escape into the lumen of the gut.

FIG. 320.—*Œsophagostomum stephanostomum* var. *thomasi:* cæcum and ascending colon. Subperitoneal cysts are seen on the top right hand, and in the lumen of the gut numerous cysts arranged transversely. The small roundish patches are areas of necrosis in the cyst walls. (After Thomas.)

Œsophagostomum stephanostomum var. thomasi, Raill. and Henry, 1909.

Body thick, pointed only at the ends. Buccal capsule much reduced. External crown of thirty-eight leaflets (the "crown" nearest the centre of fig. 319, 5). Male 17 to 22 mm. long by 750 μ thick. Spicule 1·380 to 1·475 mm., slightly curved at the tip. Female, immature, 16 to 20 mm. long by 900 μ thick, tail ending in a little conical appendage. Anus 230 μ, vulva 500 μ to 525 μ from tip. Ovejectors close together. Uteri very short in form of oblong pouch.

Œs. stephanostomum, Stossich, 1904, in the large intestine of gorilla. *Œs. stephanostomum* var. *dentigera*, Raill. and Henry, 1909, in the chimpanzee.

Habitat.—In large and small intestine of man, Brazil.

Pathology.—Nodules occur in the gut wall; 187 were found by Thomas in his, the sole case. The tumours contain each a single worm.

FIG. 321. — *Œsophagostomum stephanostomum* var. *thomasi*: portion of the ileum, showing a cyst with protruding worm. × 8. (After Thomas.)

FIG. 322. — *Œsophagostomum stephanostomum* var. *thomasi*: colon with œsophagostome withdrawn from its cyst cavity. × 20. (After Thomas.)

Œsophagostomum apiostomum, Willach, 1891.

According to Leiper, *Œs. brumpti* is identical with, and hence a synonym of, this species. Parasitic in large intestines of monkeys, producing dysentery, and in man (Northern Nigeria).

According to Walker this species is common in Philippine monkeys. Ova are scanty in the fæces. They measure 73 μ to 84 μ by 44 μ to 57 μ and are in the morula stage. They are easily cultivated. The rhabditiform larva is 340 μ by 16 μ and has a long filiform tail. It moults twice, and at the second moult becomes a filariform larva retaining the skin of this moult, this stage being that of the mature larva. It now measures 9 mm. long by 30 μ thick. Walker suggests that the mode of infection is similar to that of ancylostomes.

Group. **Ancylostomeæ**, Railliet and Henry, 1909.

Bursa with anterior ray cleft, median double,[1] postero- and postero-external arising from a common trunk, posterior bifurcate, each limb being tridigitate. Vulva in posterior third of body. Uteri divergent.

Contains the following genera : (1) Strongylus,[2] (2) Ancylostoma, (3) Uncinaria, (4) Characostomum, etc.

Genus. **Ancylostoma**, Dubini, 1843, emend. Looss, 1905.

Ventral margin of mouth capsule armed with teeth, the "roots" of which are continued backwards and appear on the *external* surface of capsule as rib-like thickenings. Terminal third of dorsal ray cleft. Genital tubes very long, with short, closely packed diagonal convolutions.

Ancylostoma duodenale, Dubini, 1843.

Male 9 mm. long by 0·45 mm. thick, female 12 mm. long by 0·6 mm. thick. Pale flesh colour, or an intense red in posterior third. Anteriorly may be more or less black due to (blood) pigment in the cells of the chyle intestine (= stomach + small intestine). The worm is about the same thickness all through and is plump and rigid. Cuticle striated. The body has a marked torsion, so that if the ventral side of the head is upwards the anus appears to open laterally and *vice versâ*. The dorsal curve of the head end is only slight and the œsophagus is roughly cylindrical.

Buccal Capsule.—The buccal capsule is bent dorsally, 0·21 mm. long, 0·19 mm. broad. If a worm is rolled under the cover-glass so that the dorsal side is upwards, we observe the following features (fig. 325) : In the dorsal edge of the chitinous capsule there is a gap as if a **U**-piece had been punched out. This is the "dorsal gap or incision." The so-called "dorsal teeth" are simply the rounded edges of the tips of this gap. They project *beyond* the skin which covers the capsule externally. Below this gap is seen a curved line which, if followed along the sides of the capsule on each side, merges into the base of the most posterior ventral tooth. This line is the optical expression of a very shallow groove on the *inside* of the capsule. The skin on the outside of the capsule, which is reflected over the edge of and into the capsule, dips into this groove, which gives it a firm attachment. Below the middle (dorsally) of this curved line there is a thickening in the capsule wall, which is perforated by the opening of the dorsal œsophageal gland. This is the "dorsal ridge"; in optical section it has a conical appearance with a lumen (of the duct).

---

[1] *I.e.*, with a distinct space between the limbs.

[2] Strongylus (Syn. : Sclerostomum) differs slightly in its posterior ray from the other genera of the group. Each bifurcation is trifurcate rather than tridigitate.

On the ventral wall one sees the two pairs of strong teeth, their points being directed somewhat backwards. They are covered by cuticle above and below, but their points are free, piercing the cuticle.

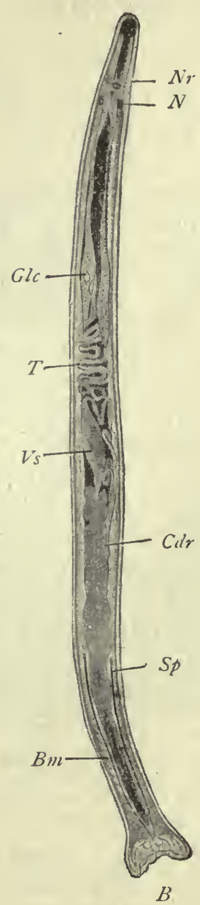


FIG. 323. — *Ancylostoma duodenale*, male. *B*, bursa; *Bm*, bursal muscles; *Cdr*, cement gland surrounding the ejaculatory duct; *Glc*, cervical glands; *N*, nucleus of cephalic gland; *Nr*, nerve ring; *T*, testes; *Sp*, spicule; *Vs*, vesicula seminalis. × 15. (After Looss.)

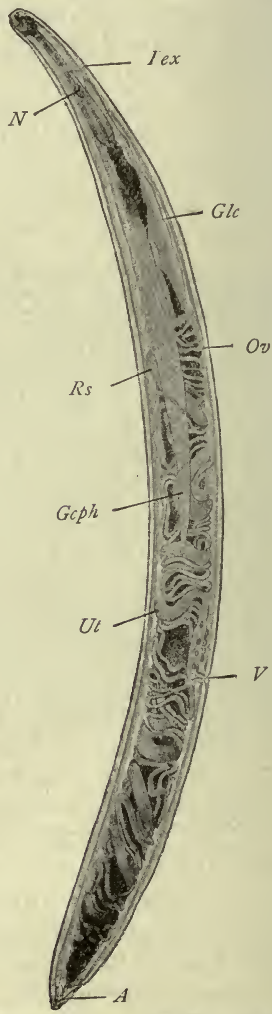


FIG. 324. — *Ancylostoma duodenale*, female. *A*, anus; *Gcph*, cephalic gland; *N*, nucleus of cephalic gland; *Glc*, cervical gland; *Ov*, ovary; *Pex*, excretory pore; *Rs*, receptaculum seminis; *Ut*, uterus; *V*, vagina. × 15. (After Looss.)

The "roots" of these teeth followed backwards appear as two thickenings or ribs on the *outside* of the capsule wall, so that the outside wall is not smooth—a characteristic of the genus Ancylostoma. In the space between these ribs lies the ventral nerve papilla, and lying against the outside of the outer root the lateral nerve papilla. The nerve papillæ are thus, as it were, concealed by these roots, and not conspicuous as they are in Necator. Following the ventral curve of the capsule on the inside, posteriorly we next find two triangular ventral lancets.[1] These stand straight up into the capsule on either side of the longitudinal axis, converging at their summits. So that to sum up, the cutting apparatus is entirely ventral, consisting of two pairs of cutting teeth and a pair of lancets.

Cervical Papillæ.—Two, one on each side behind the head at the level of the excretory pore. They consist of "pulp," *i.e.*, extensions of the substance of the lateral bands covered by cuticle and supplied with a nerve (fig. 326).

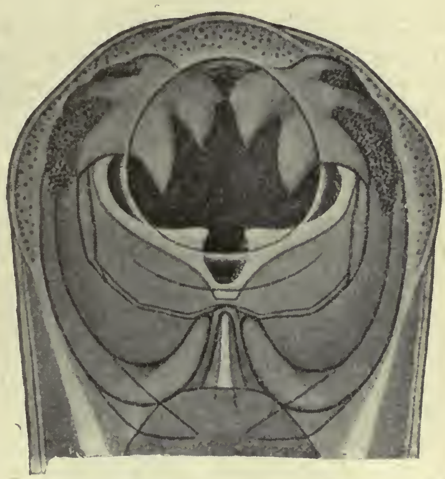


FIG. 325.—*Ancylostoma duodenale:* showing ventral teeth, dorsal cleft, and behind it the dorsal ridge with duct of dorsal œsophageal gland. × c. 200. (After Looss.)

Œsophageal Glands (3).—The chitin of the triradiate œsophagus is continuous with that of the buccal capsule. In its muscular walls are three glands—one dorsal, two subventral. The dorsal gland opens into the buccal cavity through the dorsal ridge; the two others into the lumen of the œsophagus at the nerve ring. They branch freely amidst the muscles. They are probably digestive in function.

Cephalic Glands (2).—Lie in the lateral lines or bands on either side. They begin about the middle line of the body, and their ducts open at the base of the outer ventral tooth on the surface of the skin on each side. Each is 0·15 mm. thick in the middle, and has a single nucleus about as big as an ancylostome egg (*N*, fig. 323). They probably function as poison glands.

Excretory System and Cervical Glands (2).—The excretory pore lies in the mid line ventrally behind the œsophageal nerve ring (figs. 324 and 326). It opens into the excretory vesicle, a cavity in a large cell with lateral appendages which fuse with the lateral lines, this cell thus forming the "bridge" of the excretory system. Adhering to this (bridge) cell are the spindle-shaped cervical glands (*Glc*, fig. 324), and branches from the excretory vesicle enter the glands, which are excretory in function; the vesicle also receives branches

[1] The ventral lancet (of one side) of Necator is seen in fig. 335.

from the lateral excretory canals (fig. 326) running in the lateral lines or bands. The cervical glands are swollen anteriorly, forming the so-called ampullæ just in front of the bridge. They extend backwards a little beyond the anterior loop of the testis.

Lateral Lines.—(1) Are broad elevations of the subcuticle, in which, here and there, a nucleus occurs. (2) Near the bursa in the male they increase in volume, and finally divide into branches which form the "pulp" of the different rays. (3) In addition to the lateral lines or bands, there is also a dorsal and ventral band. (4) The

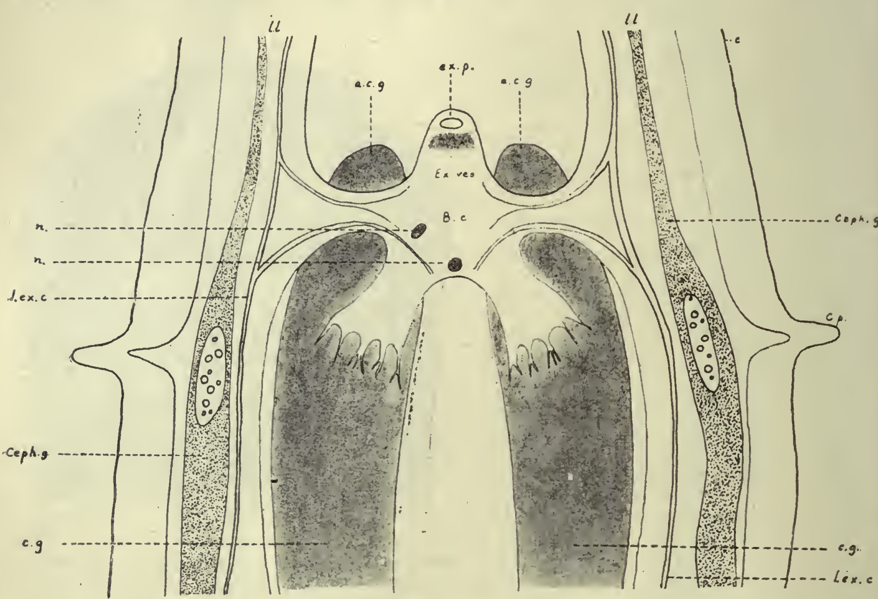


FIG. 326.—*Ancylostoma duodenale:* diagrammatic representation of excretory system *ex.p.*, excretory pore; *e.c.g.*, excretory cervical gland; *Ex. ves.*, excretory vesicle in *B.c.*, bridge cell, which is connected with *c.g.*, cervical gland, and *l.l.*, lateral lines; *ceph.g.*, cephalic gland; *l.ex.c.*, lateral excretory canal passing into the bridge cell; *l.l.*, lateral line containing excretory canal and cephalic gland; *c.p.*, cervical papilla; *n.*, nuclei of bridge cell. (After a drawing of Looss.)

ventral band is well developed caudally, forming a large pad dorsal to the cloaca, "pulvillus post-analis."

The bursal rays are outgrowths of the lateral lines. Beside this "pulp" they contain a nerve, and at their bases complex muscles.

The Bursa is closed on all sides with a short median (ventral) lobe, which may be tucked inwards. It is an outgrowth of the inner layer of the skin pushing the outer layer before it, so that it consists of three layers, not four, as it would be if it were a fold. The bursa is twice as broad as long. It is supported by a variety of rays, the arrangement of which is best followed from the figure (fig. 327). The different terminology for these rays as used by various authors should be noted: Ventral = anterior; externo-lateral = antero-external; medio-lateral + postero-lateral or antero-median + postero-median = median (doubled); externo-dorsal = postero-external; dorsal = posterior. All the rays end in tactile papillæ, seven, on each side; the postero-external and antero-external on the *outer* surface of the bursa, the five others on the *inner* surface.[1] Of the six terminal digitations of the *dorsal* ray, only the external two contain tactile papillæ.

In the male there are prebursal papillæ and minute caudal papillæ in the female.

In the female the inner layer of the cuticle projects at the posterior end as a sharp spike, 20 μ long, which may sometimes be broken off.

Ovaries.—The anterior tube runs from the cephalic to the posterior end and back again. The posterior tube begins anteriorly, runs to the

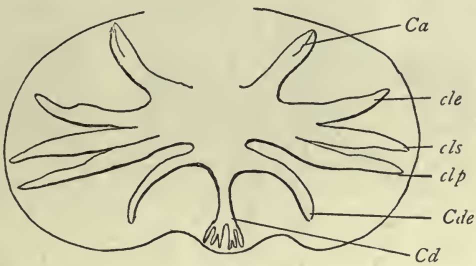


FIG. 327.—*Ancylostoma duodenale:* bursa enlarged. *Ca*, anterior ray cleft; *cle*, antero-external; *cls*, antero-median; *clp*, postero-median; *Cde*, postero-external; *Cd*, posterior bifurcated, each bifurcation tridigitate. After Railliet.)

posterior end of the body, and then back to the cephalic end, forming a vulval loop before ending. The ovaries on the whole run in oblique coils. The uterus is the thicker portion of the tube, 5 mm. long. A short tube connecting the ovary and uterus is the oviduct. The two uteri unite to form a single duct, the vagina, opening 1 mm. *behind* the middle line. The portion of the uterus next to the oviduct functions as a seminal receptacle, whereas the part next the vagina functions as an ovejector.

Testis.—The blind end begins a little behind the beginning of the *cement gland*. The transverse coils occupy the middle third of the body. About the middle of the body it passes into the spindle-shaped seminal vesicle, which, with the spicular canal and rectum, opens into the cloaca. An anterior longitudinal coil pushing in between the cervical glands is characteristic of Ancylostoma. The cement gland surrounds the ejaculatory duct for practically its whole course, and it occupies nearly the posterior half of the body and

[1] This also occurs in other *Strongylidæ*, *e.g.*, in the genus Strongylus (Syn.: Sclerostomum).

secretes a brown or black cement. The spermatozoa are curved rods about 2 μ long.

Spicules are 2 mm. long, ending in a fine point. They are moved by exsertor and retractor muscles. At first they lie free in the body cavity; next in a groove in the dorsal wall of the cloaca; then in an isolated canal, and finally in two canals. Anteriorly each has two longitudinal crests on its inner surface. These meet the corresponding crests of the other spicule, and so form a canal along which the sperm passes into the female. The gubernaculum is a thickening of the dorsal wall of the cloaca. It is not a free piece, but is moved by various muscles.

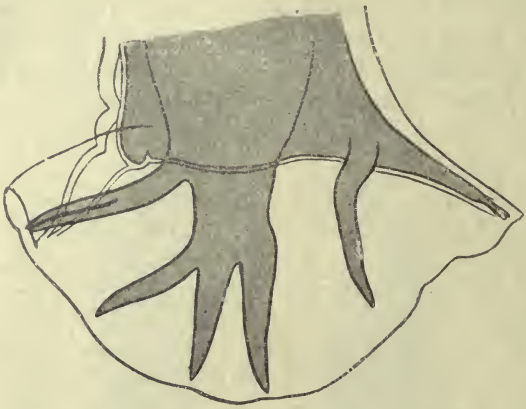


FIG. 328.—*Ancylostoma duodenale:* bursa of male. The rays from left to right are: (1) anterior cleft; (2) antero-external; (3) and (4) median doubled, *i.e.*, antero-median and postero-median; (5) postero-external arising from a common trunk with the posterior. × c. 120. (After Looss.)

Genital Cone is a prominence on the floor of the bursa on the ventral side of the body, on which the genito-anal orifice opens. The cone is only slightly marked in *Ancylostoma duodenale*, but is much more prominent in *Necator americanus.*

Distribution.—Africa, Egypt, Europe, Japan, China (mainly), but in association with *Necator americanus* in Southern States of America, British India, Assam, Burma, Hongkong, Liberia, Jamaica, Martinique, Costa Rica, Colombia, Antigua, Guadeloupe.

Habitat.—The worms live in the jejunum, less frequently in the duodenum, of man only.

Food.—The worms feed on the mucous membrane of the gut, attaching themselves to the base of the villi, sucking these in; and when these are destroyed they attack further the submucosa. As a rule the worms have no blood in the gut, but in their attack on the submucosa a blood-vessel may be eroded, and so the gut of the worm filled with blood.

Development.—The eggs are oval with broadly rounded poles, 56 μ to 61 μ by 34 μ to 38 μ. In *fresh* fæces they contain four granular nucleated segmentation masses of the ovum (fig. 329) separated by a clear space from the shell.

Egg of Ancylostome appears to have a single contour. Under high powers this appears double, but they are the outer and inner surface of the true (chitinous) egg-shell. Internal to this is the extremely delicate yolk-envelope, a kind of skin secreted by the egg cell around itself for protection. The function of this is probably to absorb water to swell and burst the outer chitinous shell. The embryos when hatched are termed larvæ.

Embryos which are ready to hatch have their bodies almost free from granules; others, though apparently mature, that have granules will not hatch.[1]

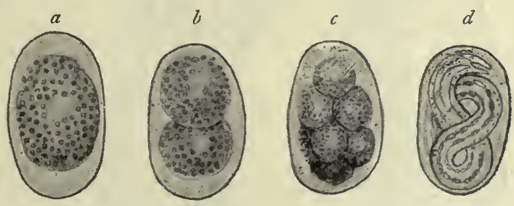


FIG. 329.—*Ancylostoma duodenale*: eggs in different stages of development. *a* to *c*, in fresh fæces; *d*, containing a larva, only in old fæces. × 336. (After Looss.)

Larva.—Stage I: Average length, 25 mm. Maximum thickness in œsophageal region, 17 μ. Head end fairly blunt, from behind the anus (the tail) tapering in an uniform manner. Buccal cavity is characteristic, 10 μ to 12 μ by 1 μ to 8 μ, longer and narrower than the corresponding larvæ of *Strongyloides stercoralis*. Œsophagus "rhabditic" in character, *i.e.*, it has three sections, but they are not so clearly marked off as in larvæ of the genus Rhabditis. The posterior bulb has a Y-shaped valve, the function of which, according to Looss, is to prevent regurgitation of food. The granules of the gut serve as a reserve of food, and are used up if the larvæ are starved. The *genital rudiment* consists of two cells half-way between the end of the

[1] TABLE OF DIFFERENCES BETWEEN LARVÆ OF *A. duodenale* AND *S. stercoralis*.

	A. duodenale	*S. stercoralis*	
(1) Vestibulum oris ...	1·8 μ broad	3 μ	Rhabditiform.
(2) Genital rudiment ...	3 μ to 5 μ long	25 μ to 33 μ	
(3) Thickness	Thicker	—	Filariform.
(4) Œsophagus	One-fourth body length	Half body length	
(5) Tail	Pointed	Two fine points	
(6) Motion	Less active than	—	
(7) Gut	Soon fills with dark granules	—	

œsophagus and the anus in the mid-ventral line. The larva lives on fæcal matter and grows to about 0·4 mm., then moult[1] I takes place in two days or more, the skin being ruptured by the activity of the larva.

Stage II : The larva is now in this stage, which does not differ much from the previous one. It grows to 0·5 mm. The mouth

FIG. 330.—*Ancylostoma duodenale* larva on fourth day of culture on right; *Strongyloides stercoralis* larva on left. (After Leichtenstern.)

opening closes. The œsophagus elongates, becoming cylindrical or "filariform"; a new skin is formed underneath the old one, and in about a week moult II takes place.

Stage III : The *mature larva* remains enclosed in the old skin. Its movements are now much more active and of a boring character. Length is now 0·6 mm. This mature stage has been erroneously called the encysted larva, because there is no cyst *secreted* from its

[1] Moults take place by the formation of a new skin below the old one, the two being in close apposition at first.

surface by the larva, but it is simply the old skin, which is not cast off, but is retained for purposes of protection, as the larva is free living, but casts it as soon as it assumes parasitic life again. From the egg to this mature stage is thus six to ten days.

FIG. 331.—*Ancylostoma duodenale:* left, four days after transmission into dog, 190/1; in the centre, at the commencement of the second stage of development (five to six days), 105/1.; on the right, fourteen to fifteen days after transmission. 42/1. (After Looss.)

Bionomics of Development.—Air: Eggs can develop when shut off from the air for a "comparatively long" time.

Temperature: Hatching takes from eight hours upwards. Eggs develop best at 25° to 30° C., but will not develop below 8° to 10° C. The larvæ, however, will stand freezing.

Moisture: Eggs and larvæ do not live long under water, because they suffocate or starve, but *mature* larvæ will live for months (six to twelve) in water; they require no food—in fact, can take none in—but live on their reserve granules, and in course of time become as clear as glass.

Thigmotropism: The mature larvæ, after casting their skin, will penetrate pith, climb up stems, stalks, etc., and creep into any pore.

It is important to recognize that this third stage of the *mature larva* is the only infective one.

Mode of Entry into the Body.—Infection is effected through the mouth (Leichtenstern and others), and also through the skin, as was first discovered by Looss and afterwards confirmed from the most diverse quarters, partly in the case of *Ancylostoma duodenale*, partly in that of *A. caninum* in dog, man, and monkey. The larvæ that gain access to the intestine partly through contaminated food, or through unwashed hands, or under some circumstances through water, first throw off their "sheath"—that is, they complete moult II. Moult III takes place four to five days after they have reached the gut, and they now have a mouth capsule supplied with four small teeth arranged crosswise, enabling them to fasten on to the intestinal epithelium, upon which they feed. On this food the worms grow in four to six days to 3 to 5 mm. in length, and now moult IV. takes place, thus attaining their definite shape and distinctive character. About eight days later the sexual organs commence to function; at this time the first copulation should be taking place—it will later be frequently repeated—and a few days later the first ova are laid, first in less and later in larger numbers, so that they appear in the fæces about four to five weeks after the infection.[1]

Infection by the Skin.—Mature larvæ, which are placed on the skin of man or suitable animals, cast their "sheath" and bore their way through delicate fissures either horizontal in the superficial scales of the epidermis, or through vertical fissures into hair follicles where these exist, and then they invade the cutis. Now according as they migrate further into the lymphatic vessels or the small vesicles, the final path to the gut differs to some extent. The blood path leads to the right heart, and from there into the lungs; here the larvæ leave the blood stream and enter the air passages, over the mucosa of which they travel further headwards, through the bronchi into the trachea and larynx, and from hence through the œsophagus to the stomach; in some cases also they are swallowed. The

[1] From the number of eggs present in a given quantity of fæces, the number of female Ancylostomes present in the gut can be reckoned by a formula of Leichtenstern's ($x = \frac{a}{47}$, in which *a* signifies the number of eggs counted in a single gramme of fæces).

lymphatic path leads finally also into the blood stream, but the lymphatic glands must first be passed, and in these many larvæ are retained and perish. In the cutaneous infection seven to ten weeks elapse till the time of appearance of the first ova in the fæces.

The penetration of the skin by the larvæ also in man causes reddening and burning at the affected points, and this is followed in a few days by transitory swelling in the subcutaneous connective tissue. Skin affections can also be set up by such Ancylostoma (and Strongyloides) larvæ as do not gain access to the blood or lymphatic vessels or gut; such larvæ apparently wander further in the connective tissue, and, as Looss has in his own person observed, gain access to the cutis at different points, thus causing progressive swellings (accompanied by intense itching), which cease when the worm again penetrates into the deep tissues. Skin affections such as "ground-itch" or "pani-ghao" occurring in the tropics and only attacking the feet, or other affections (*e.g.*, sump bunches) are now well recognized as being due to the invasion of Ancylostoma larvæ.

Other names for these skin affections are water-sore, sore feet of coolies, mazamorra, bunches, botches, quaddeln, krätze, ampoules, gourmes, taons, pitirr. Whether oral or dermal infection is the more important one further observation must decide.

The duration of life of *Ancylostoma duodenale*, which is a specific parasite of man and has not been observed in other mammals, amounts to about five years, as strayed larvæ according to Looss wander for this extent of time in the body.

Cultivation of Larvæ.—(1) Mix the fæces (free from drugs such as salines or thymol) with animal charcoal, adding water if necessary till a consistence of porridge is obtained. If the stools are very fluid, allow to sediment first and pour off the fluid. The best charcoal is that made from bones, and should not have an acid reaction. Charcoal is necessary in order to prevent fermentation, which kills the larvæ. Spread in layers 2 to 3 mm. thick in Petri dishes. Incubate at room temperature. To extract the larvæ from the culture allow the surface thoroughly to dry, then pour on water; the larvæ wander out and are poured off and subsequently further purified by sedimentation or filtering through blotting paper, the larvæ passing through.

(2) A funnel is plugged with cotton wool, then filled with washed sand to within a centimetre or two of the rim. Stand this in a jar of water so that the level of the water is slightly below that of the sand. On the surface of the wet sand now place layers of blotting paper, and spread the fæces, diluted if necessary, on this in layers of a few millimetres thick (*vide* p. 474).

Detection of Eggs.—*Vide* p. 473.

Dermal Infection of Dogs.—Infection with larvæ of *A. caninum.* In two hours most of the larvæ are free in the cutis and in four hours in the subcutaneous tissue. By scraping a few days later the mucosa of the trachea large numbers of larvæ are found there.

Ancylostoma ceylanicum, Looss, 1911.

At the anterior edge of mouth capsule one large tooth ; below or behind this towards the middle line a very small tooth, the tip only of which is seen. Male 5 mm. average. Lobes of bursa almost as long as broad, strongly projecting towards the ventral side. Rays short and relatively thick. Female 7 mm.

FIG. 332.—*Ancylostoma ceylanicum* : head end, two teeth on each side, the inner almost concealed by the outer. × c. 200. (After Looss.)

Habitat.—Intestine civet cat (*Viverricula malacensis*), Ceylon, and man in Bengal according to Clayton-Lane.

Other species are : *A. caninum* (Ercolani), in cat and dog, Europe and Africa ; *A. malayanum* (Alessandrini), 1905, in the Malay bear (*Helaretos malayanus*) ; *A. pluridentatum* (Alessandrini), 1905, in *Felis mitis*, Brazil.

Ancylostoma braziliense, Gomez de Faria, 1910.

In cats (and dog), Brazil. Female 8·5 mm., male 7·5 mm. long. Eggs 65 μ by 32 μ. Leiper considers it to be identical with *A. ceylanicum.*

FIG. 333.—*Ancylostoma braziliense* : bursa of male. (After Gomez de Faria.)

Group. **Bunostomeæ**, Railliet and Henry, 1909.

Bursa with median double, postero- and postero-external arising from a common trunk, posterior bifurcated, each limb bidigitate (fig. 336). Vulva in middle of body or a little in front. Uteri divergent.

Contains the following genera: (1) Bunostomum (= Monodontus); (2) Necator; (3) Bathmostomum; (4) Gaigeria.

Genus. **Necator**, Stiles, 1903.

Mouth capsule small, narrowed anteriorly (ventrally) by chitinous plates, as in Uncinaria. On each side of the base of the dorsal cone a lateral chitinous plate or lancet with smooth edge (not serrated), ventral lancets as in Ancylostoma. No ridges on outside of ventral wall. Aperture of dorsal œsophageal gland on tip of a cone projecting freely into the buccal capsule. Bursa closed. Posterior ray cleft to its root.

Necator americanus, Stiles, 1902.

Syn.: *N. africanus*, Harrison, 1910.

Male 8 mm. long, female 10 mm. The head is strongly bent dorsalwards so that almost by this character alone it can be distinguished from *Ancylostoma duodenale*. The buccal capsule is markedly small—

FIG. 334.—*Necator americanus*. Showing cutting plates and the projecting dorsal ridge, and deep in the cavity the edges of the ventral lancets. × c. 475. (After Looss.)

in the male, 0·093 by 0·084 mm., in the female 0·11 by 0·097 mm. There are no teeth anteriorly on the ventral side of the capsule, but instead there are two cutting chitinous plates, the anterior portions of which are prominent and angular, and meet in the middle line in front. Posteriorly on each side the plate projects less, while between the anterior and posterior parts there is a deep angle. The inner (posterior) ventral lancets which also occur in *A. duodenale* are large, and project far into the lumen, the tips of these, of the lateral lancets, and of the dorsal cone almost meeting in the centre of the lumen. As already stated in the definition of the genus Necator, there are also lateral lancets which start from the base of the dorsal cone. This dorsal ridge, or rather in this case cone, is a striking object in the mouth, and projects right out into the cavity, and on its summit opens the dorsal œsophageal gland.

FIG. 335.—*Necator americanus:* lateral view, showing the dorsal ridge perforated by the duct of the dorsal œsophageal gland, the lateral lancet and ventral lancet and the nerve papillæ. × c. 475. (After Looss.)

The bursa is about as long as broad, but has the lateral lobes strikingly lengthened, giving a trilobed appearance (fig. 336), but as in *Ancylostoma duodenale* it is closed on the ventral side. The distribution of the rays is best understood from the figure. The genital aperture lies on a marked conical protuberance; the cement gland is bilobed in transverse section. In the female the opening of the vulva is in front of the middle line, in *A. duodenale* it is behind.

FIG. 336.—*Necator americanus:* bursa of male. The rays from right (top) to left are: (1) posterior, (2) postero-external, (3) and (4) median doubled, *i.e.*, postero-median and antero-median, (5) antero-external, (6) anterior (cleft), and above it on left a pre-bursal ray. × c. 120. (After Looss.)

The spicules, 0·92 mm. long are hooked at the extremity.

Eggs more pointed at the poles than those of *A. duodenale*, 64 μ to 72 μ by 36 μ, so that it may not be possible to distinguish single eggs owing to individual variations, yet on comparing a number they can be distinguished.

Geographical Distribution.—Brazil, Porto Rico, Cuba, Central Africa, East Africa, Victoria Nyanza, Gold Coast, Uganda, North-Western Rhodesia, Ceylon, Mysore. For other localities where *A. duodenale* is also found see p. 450.

Habitat.—In small intestine of man and gorilla (*Troglodytes gorilla*).

Necator exilidens, Cummins, 1912.

Syn.: *N. africanus*, Looss, 1911.

Male 7 mm., female 9 mm. long. The edges of the cutting plates are rounded, not angular, and do not meet in the middle line. Inner (posterior) ventral lancets very small. Lateral lobes of bursa broader than long. Rays thick and plump.

Habitat.—In the chimpanzee (*Anthropopithecus troglodytes*).

ANCYLOSTOMIASIS.

Morbid Anatomy. — Organs pale and bloodless. Abdominal organs sodden, and there is fluid in the serous cavities. Lungs: œdema. Kidneys: fatty changes, especially large pale kidney. Liver and heart also show fatty changes—there is much hæmosiderin in the liver cells. Blood: early stages, a leucocytosis 20,000 upwards, and eosinophilia 50 per cent. Later, anæmia (hydræmia). The number of worms found varies from ten to 1,000. They are rare in the duodenum, but occur as far as 6 ft. from the pylorus.

Group. **Syngameæ**, Railliet and Henry, 1909.

Bursa with anterior and median ray cleft; antero-external, close to median; postero-external, arising separately from posterior; posterior bifurcate to base, each branch bifurcate or trifurcate. Vulva in the anterior fourth of body. Uteri divergent.

Genus. **Syngamus**, von Siebold, 1836.

Head thickened, not tapering; broad mouth with gaping buccal capsule.

Male and female often in permanent copulâ.

Parasitic in respiratory passages of birds and mammals.

Habitat.—*S. trachealis* in poultry; *S. bronchialis* in goose; *S. laryngeus* in cattle; *S. vasicola* in goats, etc.

Syngamus kingi, Leiper, 1913.

Buccal capsules of male and female on same level. In *S. trachealis* and *S. laryngeus*, that of male in front of that of female. In *S. dispar*, that of male behind that of female. Œsophagus of male one-sixth, that of female one-ninth of total length. Mouth capsule in male and female terminal; it is dorsal in *S. trachealis* and in mammalian species. Tail of female bluntly pointed. Ovary reaches to anus. Excretory pore opposite the middle of the bulb of œsophagus. In *S. trachealis* it is opposite the œsophageal valves.

Habitat.—Found in sputum of patient by King in St. Lucia. Normal host probably a carnivore.

Fig. 337.—*Syngamus kingi:* anterior end of male. (After Leiper.)

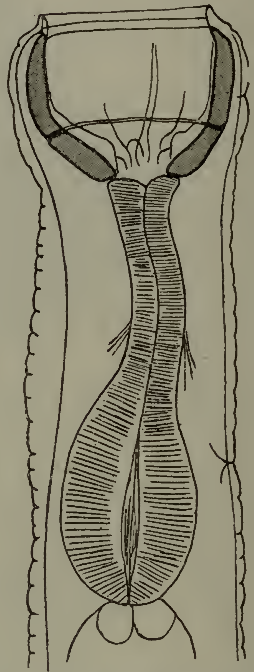


Fig. 338.—*Syngamus kingi:* anterior end of female. (After Leiper.)

Family. **Physalopteridæ.**

Genus. **Physaloptera**, Rudolphi, 1819.

Mouth surrounded by *two* large lateral lips bounded posteriorly by a cuticular band projecting anteriorly, forming a collar. Each lip bears anteriorly and inwardly a cuticular appendage, the external tooth. Immediately below and internal to the external teeth the internal teeth, one on each lip. Each lip bears two large submedian papillæ. Tail of male with four pairs of pedunculated papillæ in a row on each side external to the six pairs of unpedunculated papillæ. Spicules unequal. Vulva in the anterior region of the body. Eggs with a characteristic thick smooth shell.

Parasitic in the intestine, more especially the stomach, of mammals (twenty species), birds (twelve species), reptiles (fourteen species).

Physaloptera caucasica, v. Linstow, 1902.

The male measures 14·2 mm. in length and 0·71 mm. in breadth; the bursa is broad, rounded off in front and narrower at the back; the right spicule measures 0·62 mm. in length, the left spicule 1·76 mm.; there are two papillæ in front of the orifice of the cloaca, four behind it and six unpedunculated on the tail. The female measures 27 mm. in length, 1·14 mm. in breadth; the caudal extremity is rounded off; the vulva is on the border of the first and second sixth of the length of the body; the eggs have thick shells, and measure 57 μ by 39 μ. It has hitherto only been observed once, by Ménétriés in the intestine of man (Caucasus).

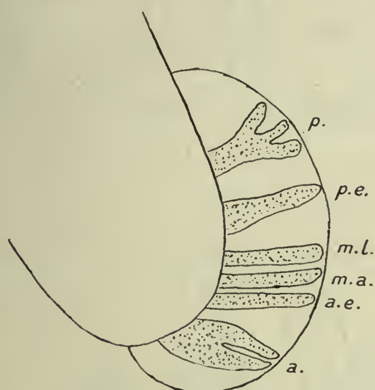


FIG. 339.—Bursa of *Syngamus trachealis*. *a.*, anterior ray cleft; *a.e.*, antero-external; *m.a.*, antero-median; *m.l.*, postero-median; *p.e.*, postero-external; *p.*, one branch of posterior (trifurcate). (Stephens.)

Physaloptera mordens, Leiper, 1907.

Large worms resembling an immature *Ascaris lumbricoides*.

The inner lancet-shaped teeth have a sharp cutting edge towards the lumen. Below each is a cuticular boss projecting into the mouth (fig. 340).

Male 30 to 50 mm., bursa with four pairs of pedunculated papillæ, the second and third lying external to the first and fourth on each side. Spicules unequal, one slender (4·6 mm.), the other stouter (6 mm.).

Female 40 to 55 mm. Tail sharp. Vulva opens between the anterior fourth and fifth of the body. Eggs 43·6 μ by 35·3 μ with a thick smooth shell.

Habitat.—Œsophagus, stomach, small intestine of man (several cases). Nyasaland and Portuguese East Africa.

Family. Ascaridæ, Cobbold, 1864.

Sub-family. Ascarinæ.

Without œsophageal or intestinal diverticula; spicules without flanges.

Genus. Ascaris, L., 1758.

Intermediate lips and auricles absent. Lips edged with fine teeth. Lips triangular in cross section. Not grooved on internal surface.

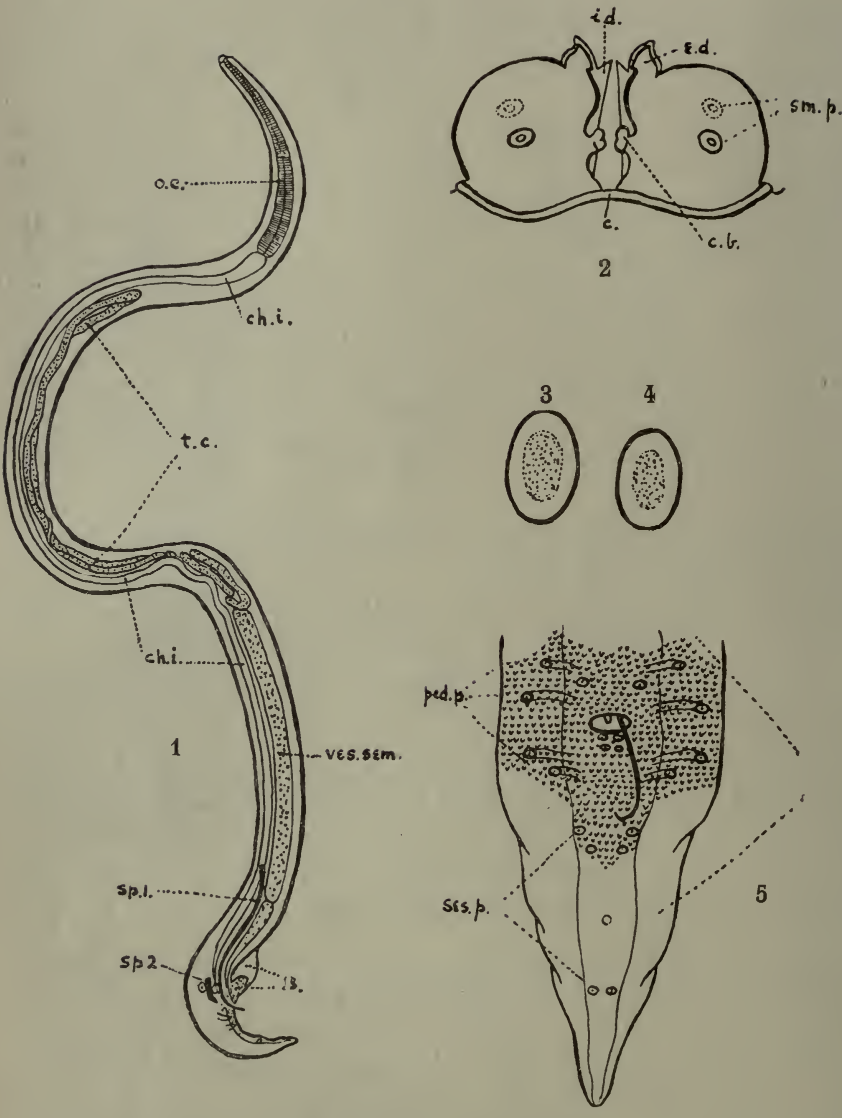


FIG. 340.—*Physaloptera mordens*, Leiper, 1907. (1) adult male : *o.e.*, œsophagus ; *ch.i.*, chyle intestine ; *t.c.*, testicular coils ; *ves. sem.*, vesicula seminalis ; *sp.*1, long spicule ; *sp.*2, short spicule ; *B.*, bursa. (2) Mouth parts : *c.*, cuticular collar embracing the two lips posteriorly ; *c.b.*, cuticular bosses guarding the mouth laterally ; *e.d.*, external tooth ; *i.d.*, internal tooth ; *sm.p.*, submedian papillæ. (3) egg of *P. caucasica*. (4) egg of *P. mordens*. (5) bursa enlarged : *ped.p.*, pedunculated papillæ ; *ses.p.*, sessile papillæ. (After Leiper.)

Ascaris lumbricoides, L., 1758.

The colouring, in the fresh condition, is reddish-yellow or greyish-yellow; the body is of an elongated spindle shape. The oral papillæ are finely toothed. The dorsal papilla carries two sensory papillæ, the two ventral papillæ each one sensory papilla. The male measures from 15 to 17 to 25 cm. in length, and about 3 mm. in diameter; the posterior extremity is conical and bent hook-like ventrally; the spicules measure 2 mm. in length, are curved, and somewhat broadened at their free end; on each side around the orifice of the cloaca there are seventy to seventy-five papillæ, of which seven pairs are post-anal. The testicular tube is much folded, showing through the body integument, and is about eight times the length of the body. The female measures 20 to 25 to 40 cm. in length and about 5 mm. in diameter; the posterior extremity is conical and straight. The vulva is at the junction of the anterior and middle thirds of the body, which, at

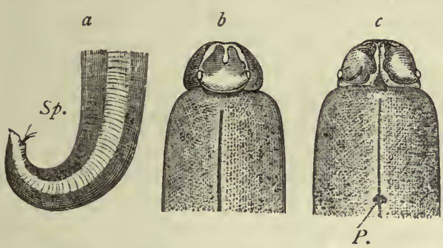


FIG. 341.—*Ascaris lumbricoides.* *a*, posterior extremity of the male with the spicules protruding from the orifice of the cloaca (*Sp.*); *b*, anterior extremity from the dorsal surface, the two lobes of the pulp of the lip separated by the "saddle"; *c*, anterior extremity from the ventral surface; *P.*, excretory pore. (From Claus.)

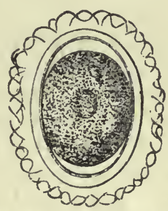


FIG. 342.—Ovum of *Ascaris lumbricoides*, with shell and albuminous envelope. 400/1.

this point, has a slight ring-like constriction; the convoluted ovaries measure ten times the length of the body.

The ova are elliptical with a thick (4 μ) transparent shell (fig. 342) and an external albuminous coating which forms protuberances; the ova measure 50 μ to 70 μ in length, 40 μ to 50 μ in breadth; they are deposited *before* segmentation; the albuminous coating is stained yellow by the colouring matter of the fæces, but is sometimes absent. The egg cell is unsegmented, it almost completely fills the shell, and its nucleus is concealed by the large amount of coarse yolk granules.

Abnormal or unfertilized eggs also occur in fæces. They are distinguished by their elongated form (80 μ by 45 μ), irregularly cylindrical, its contents consisting of refractive granules.

Ascaris lumbricoides is one of the most frequent parasites of man; it is distributed all over the inhabited parts of the world, and though it is particularly frequent in the warmer regions, yet it also occurs in Finland, Greenland, etc. In temperate climates *A. lumbricoides* occurs most frequently in young children; it is, moreover, more common amongst country dwellers than amongst the inhabitants of towns, but is not lacking in infants, adults and aged persons. As a rule only a few specimens are present in the intestine, but many cases are known in temperate zones in which several hundreds of worms have been found in the same patient. This species is particularly numerous in the negroes of Africa and America. It occurs also in the monkey, dog and pig (? *A. suilla*).

The parasite was known in ancient times; the Greeks called it ἕλμινς στρογγύλη, Plinius termed it *Tinea rotunda*, ater on it was named *Lumbricus teres*. The ἄσκαρις of the Greeks is our Oxyuris.

The small intestine is the normal habitat of *Ascaris lumbricoides*; the worms, however, often leave this part of the intestine and wander into the stomach, whence they are frequently evacuated by vomiting, or they may creep through the œsophagus into the pharynx and crawl out through the nose or mouth; very rarely they may find their way into the Eustachian tube or into the naso-lachrymal duct, or into the excretory ducts of the liver and pancreas; exceptionally they may gain the trachea, and they have also been found in the abdominal cavity. They may bore through adhesions between the intestinal wall and the omentum (worm abscess); they occasionally penetrate the urinary apparatus and are passed with the urine; in febrile diseases *A. lumbricoides* usually leaves the intestine spontaneously. It is obvious that these wanderings may be accompanied by the most serious symptoms, but in sensitive persons the invasion of even only a few intestinal Ascarides gives rise to a series of almost inexplicable symptoms (hysterical, epileptiform attacks, cerebral congestion, aphonia, etc.), which cease with the expulsion of the worms, so that many authors are driven to the conclusion that these Acarides secrete a toxin. Fortunately, the presence of *A. lumbricoides* in the intestine is easily demonstrated by the microscopical examination of the fæces.

Development.—Several authors (Gros, Schubart, Richter, Leuckart and Davaine) have demonstrated that the ova of Ascaris develop in water or moist earth after a long period of incubation. Freezing and desiccation (if not too long) do not injure their powers of development; the duration of the development depends on the degree of the surrounding temperature. At a medium temperature, after a varying period of incubation, it takes from thirty to forty days for the embryo to become formed. The spirally rolled up embryo, with its so-called "tooth," formed by three papillæ close together, never leaves the egg-shell in the open, even if the eggs are kept for years under favourable conditions. Davaine proved that the larvæ hatch out in the intestine of the rat, but are again expelled with the fæces; he therefore concluded that the hatching likewise takes place within the intestine of man, but is followed by the invasion of the larvæ. In the meantime Leuckart had sought to infect himself by swallowing embryo-containing eggs, but without results; he therefore conjectured that there must be an intermediary host, and v. Linstow thought he had found it in myriapods (*Julus guttulatus*). Subsequently, Davaine's opinion proved correct. First of all Grassi succeeded in infecting himself by swallowing 100 embryo-containing eggs of *Ascaris lumbricoides;* five weeks after ingestion the worms had attained maturity and their ova appeared in the fæces. Calandruccio also sought to infect himself, but failed, yet he succeeded in infecting a little boy aged 7. Lutz also reports a successful experiment which must have been positive, as young worms 5·5 to 18 mm. long were expelled. Lutz proved that the eggs lost their albuminous shell by long lying in water and then died when introduced into the stomach; this would explain the failure of Leuckart's experiment; in moist earth the albuminous shell is retained. Finally, Epstein conducted unimpeachable experiments on three children which place direct infection with embryo-containing eggs beyond doubt; he, moreover, proved that the development of the eggs takes place more rapidly in the fæces when there is free admission of air, sun, and a sufficiency of moisture.

Accordingly, infection occurs partly through water, but principally direct from the soil.

Ascaris, sp.

Wellmann states that yet another species of Ascaris in man occurs in the highlands of Angola: up to the present nothing certain is known about it (Welland, "Critical Notes on Tropical Diseases of the Angola Highlands," *New York Med. Journ. and Philadelphia Med. Journ.*, August 12 to September 2, 1905.)

Ascaris texana, Smith et Goeth, 1914.

Female alone known; 58 to 60 mm. and upwards in length; characterized by the serration of the anterior border of the lip and by the appearance of interlabia. Evacuated by a white settler in Texas. Position of this worm doubtful.

Ascaris maritima, Leuckart, 1876.

Only one immature specimen, a female (43 mm. in length and 1 mm. in breadth), has hitherto been described, and it was vomited by a child in North Greenland in 1865. (R. Leuckart, "Die menschlichen Parasiten," 1876, edition 2, i, p. 877.)

Genus. **Toxascaris** (*τόξον*, an arrow), Leiper, 1907.

Body anteriorly bent dorsally, cuticle finely striated. Œsophagus without a distinct bulb. Tail of male tapers to a point. Testis in anterior portion of posterior half of body. Vulva about middle of body. Eggs oval and smooth.

Toxascaris limbata, Railliet and Henry, 1911.

Syn.: *Lumbricus canis*, Werner, 1782; *Ascaris teres*, Goeze, 1782; *Ascaris cati* et *caniculæ*, Schrank, 1788; *Ascaris canis* et *felis*, Gmelin, 1789; *Ascaris tricuspidata* et *felis*, Bruguiere, 1791; *Ascaris werneri*, Rud., 1793; *Fusaria mystax*, Zeder, 1800; *Ascaris marginata* et *mystax*, Rud., 1802; *Ascaris alata*, Bellingham, 1839.

Striations 6 μ to 12 μ apart. Cephalic wings long, narrow, semi-lanceolate. Male, 4 to 6 cm. Spicules, 1,002 μ and 1,005 μ. Female, 0·5 to 10 cm. Eggs, 75 μ to 85 μ, shell thick and smooth. Host: dog, occasionally man.

FIG. 343.—Ovum of *Toxascaris limbata*, with thin albuminous envelope. Magnified.

FIG. 344.—Transverse section through the head part of *Belascaris cati* from the cat, with the lateral wings. In addition, one may note the four fields of muscles, the longitudinal lines with the œsophagus in the centre. Magnified. (After Leuckart.)

Genus. Belascaris (βέλος, an arrow), Leiper, 1907.

Body anteriorly bent ventrally, cuticle coarsely striated. Œsophagus with a distinct bulb. Tail of male conical. A papillæ-bearing protuberance behind the anus. Testis in anterior half of body. Vulva in anterior part of body. Eggs corrugated.

Belascaris cati, Schrank, 1788.

Syn.: *Belascaris mystax*, Leiper, 1907; *Ascaris mystax*.

Striations 12 μ to 16 μ apart. Cephalic wings lanceolate. Male 3 to 6 cm. Spicules 1·7 to 1·9 mm. Female 4 to 10 cm. Eggs, 65 μ to 75 μ in diameter, surface finely honeycombed. Host: domestic cat, and man, eight or nine cases.

Belascaris marginata, Rudolphi, 1802.

Striations 16 μ to 22 μ apart. Cephalic wings long, narrow, semi-lanceolate. Male, 5 to 10 cm. Spicules, 750 μ and 950 μ. Female, 9 to 18 cm. Eggs, 75 μ to 80 μ. Shell finely honeycombed. Host: dog.

Genus. Lagocheilascaris, Leiper, 1909.

Thick lips separated by a furrow from the body; between the lips small intermediate lips without "pulp." The cutting angle of each lip bifurcated. Along each lateral line a cuticular wing extending the whole length of the body. Eggs, thick shell with a mosaic pattern.

Lagocheilascaris minor, Leiper, 1909.

Male, 9 mm., tail sharply curved. Spicules colourless, 3·5 and 4 mm. long. More than twenty-four pairs of pre-anal papillæ, at least five pairs of post-anal. Female, 15 mm. Straight posteriorly. Vulva 6 mm. from head with two lips. Eggs, 65 μ in diameter. Host: man, cutaneous abscesses. Trinidad.

Family. Oxyuridæ.

Genus. Oxyuris, Rudolphi, 1803.

Mouth unarmed. The three labial papillæ are only slightly protuberant, the œsophagus is long and presents two well-marked bulbs. The vulva is in the anterior part of the body.

Oxyuris vermicularis, Linnæus, 1767.

Syn.: *Ascaris vermicularis*, L.; *Fusaria*, Zeder, 1803.

Colour white, the striated cuticle forms projections at the anterior end which extend some distance back along the middle of the ventral and dorsal surfaces; the longitudinal lateral flanges of the skin corresponding to the lateral lines are well seen in transverse sections; there are three small retractile labial papillæ around the mouth. The male measures 3 to 5 mm. in length, and shortens on death; the posterior extremity of the body is curved ventrally and presents six papillæ. Spicule 70 μ long, hook-like. The female is 10 mm. in length and 0·6 mm. in diameter; the anus is about 2 mm. in front of the tip of the tail; the vulva is in the anterior third of the body; the eggs are oval, asymmetrical, with double-contoured shells, and measure 50 μ to 55 μ by 16 μ to 25 μ; they are deposited with clear, non-granular tadpole-like embryos already developed.

Habitat.—Adults in large intestine of man. Young forms in small intestine and often in the appendix.

The worm lives in the lower part of the small intestine, cæcum and vermiform appendix, and before becoming adult undergoes two or three moults (Heller). According to Wagener the worms at times live in the gut wall, giving rise to calcareous nodules. When the uterus of the fertilized females begins to fill with eggs they leave the cæcum and travel through the colon to the rectum. The uterus is now packed with eggs which contain a tadpole-shaped embryo. Egg-laying now takes place, partly in the rectum, partly outside, the mode of exit being not only passive through defæcation but also an active one on the part of the worms when the patient is in bed. In this case the worms crawl out of the anus, producing a most intolerable itching as they scatter their eggs between the nates and the perinæum. From here in the case of girls they may get occasionally into the vulva and vagina, and even into the oviducts and so into the body cavity. The worms also may wander through the alimentary canal in the opposite direction, getting out occasionally through the mouth. Recently a *rôle* has been assigned to them, as to other gut parasites, in appendicitis and typhlitis.

It is stated that the males die after fertilizing the females, thus explaining why they are so rarely met with in fæces [but it is probable that they often escape notice from their small size.—J. W. W. S.].

Development.—The eggs, which often adhere together, contain a tadpole-like embryo, the thin tail of which is bent upwards ventrally;

FIG. 345.—*A*, male, and *B*, female, of *Oxyuris vermicularis*. 5/1.

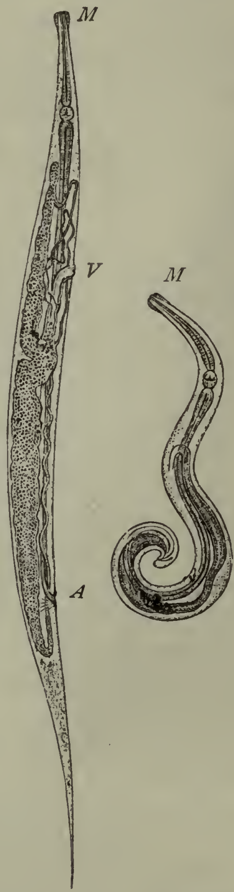


FIG. 346.—On the left, female; on the right, male. *A*, anus; *M*, mouth; *V*, vulva. Greatly enlarged. (After Claus.)

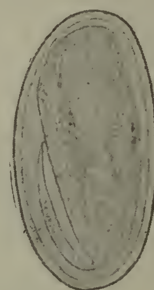


FIG. 347.—*Oxyuris vermicularis*: egg freshly deposited, with tadpole-like embryo. × 640.

FIG. 348.—*Oxyuris vermicularis*: egg twelve hours after deposition, with nematode-like embryo. × 640.

the embryo in a short time, given a sufficiently high temperature, passes into a second folded nematode-like embryonal stage, lying in the eggshell, either in the fæces, with which also numerous females pass out, or in the moisture of the groove between the buttocks, and they there await the opportunity of being reintroduced into man *per os*. It is very improbable that infection takes place directly in the large intestine, as is occasionally stated, because although the harbourers of Oxyuris are frequently liable to auto-infection, this takes place exclusively through the mouth, and is conveyed by the fingers, on which the ova of Oxyuris, and occasionally the female worms, have clung.

The opportunity for this is afforded every evening, as naturally the troublesome itching caused by the wandering of the worms is met by scratching and rubbing with the fingers. It is therefore possible that the eggs may even thus be introduced into the nose, where the young Oxyuris are perhaps hatched out, if they get high enough up on the moist pituitary mucous membrane. As a matter of fact, the larvæ of Oxyuris have been found in the nose. Moreover, one can understand that the eggs of Oxyuris are transferred from person to person by the hand, directly or indirectly. This again explains the wholesale infections which occur in collective dwellings, after a person harbouring Oxyuris has been admitted into boarding-houses, etc. The primary infection may be also caused in other ways—by foods, fruits, vegetables and other articles that are eaten raw, and are polluted with the ova. Perhaps also flies or their excrement play a part in the distribution of the parasite, similar to that demonstrated by Grassi as taking place in the spread of the ova of Trichocephalus and Tænia.

The assumption of a *direct development* without an intermediary host was first substantiated by Leuckart by experiments on himself and three of his students; about fourteen days after swallowing the eggs the Oxyuris has attained 6 to 7 mm. in length; Grassi, and later on Calandruccio, infected themselves by swallowing adult female Oxyuris, with the same results. Heller found worms in the gut (appendix vermiformis) of a male child five weeks old.

Other species are : *O. compar* in the cat; *O. curvula* and *O. mastigodes* in horse, ass, mule ; *O. ambigua* in the rabbit ; *O. poculum* in the horse ; *O. tenuicauda* in the horse. Many species occur in insects, especially in *Blattidæ* and *Hydrophilidæ* (aquatic beetles).

Family. **Mermithidæ.**

Genus. **Mermis,** Dujardin, 1845.

With characters of the family.

Mermis hominis oris, Leidy, 1850.

Fourteen centimetres in length, 0·16 mm. in breadth; mouth terminal; posterior extremity obtuse and provided with a recurved hook 50 μ long.

The parasite was "obtained from the mouth of a child." Stiles considers it to be probably a Mermis, possibly swallowed in an apple.

Agamomermis, Stiles, 1903.

Group name for immature *Mermithidæ*.

Agamomermis restiformis, Leidy, 1880.

This worm measures 65 cm. in length, pointed anteriorly, the posterior extremity broadened and rounded off (1·5 mm. in breadth); the mouth is terminal, without lips. Behind the mouth six papillæ; the œsophagus measures 1·125 mm. in length; the intestine appears to terminate blindly.

This parasite was obtained in West Virginia from the urethra of a young man, aged 20, who for a few days previous to expelling the worm passed turbid and bloody urine.

TECHNIQUE.

Preservation and Examination of Flukes.

Fixation.—(Method A.) (1) Place the flukes in a test tube or small bottle a quarter full of normal saline. Shake the contents *as hard as possible* (the object of this is to *extend* the flukes) for half a minute.

(2) Add *immediately* an equal bulk of saturated aqueous solution of corrosive sublimate and shake again as vigorously as possible for a few minutes.

(3) Transfer when convenient to 70 per cent. alcohol. (Before staining and mounting remove the sublimate with tincture of iodine.)

(Method B.) In case of large flukes, *e.g.*, *Fasciola hepatica*, *Fasciolopsis buski*, compress the flukes between two glass slides with rubber bands or thread. Fix in sublimate or in absolute alcohol, or in 10 per cent. formalin.

(Method C.) Place the flukes in 10 per cent. formalin solution.

Staining is successfully effected by using quite *dilute* solutions of carmine or hæmatein overnight. This is far preferable to using strong solutions, as it may be almost impossible to remove a too intense stain. Almost any dilute carmine solution suffices. One of the best is acetic-alum carmine (boil excess of carmine in a saturated aqueous solution of potash-alum for about fifteen minutes; add glacial acetic acid to the extent of 10 per cent.; let it stand for a week; filter). For use, dilute about thirty times with water. Place the flukes directly in the stain. Stain overnight or longer.

Differentiation.—In order to get the sharpest picture, it is best now to differentiate (but this may often be omitted) with acid alcohol (70 per cent. alcohol 100 parts, HCl 5 drops). Allow to act from one to twenty-four hours, according to the appearance of the flukes. Similarly, in staining with *hæmatoxylin* solution, dilute twenty to thirty times so that the water is merely tinged with the stain. Differentiate as before. After staining, dehydrate, clear, and mount in balsam if required.

Clearing and Mounting.—(1) *Carbolic acid* (carbolic acid 94, water 6) is a very convenient clearing agent. It may be used for stained or unstained specimens. It will clear rapidly without previous dehydration. If it is required to mount a specimen permanently, transfer from carbolic to alcohol, then cedar-wood oil (or xylol, etc.), then balsam.

(2) *Creasote.*—Dehydrate the specimen, stained or unstained, transfer to creasote. If it is desired to mount permanently, transfer back to alcohol, then cedar-wood oil, then balsam.

(3) *Cedar-wood Oil.*—Preferable to xylol or oil of cloves. Dehydrate the specimen in alcohol. To mount permanently, transfer to balsam.

(4) *Glycerine.—Vide* under methods of preservation of ova; to mount permanently, transfer to glycerine jelly; subsequently to harden the jelly, expose to formalin vapour.

Of these media, carbolic acid has the greatest refractive index excepting that of balsam. The latter may, in some cases, render structures too transparent, and it may be advisable to use only glycerine or glycerine jelly.

Preservation of Ova in Fæces, Urine, Bile, etc.

Heat some 70 per cent. alcohol in a basin to about 60 to 70° C. (until bubbles begin to appear). Add the fæces, etc., in the proportion of one part to about nine of fixative; keep stirring. Allow the sediment to settle. Transfer to a bottle with some fresh 70 per cent. alcohol.

Transference to Glycerine.—Prepare 5 per cent., 10 per cent., 20 per cent. solutions of glycerine in 70 per cent. alcohol. Pour off the alcohol in the bottle of fæces, etc., and replace by 5 per cent. glycerine solution. Allow to stand an hour or so. Then in the same way replace the 5 per cent. by a 10 per cent. glycerine, and finally by a 20 per cent. glycerine solution. When in this latter expose freely to the air (protecting from dust), so as to allow the alcohol and water to evaporate. Add a few drops of glycerine from time to time till eventually the ova are in pure glycerine. (In a very moist climate it may be necessary to use lime or calcium chloride to dry the air.) To mount permanently transfer some of the sediment to glycerine jelly.

Preservation and Examination of Cestodes.

Fixation.—(1) *Saturated aqueous corrosive sublimate.*—Add to this glacial acetic acid to the extent of 1 per cent. (Note this fixative will dissolve the "calcareous corpuscles"; 10 grammes of sublimate to 160 c.c. of water will give a saturated solution.) Warm the fixative to 70° to 80° C. (Avoid the use of needles.) Use plenty of fixative. Allow to act for a quarter of an hour or so. (*a*) Transfer to 70 per cent. alcohol. (It is advisable to remove the sublimate by the use of Lugol's solution, or a solution containing tincture of iodine, adding this until the iodine colour is permanent.) Or (*b*) transfer for preservation to 10 per cent. formalin.

Or (2) 10 *per cent. formalin.*—In order to prevent contraction it is advisable to extend the tapeworm and keep it fixed by glass plates, or wind the worm around a wide glass tube or bottle, and then fix it.

Or (3) *fix in hot alcohol.*

Staining.—As under flukes. It is necessary to sacrifice portions of the tapeworm for this purpose, cutting out, *e.g.*, mature segments, so as to study the topography of the genitalia.

Clearing.—As under flukes. To examine the hooks satisfactorily it is best to cut off the head with a sharp knife and mount. A certain amount of pressure is then advisable in order to view the hooks completely so as to measure them.

Preservation of Ova in Fæces, etc.

As under flukes.

Preservation and Examination of Nematodes.

Fixation.—(1) Thoroughly wash the worms to get rid of mucus, etc., by shaking up in warm saline (or water) till the washings are clean. Then transfer to 70 per cent. alcohol *heated* to about 70° C. It is absolutely necessary to use *hot* fixatives in order to *extend* the worms. If no alcohol or spirit is immediately available, drop the worms into *hot* water, or saline, and transfer later to 70 per cent. alcohol.

(2) Drop into hot 10 per cent. formalin.

Clearing.—(1) Carbolic acid, *vide* p. 471.

(2) Creasote, *vide* p. 471.

(3) Glycerine, *vide* p. 472.

Staining.—In case of quite small Nematodes, *e.g.*, *Anguillulidæ*, carmine may be used, but as a rule staining is not advantageous.

Rolling.—In order to study the mouth parts, or bursa, etc., it is necessary to place the worm in any desired position. This is done as one would roll a penholder along the table by one's finger placed on top of it. In the case of a worm, one edge of the cover-glass is placed over the worm, the other is supported by a strip of cardboard. By tapping the cover-glass the worm will now revolve as much as required provided it is *round* and *straight.* In certain cases it may be necessary for this purpose to cut off the head or tail. Roll these separately.

When a suitable position is got, the worm may be fixed in this position by pressure on the cover-glass, so as slightly to flatten it.

Mounting the Head.—If it is required to get an end view, it is necessary to cut off the head transversely as near the end as possible, and then mount.

Detection of Eggs (Bass and Hall).—Mix the fæces thoroughly with ten times the volume of water. Filter through gauze. Centrifugalize the filtrate. Wash the sediment and centrifugalize. Repeat twice. To sediment add $CaCl_2$ solution, sp. gr. 1250. The eggs float to surface. Pour off surface fluid. Dilute to sp. gr. 1050. Centrifugalize. Examine sediment, which contains practically all the eggs in the stool.

Detection of Small Nematodes.—Mix the fæces thoroughly with water. Allow to settle for five minutes. Carefully decant off, or better, syphon off the fluid. Mix the sediment again with water. Allow to settle. Remove the fluid. Repeat several times. Examine the sediment in a Petri dish. As the fluid is poured off, the worms will be seen collected in the backwater. Remove them with a brush. Fix in hot 70 per cent. alcohol.

Cultivation of Larval Forms of Ancylostoma and Strongyloides.

A modification of the second method of Looss (p. 455) is that of Fülleborn. A glass filter funnel is lined with linen or with cotton wool dyed black with iron-tannin. On this is placed a layer of sterile sand, and on top of this the fæces. The whole is moistened. The larvæ hatch out and wander through the meshes of the wool, appearing on the edges of the same as white threads visible to the naked eye. With a platinum needle these can be easily removed. The glass filter can be placed on a glass cylinder, and this in another large stoppered cylinder containing caustic potash solution at the bottom, so that any larvæ escaping from the funnel are killed.

D. ACANTHOCEPHALA, Rud.

GUTLESS, nematode-like worms that carry at their anterior end a retractile rostrum beset with hooks. In their adult condition they only live in vertebrate animals. During their larval stage they are often parasitic in invertebrate animals.

The *Acanthocephala* are elongated cylindrical worms, with a rounded posterior end. In some species an annulation is distinctly recognizable; they are, however, not segmented. The size varies according to the species, between about 5 to 10 mm. and 40 to 50 cm.; in general, however, there is a preponderance of the small species. The sexes are separate, and the males can easily be distinguished from the females without examination of the genitalia, as the females are both larger and thicker.

The body wall of Echinorhynchus is limited by a thin cuticle, which is attached inwardly to the hypodermis. In only exceptional cases a syncytium with large nuclei, even in the adult condition, is represented by the hypodermis; and in it fibre systems, the elements of which run in layers in various directions, appear, and it is only towards the interior from these strata of fibres that the nuclei of the hypodermis are found. As a rule, these fibres, at all events the radiary fibres, are regarded as muscles. Hamann desciibes them as elastic fibres, which lie in a viscid gelatinous connective substance (transformed protoplasm ?); a lacune system filled with a granular fluid, the central part of which are two longitudinal lacunes lying at the sides, also belongs to the cutaneous strata, as do the so-called lemnisci, two short, flat organs suspended in the body cavity, and the pedicles of which are attached anteriorly at the border between the rostrum and body; their structure as well as their origin permit them to be traced to the skin (fig. 348A).

Finally, inwardly below the skin there follows a layer of annular, and after these a layer of longitudinal muscles, the structure cells of which remain present in the residues, carrying nuclei. The motor apparatus of the rostrum, the sheath of the rostrum, and the lemnisci also belong to the muscular system. The rostrum represents a finger-shaped hollow process of the cutaneous layer; but, according to Hamann, it originates from the entoderm and passes through the skin secondarily. It is covered by a thin cuticle, and as a rule contains a large number of regularly placed chitinous hooks that adjoin a granular formation tissue. From the base of the rostrum springs a tubular hollow muscle extending into the body cavity; this is the RECEPTACULUM PROBOSCIDIS, from the base of which again bundles of longitudinal muscles originate, which pass along its axis and that of the rostrum itself, and are inserted at the inner surface of its anterior end (RETRACTOR PROBOSCIDIS). These muscles when they contract invaginate the proboscis and draw it into the receptaculum; when reversed they act again as PROTRUSOR PROBOSCIDIS. The whole of the anterior body, however, can be invaginated, and for this purpose there is a muscle that originates from the body wall at a variable distance back, and which is joined to the receptaculum (RETRACTOR RECEPTACULI); there is also a bell-shaped muscle which springs from the body wall behind the lemnisci in rings, and passes forward to the spot of attachment of the lemnisci.

The nervous system consists of a cluster of ganglia situated at the base of the rostrum, from which three nerves pass towards the front and two towards the back. No sensory organs are known.

The excretory organs, according to Kaiser, lie at the upper border of the ductus ejaculatorius in the male and at the so-called bell in the female. Here they represent the long-known villous tufts, placed on disc-like cushions. In each of the cylindrical villi—which terminate blindly towards the body cavity—there lies a cilium, which springs from the membrane lining the villus, and which lies in a space cavity of the villus, which ultimately proceeds as a little canal. There are three canals discharging into the uterus that serve to conduct the excretory materials from the body cavity; special glandular cells corresponding to the terminal cells of the Platyhelminths, at the commencement of the system, are not present in the Acanthocephala.

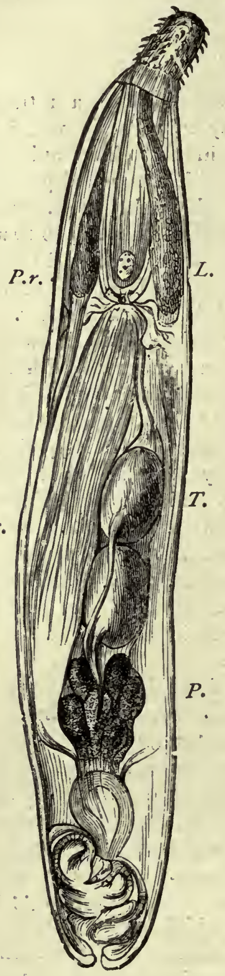


FIG. 348A. — The male of *Echinorhynchus augustatus*. *L.*, lemnisci; *T.*, testicles; *P.*, prostatic glands; *P.r.*, sheath of proboscis, with ganglion; *R.r.*, retractor of sheath of proboscis. 25/1.

SEXUAL ORGANS.

(*a*) *Male Organs.*—The greatest part of the male genital apparatus is contained in a muscular sheath—the ligament—which originates at the posterior end of the receptaculum proboscidis, passes along longitudinally through the body cavity, and is inserted at the posterior end of the worm. The two oval testicles usually lie one behind the other; their vasa efferentia unite sooner or later into a vas deferens which passes backwards, and finally terminates in the penis; the terminal portion of the conducting apparatus is surrounded by six large glandular cells (prostatic glands)

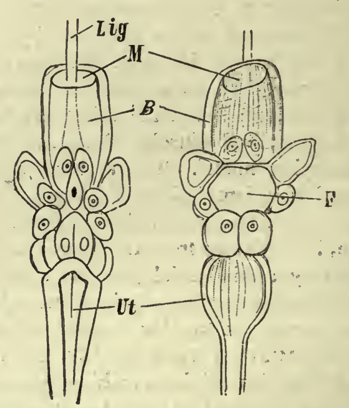


FIG. 348B.—Anterior portion of the female apparatus of *Echinorhynchus acus*. On the left seen from behind, on the right seen from the front. *F*, inferior orifice of the bell; *B*, bell; *Lig*, ligament; *M*, mouth of bell; *Ut*, uterus. Magnified. (After Wagener.)

the excretory ducts of which open into the vas deferens. The penis itself is placed at the base of a bell-shaped invagination of the posterior end, the bursa, which is everted during copulation.

(*b*) *Female Organs.*—There are only two ovaries present in the ligament during the larval stage. During the course of growth they divide into accumulations of cells (placentulæ, loose or floating ovaries), which finally cause the ligament to burst and they thus attain the body cavity. Thence a peculiarly constructed apparatus finally conveys the eggs out. This apparatus consists of the uterine bell and vagina, the latter discharging at the posterior extremity of the body. The bell is a muscular canal provided with apertures at both the anterior and posterior extremities. Its interior space is in direct communication with the body cavity, and the anterior orifice takes up all materials floating in the cavity—egg-balls, mature and immature eggs—and pushes these further backwards. The continuation of the bell lumen is now narrowed by a number of large cells in such a manner that only bodies of a certain form can pass through this tract and attain the uterus; everything else is conveyed back into the body cavity through the posterior opening of the bell.

The eggs are already fertilized in the body cavity, and in this position go through their development to the formation of the embryo. Completely developed eggs are surrounded by three shells, and are generally fusiform. The eggs agglomerate in masses in the uterus until they are finally deposited through the vagina and vulva. For the further development, the transmission of the eggs into an intermediary host—usually a crustacean or an insect—is necessary; the metamorphosis is very complicated; but this transmission may be very easily effected artificially by feeding suitable crustaceans (*Asellus*, *Gammarus*, etc.) with the eggs of *Acanthocephala;* this being the only method of inducing the larva to hatch out so that its structure may be studied. The larva appears in the form of an elongated, somewhat bent body, at the stumpy anterior end of which there is a crown of hooks or spines, whereas the posterior end is pointed. Especial retractors draw in the hook-beset anterior surface, and an elastic cushion beneath them jerks them forward again when required. In the middle of the body a roundish heap of small cells is seen, from which the entire body of the Echinorhynchus originates, even to the cutaneous layer; the latter is also the larval skin in which the small Echinorhynchus gradually grows. The development of all the organs takes place within the intermediary host, and the parasite only needs to be imported into the terminal host to attain the adult stage after a certain growth. In some cases, however, a second intermediary host is utilized.

Species of *Acanthocephala* only occur exceptionally in human beings.

Echinorhynchus gigas, Goeze, 1782.

Syn.: *Tænia hirudinacea*, Pallas, 1781.

The body is elongated, gradually decreasing in thickness towards the back. The rostrum is almost spherical, and is beset with five or six rows of recurved hooks. The males measure 10 to 15 cm. in length, the females 30 to 50 cm.; the eggs are provided with three shells, of which the middle one is the thickest. The eggs measure 0·08 to 0·1 mm. in length. The GIANT ECHINORHYNCHUS occurs especially in the intestinal canal of the domestic pig; it is less common in other mammals. It bores deep into the mucous membrane with its rostrum, and causes an annular proliferation around the perforated spot; occasionally also it causes perforation of the intestine.

FIG. 348C.—Egg of *Echinorhynchus gigas*. 300/1. (After Leuckart.)

It is doubtful whether the giant Echinorhynchus occurs in man. Leuckart admitted that there were a few positive cases. According to Lindemann, *Ech. gigas* occurs in human beings in South Russia, and its presence is not rare. This statement, however, has not been confirmed. Its presence in man is by no means impossible, as its intermediary host, the cankerworm, or cock-chafer (*Melolontha*), is, according to Schneider, occasionally eaten raw by human beings. According to Kaiser, the golden beetle (*Cetonia aurata*) and, according to Stiles, another beetle in America (*Lachnosterna arcuata*) are also intermediary hosts.

Echinorhynchus hominis, Lambl, 1859.

This term is applied to an ECHINORHYNCHUS found by Lambl in the intestine of a boy who had died of *leucæmia;* the worm was 5·6 mm. in length, and the almost spherical head was beset with twelve transverse rows of hooks.

Echinorhynchus moniliformis, Bremser, 1819.

The male is 4 cm. in length, the female 8 cm. long. This species lives in the intestine of field-mice, rats, marmots and *Myoxus quercinus.* A beetle (*Blaps mucronata*) is the intermediary host.

This species has also once been artifically cultivated in man (Grassi and Calandruccio).

E. GORDIIDAE.

VERY long thin worms similar to Filariæ, which, in their adult condition, live free in brooks, pools and springs; the mouth and the commencement of the intestine are obliterated; there are no lateral ridges, and the muscular system presents a structure different to that of the *Nematoda*. The posterior end of the male is split, and spicules are lacking; there are two testicles. In both sexes the genitalia discharge through the terminal gut.

The larvæ, which carry a rostrum beset with hooks, force themselves into the larvæ of water-insects; more rarely they invade molluscs, and they then become encysted within the body of the host. According to Villot, at least a part of them attain the intestine of fishes, where they again become encysted, and after a period of rest they travel into the tissues of their hosts, and finally again reach the exterior by way of the intestine, where they then become adult. In most cases, however, the gordius larvæ are taken up by predacious water insects; they live for a while in the body cavity of these insects, undergo a metamorphosis, and finally wander into the water.

A few species invade man accidentally with water, in which case they are usually vomited up:—

Gordius aquaticus, Dujardin, 30 to 90 cm. in length (Aldrovandi, Degland, Siebold, Patruban).

Gordius tolosanus, Duj., 11 to 13 cm. in length (Fiori).

Gordius varius, Leidy, 10 to 16 cm., female, up to 30 cm. in length (Diesing).

Gordius chilensis, Blanch. (Guy). *Gordius villoti*, Rosa (Bercutti, Camerano); *Gordius tricuspidatus*, L. Def. (R. Blanchard), *Gordius violaceus*, Baird (Topsent), and *Gordius pustulosus*, Baird (Parona).

F. HIRUDINEA s. DISCOPHORA (Leech).

THE *Hirudinea*, which have been appropriately included amongst the Annelida, differ in many respects from the typical members of the group; their body is long and flat, it lacks the parapodia that are characteristic to all forms of Annelida; but, on the other hand, possesses a terminal posterior sucker, and in many species there is also an anterior sucker. The mouth is terminal at the anterior end, the anus lies dorsally above the posterior sucker (fig. 348D). The body is segmented, but this is less manifest in the body covering than it is in the arrangement of the internal organs; the segmentation, nevertheless, is also indicated exteriorly by the appearance of the cutaneous sensory organs which correspond to the segments. This shows what the condition of the ganglia in the abdominal ganglion chain has taught us, that the anterior and the most posterior segments are considerably abbreviated—a part of the latter taking part in the formation of the suctorial organs. In a great many species the skin is distinctly annulated, four or five of such rings, at least in the central region of the body, appearing on one segment of the body. The condition of their body cavity is another peculiarity of the *Hirudinea;* it is narrowed by the powerful development of the connective tissue and the muscular system into four tubular sinuses, which have the appearance of blood-vessels. There are usually one dorsal and one ventral median trunks, as well as two lateral trunks; in addition, a particular blood-vessel system exists.

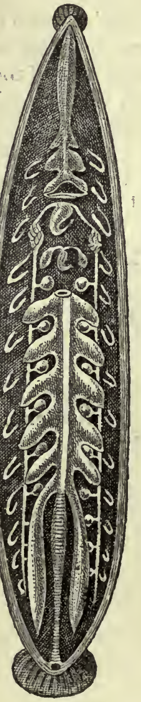


FIG. 348D.—The internal organs of the leech. The creature has been opened from the dorsal surface, and part of the intestine has been removed. The testicles, with vas deferens, may be seen between the blind ducts of the intestine; beyond these on either side the segmental organs. The female genital organs are in front of the most anterior pair of testicles. (After Kennel.)

The skin consists of a very thin cuticle that is cast off from time to time; it is secreted by the underlying cylindrical epithelium, which contains numerous goblet cells. The muscular system is strongly developed; it consists of long tubular fibres, which run circularly, longitudinally and in the dorso-ventral direction; the muscular system is subject to a particular expansion in the clinging organs and at the commencement of the intestine. On the whole, the alimentary canal represents a tube running straight from the mouth to the anus, which possesses a number of blind sac-like protuberances at the sides varying according to the species. The most anterior section, the pharynx, in the leeches with maxillæ carries three chitinous, semicircular plates furnished with teeth—the jaws—which serve to tear up the epidermis in order to open the blood-vessels; in the leeches with rostra a long protractile proboscis rises from the base of the elongated pharynx. Numerous salivary glands, the secretion from which possesses toxic properties, discharge into the pharynx. The œsophagus, which follows the pharynx, and to the exterior of which numerous radiary muscles are fixed, is a suctorial organ in its entire structure. The nutriment in the larger species consists of the blood of vertebrate animals, in smaller species and in the young stages the food consists of small invertebrate animals.

The NERVOUS SYSTEM exhibits the typical structure of other segmented worms; the sensory organs consist of the previously mentioned goblet-shaped cutaneous sensory organs, of the organs of taste, and of eyes, the latter frequently being present in large numbers.

The EXCRETORY or segmental organs exhibit many peculiarities, which cannot, however, be detailed here. They commence with funnels in the lacunes of the body cavity, and usually discharge on the ventral surface.

Almost all the *Hirudinea* are hermaphrodite and copulate reciprocally. The two ovaries are very small, and the oviducts that proceed from them soon unite into a common duct, which then passes into the uterus and discharges through the short vagina in the median line of the ventral surface behind the male organs into the so-called clitellar region. The male sexual apparatus consists of symmetrically arranged testicles, varying in number according to the species, the short vasa efferentia of which, one by one, run into the vas deferens, passing towards the front on each side. In front, at about the level, or a little in front, of the female genitalia, the two vessels pass into a convoluted mass of tubes to the so-called epididymis, and then discharge into the single protractile penis (fig. 348D).

All leeches deposit so-called COCOONS. These are small barrel-shaped or pouch-like bodies, which are surrounded by a thicker shell and contain a number of eggs in a large mass of albumen; the albumen originates from glands of the generative organs, the shell substance from cutaneous glands of the clitellar region.

Family. Gnathobdellidæ (Leeches with Jaws).

These are distinguished by the possession of usually three jaws in the pharynx; the body consists of twenty-six segments. The posterior sucker is large and flat; the anterior sucker is smaller. The *Hirudinea* have five pairs of eyes, the *Nephelinæ* have four pairs.

Genus. Hirudo, L., 1758.

The entire body consists of 102 annulations, five appearing on one segment in the central region of the body. The pharynx has three semicircular jaws, the arched border of which is beset with numerous teeth (50 to 100). The male sexual orifice lies between the thirtieth and thirty-first rings, the female orifice between the thirty-fifth and thirty-sixth. There are numerous species, some of which are utilized for medicinal purposes.

Hirudo medicinalis, L., 1758.

It occurs in numerous colour varieties, one of which has been designated *Hirudo officinalis*, Moq.-Tandon. Usually the dorsal surface is greyish-green and is marked with six rusty-red longitudinal stripes. The ventral surface is olive-green, more or less spotted with black, and marked at the sides with a black longitudinal line. The length averages 8 to 12 to 20 cm. This leech lives in swamps, ponds and brooks, overgrown with plants and having a muddy bed. The cocoons are deposited in the soil at the sides. Europe, as well as North Africa, is its home. At the present day it has been exterminated from most parts of Central Europe, but it is still very common in Hungary. Its use for medicinal purposes is well known. A large leech can suck about 15 grs. of blood, and about the same amount is lost through secondary hæmorrhage.

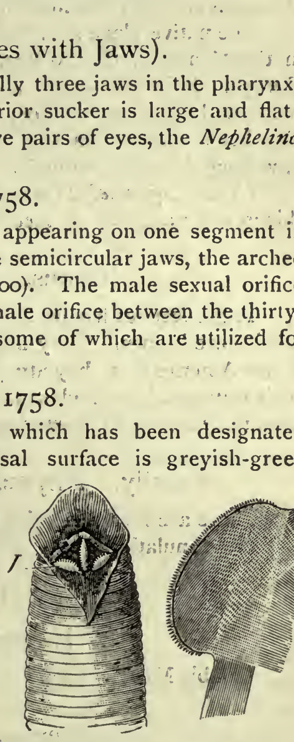


FIG. 348E.—*Hirudo medicinalis*. *a*, anterior end, with open buccal cavity, with the jaws, *J*, at the; *b*, one jaw isolated. (After Claus)

Hirudo troctina, Johnston, 1816.

Syn.: *Hirudo interrupta*, Moq.-Tandon, 1826.

This species measures 8 to 10 cm. in length. The back is greenish, with six rows of black spots surrounded by red; the lateral borders are orange-coloured; the abdomen spotted or unspotted. Its habitat is in North Africa and Sardinia. It is applied medicinally in England, Spain, France, Algeria, etc.

Genus. Limnatis, Moq.-Tandon, 1826.

Nearly related to Hirudo, but is differentiated by a longitudinal groove on the inner surface of the upper lip of the anterior sucker. The jaws are furnished with over 100 very sharp toothlets.

Limnatis nilotica, Savigny, 1820.

Syn.: *Bdella nilotica*, Sav.; *L. nilotica*, Moq.-Tandon; *Hæmopis* (*vorax*), Moq.-Tandon, 1826, *p. p.*; *Hæmopis sanguisuga*, Moq.-Tandon, 1846 (*nec Hir. sanguis*, Bergm., 1757).

This species measures 8 to 10 cm. in length, and becomes gradually more pointed towards the front; the body is always soft. The back is brown or greenish, and has usually six longitudinal rows (rarely only two or four) of black dots. The abdomen is dark; but numerous colour variations occur.

The native place is North Africa, especially the coastal regions; it is also found in the Canaries, the Azores, Syria, Armenia, Turkestan, perhaps also Southern Europe. It is taken into the mouth with drinking water, and may settle in the pharynx, larynx, œsophagus, and nasal cavities of human beings. This species has also been observed in the vagina and on the conjunctiva. It is equally fond of attacking domestic animals.

Hirudo mysomelas (Senegambia) and *Hirudo granulosa* (India) are placed with this genus, and, like our leech, are also used for medicinal purposes.

Genus. Hæmadipsa, Tennent, 1861.

These leeches live on land, and measure 2 to 3 cm. in length. About a dozen species are known. They are a veritable scourge to persons in the tropics (Asia, South America), as they attack them to suck their blood. They are able to force their way even under close-fitting garments, so that it is difficult to protect oneself from their assaults (*Hæmadipsa ceylonica*, Bl., and other species).

Family. Rhynchobdellidæ (Leeches with Rostrum).

These are furnished with a proboscis in lieu of the jaws; the segment consists of three annulations.

Genus. Hæmentaria, de Filippi, 1849.

Hæmentaria officinalis, de Fil.

Inhabit Mexico, where they are used for medicinal purposes.

Genus. Placobdella, R. Blanch.

Placobdella catenigera, Moq.-Tandon.

Indigenous to South Russia, Hungary, Italy and South France. It is a parasite of the swamp turtle, but frequently attacks human beings.

G. ARTHROPODA (Jointed-limbed Animals).

BY

FRED. V. THEOBALD, M.A.

BILATERALLY symmetrical segmented animals which are covered with a thick cuticle that is frequently calcareous (*Crustacea*), but always thinner between the segments; they carry (primitively) a pair of jointed appendages on every segment.[1] The segments of the body are uniform in certain regions, but differ from those of contiguous regions, so that it is easy to distinguish three parts (head, thorax and abdomen), each composed of segments. The cephalic segments are always formed into a uniform head, the segmentation being scarcely recognizable at either end; the thoracic segments may also fuse, or part or all of them may coalesce with the head; the abdomen, as a rule, retains its segmentation, but this may possibly also be lost, in which case it is [sometimes] united to the cephalothorax. The structure of the three regions depends mostly on the varying form and function of the appendages: those on the head are primitively locomotive organs (and frequently are still so in the early stages), but they become transformed into feelers and mouth-parts (mandibles, maxillæ); the limbs of the thorax, however, usually retain their ambulatory functions, as frequently do those of the abdomen; sometimes, however, the abdominal limbs disappear, entirely or partly; in the latter case they are then utilized for other purposes.

In their organization the *Arthropoda* approach the segmented worms.

The *Arthropoda* are generally divided into five groups (*Crustacea*,[2] *Protracheata*, *Arachnoidea*, *Myriapoda*,[3] and *Insecta* or *Hexapoda*), of which only the *Arachnoidea* and the *Hexapoda* interest us here.

A. **ARACHNOIDEA** (Spiders, Mites, etc.).

The head and thorax are always united together; the abdomen is either segmented or without exterior segmentation, in which case it is united with the cephalothorax.[4] The number of pairs of appendages

[1] [In most *Arthropoda* the skin is hardened by a deposit of chitin (*Hexapoda*, etc.).—F. V. T.]

[2] Parasitic or free-living Crustaceans may now and then invade man abnormally. Thus, according to Betten, *Caligus curtus* invade the cornea (Betten, R. A., "Par. Crust. as a Foreign Body on the Cornea," *Lancet*, 1900, i, p. 1002; and *Centralbl. f. Bakt. u. Par.*, xxix, p. 506). According to Laboulbène, also *Gammarus pulex* (Laboulbène, A., "Obs. d'accid. caus. par le *G. pul.* apport. avec l'eau de boison dans l'estomac d'un homme," *Bull. Acad. méd.*, 1898, p. 21).

[3] R. Blanchard has compiled thirty-five cases in which *Myriapoda* have been observed in the intestine as well as in the nose of human beings ("Sur le pseudopar. d. myriap. chez l'homme," *Arch. de Par.*, 1898, i, p. 452). E. Munoz Ramos reports an additional case (*ibid.*, p. 491). A few years ago a doctor in East Prussia sent me a rain worm out of a lady's nose (*cf.* Hanan, A., "Wahrsch. Pseudoparas. v. Schweiss fliegenlarv. u. angebl. Paras. v. Regenwurmern b. ein Hysterisch," *Arch. de Par.*, 1899, ii, p. 23).

[4] [This is only so in the *Acarina* or mites, not in the *Araneida* or spiders.—F. V. T.]

amount to six, of which the two front pairs, the cheliceræ and the pedipalpi, are attached to the head region and the four remaining pairs to the thoracic region.[1] The abdomen in the adult condition has no appendages. The Arachnoids are air-breathers, and for this purpose are either provided with tracheæ or with so-called lung-sacs, or they breathe through the surface of the body. Some aquatic forms breathe by gills.

There are eight or ten orders of Arachnoids,[2] of which, however, only two, the *Acarina* and the *Linguatulida*, have to be considered here.[3]

Order. **Acarina** (Mites).

Small Arachnoids, the three parts of the body of which are, as a rule, coalesced; it is only rarely that a faint line indicates the division between a cephalothorax and abdomen. The two appendages on the head are designed for biting or puncturing and sucking, and vary according to their use. The cheliceræ[4] are fang-like jaws or puncturing bristles forming a kind of rostrum, the pedipalpi are claw-like or shear-shaped, or form a suctorial proboscis.[5] The four pairs of legs are usually well developed, more rarely they are rudimentary or have partly vanished; many parasitic forms are provided with pedunculated suckers [ambulacra—F. V. T.]. Respiratory organs (tracheal tufts) may be present or absent. The nervous system is reduced to a minimum, eyes are usually lacking. The intestine, situated in the central part, generally has three blind appendages; the anus is situated on the venter above the posterior end. Sexes separated; nearly all the species deposit eggs, from which six-legged larvæ hatch. The *Acarina* live either free in the water or in moist soil, or they are parasitic on plants and animals.[6]

---

[1] [The true character of the *Arachnoidea* is the presence of four pairs of ambulatory appendages. This number is reduced to two pairs in the gall-making *Phytoptidæ*, and they differ from all other *Arthropoda* in having no antennæ.—F. V. T.]

[2] Twelve orders are now recognized, as follows: *Pentastomida* or Linguatulids; *Tardigrada* or bear-animalcules; *Phalangidæ* or harvest-men; *Acarina* or ticks and mites; *Palpigradi; Solifugæ; Pseudoscorpionidea* or book mites; *Pedipalpi* or false scorpions; *Scorpionidea* or true scorpions; *Araneida* or spiders; *Xiphosura* or king crabs; and *Pycnogonida*, marine Arachnoids.

[3] *Chelifer cancroides* has also been observed as a pseudoparasite in man (Arnault de Very, S., "Pseudopar. du. *Chel. cancr.* chez l'homme," *Compt. rend. Soc. de Biol.*, 1901, liii, p. 105).

[4] [The cheliceræ are sometimes regarded as modified antennæ, but it is more natural to regard them as the morphological equivalent of the mandibles of *Hexapoda.*—F. V. T.]

[5] [The pedipalpi, or second pair of jaws, consist of a stout basal segment and a palp, which may have the appearance of a leg in *Arachnida;* this may end with or without a claw, or with a chela (scorpions); they may also form a tube enclosing the styliform cheliceræ (mites). —F. V. T.]

[6] [*Acarina* are also found living upon trees, feeding upon other Arthropods and also upon spores of lichen and fungi (*Oribatidæ* or beetle mites); they also swarm indoors amongst stores and provisions (*Tyroglyphidæ* and *Glyciphagi*, household, sugar and cheese mites). This order is very important, as many are parasites upon man, his domestic animals and his cultivated plants, and attack his provisions and stores. Some live on blood, and in some of the ticks distribute various protozoal and other blood parasites and germs.—F. V. T.]

Family. **Trombidiidæ** (Running Mites).

Soft-skinned *Acarina* with tracheæ and with two eyes, usually pedunculated; they are often brightly coloured; cheliceræ lancet- or claw-shaped; pedipalpi claw-like; legs composed of six segments, with suctorial discs between the terminal ungues.[1] Larvæ six-legged. To the latter belong the larvæ of several species of Trombidium such as :—

Genus. **Trombidium**, Latreille (and **Leptus**).

Leptus autumnalis, Shaw, 1790.

Leptus occur as parasites in the human skin and cause a cutaneous disease known as autumn erythema, and produce a very unpleasant sensation on account of the troublesome itching; in children it is very often accompanied by fever.[2]

Formerly these mites were considered adult forms, but when they were recognized as mite larvæ they were taken for those of the spider-mite (*Tetranychus telarius*); the investigations of Hanstein, however, showed this to be a mistake.

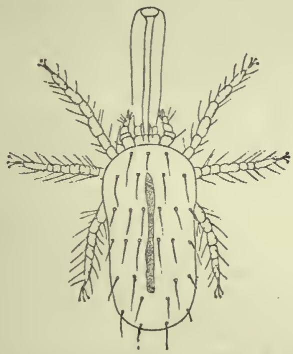


FIG. 349.—*Leptus autumnalis*, with so-called sucking proboscis. Enlarged. (After Gudden.)

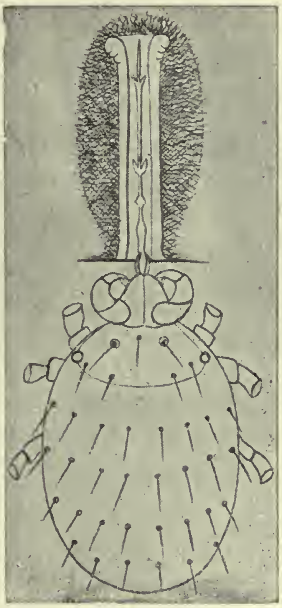


FIG. 350.—*Leptus autumnalis:* the so-called proboscis is formed around the hypopharynx sunk into the skin. 100/1. (After Trouessart.)

When Henking first investigated the development of *Trombidium fuliginosum*, parasitic in the larval stage on vine-fretters, he demonstrated the occurrence of a form very similar to *Leptus autumnalis*, and the "autumn, grass, or gooseberry" louse was commonly designated the Trombidium larva. Even before Henking's work it had been described by Mégnin as the larva of *Trombidium holosericeum*, a red-coloured species, frequently occurring in spring and summer on the ground, trees, etc. This assumption, however, as Moniez was the first to explain, is not correct;

[1] [Some have seven segments to the legs.—F. V. T.]

[2] [This minute parasite is especially obnoxious in barley fields. In walking over barley stubble one is sure to be attacked by this Acarus in many districts. Trombidium is often very prevalent in gardens, especially along rows of peas, and in spring they may be found on fruit trees and bushes. Nut-pickers are frequently attacked by Leptus, and also pickers in other fruit plantations. It is often called the harvest mite.—F. V. T.]

indeed, as many as three species come under consideration: *T. gymnopterosum*, L., *T. fuliginosum*, Herm. (according to Brucker), and two species known hitherto only in the early stage, *T. striaticeps*, Helm. et Oudem., and *T. poriceps*, Helm. et Oudem., which are not only parasitic on mammals, but on birds, on Arthropods and especially on insects. Arthropods appear to be the normal hosts for the larvæ.

The above-mentioned forms invade the skin of man by means of their oral apparatus, by preference invading the orifices of the sebaceous glands so as to suck the blood; around the point attacked there arises a wheal about the size of a lentil, and around the inserted hypopharynx a fibrinous secretion, the "proboscis," which, however, is a product of the host, just as chitinous secretions are provoked by Trombidia parasitic on Arthropods.

Further species, analogous in habit to *Leptus autumnalis*, are described by Riley from Central and South America as *L. americanus* and *L. irritans*.

[*L. autumnalis* attacks small mammals by preference, such as moles and hares, which are often literally covered with them. Dogs are also subject to their attack, and cats suffer similarly. This mite also frequently appears in colonies on cows; cavalry horses after autumn manœuvres often suffer from an erythematous affection about the hocks and knees due to this pest.

[A number of Leptus, so far undescribed, occur abroad which attack man in the same way as *L. autumnalis* in Europe. Dr. Durham has brought me specimens from British Guiana called *bête rouge;* this species works under the skin much as does our European species, but it is very distinct, being considerably larger.—F. V. T.]

Trombidium tlalsahuate, Lemaire, 1867.

T. tlalsahuate occurs in Mexico under conditions similar to those of Leptus here. It also frequently attacks men, and especially fastens itself on to the eyelids, in the axillæ, navel, or on the prepuce; it induces itching and swelling of the parts affected, and sometimes even causes suppuration; the symptoms, however, generally disappear after a week and remain localized.[1]

Other species of mites which attack man are reported, mostly by travellers, from various other places; zoologically, however, there is little known about them. The pou d'agouti in Guiana, niaibi in New Granada, colorada in Cuba, mouqui in Para, and the buschmucker in New Guinea represent a few of these.

---

[1] Lemaire, "Import. en France du tlalsahuate," *Compt. rend. Acad. Sci.*, Paris, 1867, lxv, p. 215.

Akamushi or Kedani.

In a few districts of Japan there occurs a serious illness, with a mortality of 40 to 70 per cent. It is called river or flood fever, and the Japanese doctors have connected it with a small mite (akamushi, kedani). Baelz has opposed this opinion on the grounds that he has repeatedly observed the same species of mite in his dwelling without any subsequent illness occurring. According to Keïsuke Tanaka, however, a connection certainly does exist, inasmuch as the akamushi, like Leptus, attacks persons to suck blood. If the mite is not removed, or if the spot attacked is injured by scratching, etc., a papule surrounded by a red area

FIG. 351.—The kedani mite. Enlarged. (After Tanaka.)

forms, and a pustule ensues; and finally a black scab covers the seat of injury. The lesion becomes the point of entrance of bacteria, especially a species of *proteus* which produces river fever. If the mites are carefully removed no general illness takes place.

The orange-red mites, which we only know in their larval condition, measure 0·16 to 0·38 mm. in length by 0·10 to 0·24 mm. in breadth. They have leg-like palpi with three joints, hirsute bodies, and very hairy legs composed of five segments, terminating with three ungues.

Family. **Tetranychidæ** (Spinning Mites).

These have tracheæ and eyes; the palpi are composed of four segments, of which the last but one has a powerful claw. The legs have six segments with sucker discs between the claws.

[The red spiders or spinning mites (Tetranychi) are usually placed in the family *Trombidiidæ*.—F. V. T.]

Genus. **Tetranychus**, Dufour.

Tetranychus molestissimus, Weyenbergh, 1886.[1]

Found in Argentine and Uruguay on the under surface of the leaves of *Xanthium macrocarpum*; it attacks mammals and men, producing severe itching, accompanied by fever in the latter.

It has been asserted by Haller that the CAPE AILMENT (Port Natal sickness) is caused by mites, but this statement has been contested.

FIG. 352.—*Tetranychus telarius* var. *russeolus*, Koch. Enlarged. (After Artault.)

Tetranychus telarius, L., 1758,[2] var. **russeolus**, Koch.

This common spinning mite likewise attacks human beings, but the papules produced by it very soon disappear.

Family. **Tarsonemidæ**.

A family distinguished by complete sexual dimorphism, the species of which are provided with tracheæ; the legs have five segments; the terminal segments of the front pair of legs of both sexes possess a claw; the terminal segment of the posterior pair of legs of the male likewise has a claw. In the female this pair of legs, like the second and third pairs of both sexes, is provided with two hooklets and a sucking disc. The cuticle of the body on the back is "annulated."

[This family of small transparent mites live normally as plant parasites. The last two pairs of legs are widely separated from the two front pairs.—F. V. T.]

---

[1] [This species is also known as *Bicho colorado*. It spins a web under the lower surface of the leaves, and it is only from December to February that it attacks warm-blooded animals and man.—F. V. T.]

[2] [There is something wrong here, probably in the identification. *T. telarius* is purely a plant-feeder, and it is extremely unlikely a variety would attack man. Anyhow, it will not do so in Great Britain.—F. V. T.]

Genus. Pediculoides.

Pediculoides ventricosus, Newport, 1850.

Syn.: *Heteropus ventricosus*, Newport, 1850; *Acarus tritici*, Lagrèze-Fossot, 1851; *Physogaster larvarum*, Lichtenstein, 1868; *Sphærogyna ventricosa*, Laboulbène and Mégnin, 1885.

Males are oval in shape, 0·12 mm. in length and 0·08 mm. in breadth, flattened. There are six pairs of chitinous hairs on the dorsal surface and a lyre-shaped lamella on the posterior part. The female in the non-gravid state is cylindrical in form, 0·2 mm. in length and 0·07 mm. in breadth; when gravid the posterior part of the body becomes enlarged into a ball, which may attain 1·5 mm. in size, as in the case of *Pulex penetrans* and of the female Termites. On emerging the young are already provided with four pairs of legs and copulate soon after birth.

a *b* *c*

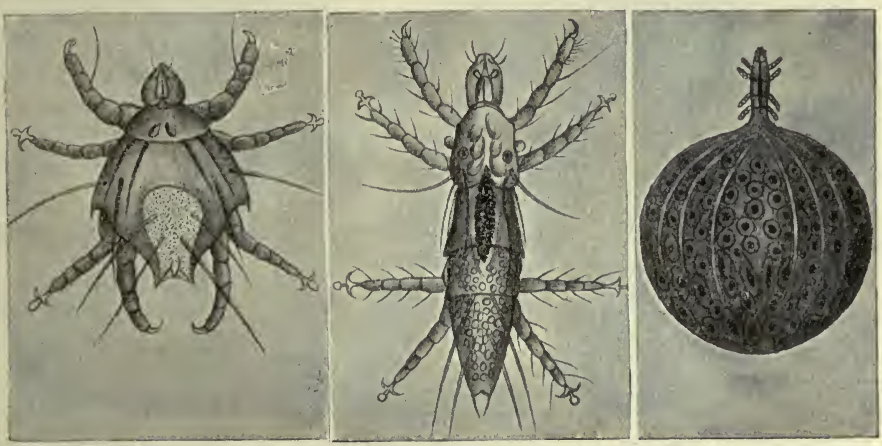


FIG. 353.—*Pediculoides ventricosus.* *a*, male; *b*, young female; *c*, gravid female. Enlarged. (After Laboulbène and Mégnin.)

These animals live on the stalks of cereals, and feed on vegetable and animal juices; they are also found on corn-infesting insects. They invade the barns and seek out the insects living in the dry grains of corn, or wait for an opportunity of obtaining food. They have been repeatedly observed on human beings, particularly labourers occupied in handling grain; their bite causes severe irritation, local elevation and reddening of the epidermis, as well as fever. It cannot be positively asserted that all cases of the occurrence of cereal mites on man relate to *P. ventricosus*, as the descriptions are often insufficient. Geber states that one form is *Chrithoptes monunguiculosus*, or *Acarus hordei;* Flemming mentions *Tarsonemus uncinatus;* Koller *Oribates* sp.; and Karpelles *Tarsonemus intectus.*

[The pregnant female Pediculoides has a large round inflated abdomen, in which the ova hatch and the young mature. Later they escape from the parent as adults.—F. V. T.]

Genus. **Nephrophages.**

Nephrophages sanguinarius, Miyake and Scriba, 1893.

Males measure 0·117 mm. in length and 0·079 mm. in breadth; females up to 0·360 mm. in length by 0·120 mm. in breadth. The head is provided with two very large scissors-like jaws and two large round eyes. The legs are composed of five segments and are all of equal length; the three anterior pairs of legs have pedunculated ambulacra, the posterior ones terminate in a claw. The cuticle on the back is thickened in three places, shield-like; the abdominal surface without scutellum is longitudinally striped and is beset with chitinous hairs. Colour greenish to brownish-yellow. Eggs 0·046 to 0·040 mm.

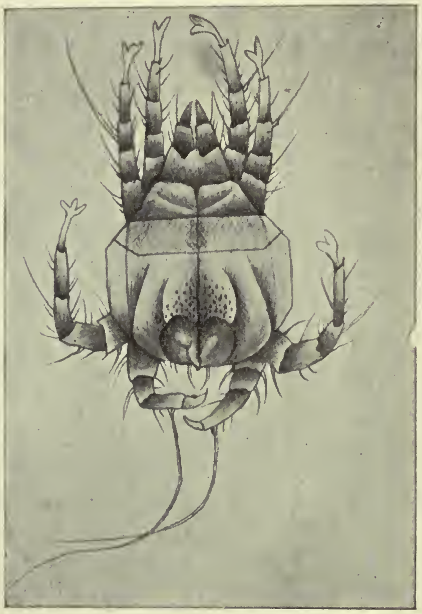


FIG. 354.—*Nephrophages sanguinarius:* male, ventral surface. Enlarged. (After Miyake and Scriba.)

FIG. 355.—*Nephrophages sanguinarius:* female, dorsal aspect. Enlarged. (After Miyake and Scriba.)

The authors discovered these mites, but always dead, in the urine of a Japanese suffering from fibrinuria complicated with chyluria and hæmaturia. They surmised that they were endoparasites, probably situated in the kidney; but this view is not convincing, though they also report that for a week, day after day, the mites were found in the patient's urine, as well as in urine drawn off by means of a catheter, and in the water used to wash out the bladder (one or two specimens and an egg). The statement that these mites have large eyes makes the discovery suspicious, to say the least. The significance of the discovery is not supported by the further statement that Disse is supposed to have found an encapsuled mite closely related to the Tyroglyphides on the wall of the vena cava.

In the case of Marpmann, who found a dead Acarid in the urine of a man suffering from chronic nephritis, and in whom later examinations proved negative, the author himself was of opinion that the mite had reached the urine from outside.

We are certainly acquainted with mites living endoparasitically, namely, the *Cysticolæ*, *Analgesinæ*, of which *Laminosioptes gallinarum* live in the intramuscular and subcutaneous connective tissue of fowls, and *Cytoleichus sarcoptoïdes* in their air sacs. Another kind of mite (*Halarachne halichœri*) is occasionally found in the nasal mucous membrane of the seal (*Halichœrus grypus*), and, quite recently, *Pneumonyssus simicola*, which is more nearly related to Halarachne, has been found in the lung of *Cynocephalus* sp. It is therefore not improbable that endoparasitic mites are found in man; but no definite discovery has yet been made.

Family. **Eupodidæ.**

Small tracheate mites, with moderately long or short pedipalpi, composed of four segments, of which the last segments bend; cheliceræ forceps-shaped, with serrated edges; legs with two claws, more rarely with one, and terminating in a tuft ornamented with fine hairs; genital orifices on the abdomen, surrounded by a circle of little hairs. Most species live free—one lives parasitically on the bodies of slugs.

Genus. **Tydeus,** Koch.

Tydeus molestus, Moniez, 1889.

Male, 0·2 mm. in length, 0·125 mm. in breadth. Females, 0·225 mm. in length, 0·135 mm. in breadth; gravid female 0·315 to 0·360 mm. in length and 0·180 mm. in breadth. They were observed by Moniez on an estate in Belgium, whither the creature had apparently been imported twenty-five years previously with Peruvian guano; they appeared regularly in the summer and remained until the first frost set in; they were found on grass-plots, on trees and bushes in masses; they regularly attacked human beings, mammals and birds, tormenting their hosts in a terrible manner.

FIG. 356.—*Tydeus molestus*: seen in profile. Enlarged. (After Moniez.)

Family. **Gamasidæ** (Coleopterous or Insect Mites).

Cheliceræ chelate or styliform; pedipalpi filiform; the legs are composed of six segments with two terminal ungues and a bladder-like sucking disc [caruncle—F. V. T.]. Stigmata situated between the third and fourth pairs of legs; the cuticle thickened, leather-like; no eyes; the larvæ have six legs.

The *Gamasidæ* are predaceous on small insects and other mites; some are parasitic on insects, and one is noticeable as a pest on birds, etc.

Genus. Dermanyssus, Dugés.

Dermanyssus gallinæ, de Geer, 1778.

Syn.: *Pulex gallinæ*, Redi, 1674; *Atarus gallinæ*, de Geer, 1778; *Dermanyssus avium*, Dugés, 1834.

The male measures 0·6 mm. in length by 0·32 mm. in breadth; the female 0·7 to 0·75 mm. in length by 0·4 mm. in breadth. The body is somewhat pear-shaped; the colour whitish, reddish, or reddish-black, according to the contents of the intestine. The legs are fairly short and strong. During the day they live concealed in the nests, cracks, etc., of the hen-house, and at night attack the inmates in order to suck their blood; they rarely remain long on the birds. They have been repeatedly found on persons, on whose skin they produce an itching eruption.

Dermanyssus hirundinis, Hermann, 1804.

Syn.: *Acarus hirundinis*, Herm., 1804.

Of a brownish colour, 1·2 or 1·4 mm. in length; lives in the nests of swallows and is occasionally found on man.

[The red hen mite (*Dermanyssus gallinæ*) not only attacks poultry and man, as stated above, but is found on all birds and

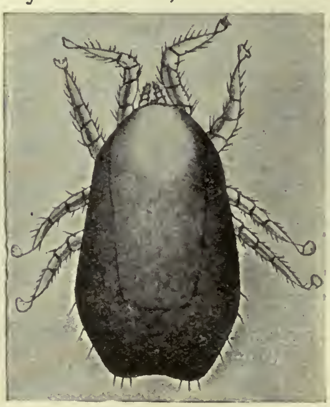


FIG. 357.—*Dermanyssus gallinæ*. Enlarged. (After Berlese.)

FIG. 358. — *Dermanyssus hirundinis*. 40/1. (After Delafond.)

many mammals. The *D. gallinæ* is the same as *D. avium*. The species found in swallows' nests is also said to be the same. This mite can remain for weeks without any food from its normal host. They only attack man when entering or cleaning dirty and neglected fowl-houses; they do not produce a true dermatosis. They chiefly attack the backs of the hands and forearms of those who constantly attend poultry and give rise to symptoms similar to the papular eczema of scabies. That they may remain some time upon the human body we know from the following cases out of many recorded: Geber observed that the Dermanyssus had caused a diffused eczema on a woman, which lasted four weeks and then disappeared. The *tique* of F. V. Raspail is the bird Dermanyssus; he records children and adults being attacked not only when handling pigeons, but even when walking in a garden manured with pigeons' dung. The affection soon disappeared when the pigeons were destroyed and the excreta buried. I have frequently heard of poultrymen being seriously attacked by this pest.—F. V. T.]

Genus. **Holothyrus.**

Holothyrus coccinella, Gervais, 1842.

Measures 5 mm. in size; lives on birds in the Island of Mauritius; ducks and geese frequently fall victims to its bite; it also attacks human beings, on whose skin it causes severe burning and swelling, but no reddening; it may be dangerous to children, especially by settling in the oral cavity.

Other Gamasides occasionally occur in man, for instance, according to Moniez, *Leignathus sylviarum*, Canestr. et Fanzago; according to Neumann *Lælaps stabularis*. The former live normally in the nests of various species of *Sylvia*, Lælaps on dried vegetable substances, also in houses.

[Marchoux and Conoy (*Bull. Soc. Path. exot.*, 1912, v, No. 10, pp. 796-798) found Leishman granules in *Lælaps echidninus*. It is assumed that Leishman granules may be found in most Arachnoids, and have no connection with Spirochæta.—F. V. T.]

Family. **Ixodidæ** (Ticks).

Comparatively large Acarines with a leathery skin; they are flattened in form, but after sucking blood the abdomen becomes spherical; the chelicerae are rod-like and possess a serrated terminal joint, bent hook-like; the median parts of the pedipalpi (maxillæ) form a rostrum furnished with barbed hooks (fig. 359); the maxillary palpi themselves are club-like or rounded; the legs are composed of six segments with two terminal ungues, often also with "sucking discs"; the stigmata are at the sides of the body, posterior to the fourth or third pair of legs. The larvæ are six-legged.

[The true ticks (*Ixodidæ*) are all blood-suckers, and as far as is known they do not take vegetable food at all. Not only are the *Ixodidæ* important as actual parasites, but they are most so on account of the fact that they are the active agents in carrying various diseases in animals and apparently in man. It has been conclusively proved that the bont tick (*Amblyomma hebræum*) is the carrier of the fatal "heart-water fever" so rife amongst sheep in South Africa, that the dog tick (*Hæmaphysalis leachi*) is the agent by which the protozoa that cause malignant jaundice in dogs are distributed, that

Texas fever in cattle is spread by *Rhipicephalus annulatus*, and Coast or Rhodesian fever by *R. appendiculatus* and *R. simus*. Their importance as disease carriers amongst mammals is therefore considerable, and it may prove to be so for man.[1] They frequently attack man, but chiefly, according to my observations, in their early stages in Europe; this is not so, however, abroad. The life-history of a number of ticks has been clearly demonstrated. Mr. Wheler has shown that in *Ixodes reduvius* it is as follows: the female deposits her eggs in masses upon the ground, gradually reducing in size as the eggs pass out, until she finally remains a mere shrivelled empty bag and then dies. The eggs are oval, golden brown in colour and smooth; in length they are 0·59 mm.; as in all *Ixodidæ* they are covered with a glutinous secretion, by means of which they adhere together in masses. These egg masses may be deposited anywhere on the ground, but amongst rough, coarse herbage seems to be the favourite place. The egg stage may last as long as twenty-two weeks, or it may only take eight weeks. In the case of the bont tick a single female may deposit 15,000 or more eggs. The process of egg-laying is described as follows by Mr. Wheler: "When egg-laying is about to take place, the head is further depressed till it rests close against the under side of the body. In this attitude the end of the rostrum actually touches the genital orifice, the palpi being at the same time widely opened out. Behind the head and from beneath the shield, at what for the purposes of explanation may be described as the back of the neck, a white, perfectly transparent, delicate gelatinous membrane is brought down through inflation, either with air or with a transparent fluid, above the head, which it temporarily conceals. The end of this membrane terminates in two conical points which appear to be covered with a glutinous secretion, and at the same time an ovipositor of a somewhat similar character, but only semi-transparent, is pushed forward from the genital orifice. This latter is a tube, within which is the egg. As the ovipositor projects it turns itself inside out, like the finger of a glove, leaving the egg protruded at the end and lying between the two finger-like points of the membrane. The membrane and the ovipositor are then withdrawn each from the other. The egg adheres to the former, which collapses through the withdrawal of its contents, dragging the head forward and depositing it on the top of the head. Neither legs, palpi, nor the organs of the mouth take any part in oviposition, but after the collapse of the membrane the palpi are closed and the head is raised, by which action the egg is pushed forward to the front edge of the shield, forming

[1] This has been proved in Uganda—so-called tick fever in man.

in time an adherent mass of eggs, which are deposited in front of the tick."

[The egg gives rise to the larval form, the so-called "seed-tick" stage. At first these minute specks are pallid and soft, but they soon harden and darken in colour. These larvæ are six-legged and crawl up grasses and various plants, and there await a passing host, waving their two front legs in the air and becoming attached by this means. The larval ticks feed upon the blood of the host, and when replete fall to the ground, the body becoming inflated in the meanwhile. These larvæ may remain on the host only two days, or they may remain much longer. Eventually they moult on the ground and change to the nymph or pupal stage, which has four pairs of legs. This pupa acts just as the larva, crawls up plants and waits to regain the host. After a time the nymphs, having gorged themselves with blood, fall off and remain on the ground for nearly three months; they then moult and become adult males and females. In about ten days they assume their normal colour and regain the host afresh; the female gradually swells until she attains that large inflated form so characteristic of ticks. The male does not swell, but nevertheless feeds upon the host and fertilizes the female.

[The act of coitus is strange: the male tick inserts its rostrum and other mouth organs into the sexual orifice of the female, between the base of the posterior pair of legs. The males then die and the females fall to the ground and deposit the ova. There are variations in the different species, of course, from those given above, which apply solely to *Ixodes reduvius*. The larvæ and nymphs seem to attack most animals, but the adults mainly keep to the same host. The periods in the life-cycle of ticks not only vary in the different species, but in each species according to climatic conditions; for instance, in the bont tick (*Amblyomma hebræum*, Koch), Lounsbury has shown that the development is rapid in summer, slow in winter. The period from the time that the female drops to the time she commences to lay eggs varied in specimens observed by him from twelve days in summer to twelve weeks in winter, and the complete period from the dropping of the female to the hatching of the eggs, from eleven weeks in summer to thirty-six weeks through the winter. Other stages vary in a similar manner.

[Ticks may live a long time away from the host provided they are supplied with a certain amount of moisture. Mr. Wheler kept dog ticks (*Ixodes plumbeus*) in the larval stage for ten months; the pupæ, male and female, of *I. reduvius* for six months.

[I have kept *Ornithodorus moubata* alive for eighteen months without food.

[In many species moulting takes place off the host, but in *I. bovis*, now known as *Rhipicephalus annulatus*, Say (the carrier of Texas fever), moulting takes place on the host, and in many other species also.[1] Some species of ticks leave their host on its death (as the dog tick, *Hæmaphysalis leachi*), but others die with the host (bont tick, *Amblyomma hebræum*).

[Two species are of special importance, namely *Ornithodorus moubata*, Murray, which may infect human beings with the spirillum of African tick fever, and *Dermatocentor reticulatus* var. *occidentalis*, which is said to be the carrier of Rocky Mountain spotted fever.

CLASSIFICATION OF *Ixodidæ*.

[The TICKS, or *Ixodidæ*, are divided into two groups, known as (1) *Argantinæ*, (2) *Ixodinæ*. The *Argantinæ* are told from the *Ixodinæ* by the absence of dorsal or ventral shields in both sexes, and also by the rostrum being placed beneath the cephalothorax, which covers it over: except in the larval stage, in which it is subterminal, and in the pupal, when it partly projects. Legs nearly equal in length. The sexual orifice is situated between the two first pairs of legs. The males usually smaller than the females.

[The *Ixodinæ* have the legs unequal, of six segments with two false segments, making them look as if composed of eight segments. The rostrum is terminal and never hidden beneath the body. The sexual orifice is situated between the bases of the first three pairs of legs. In the males the orifice is obsolete or very rudimentary, sexual intercourse being effected by the rostrum. The males are smaller than the females. The shield in the females never covers so much as one-half of the body even when fasting, also in the larvæ and nymphs; but in the males, which do not distend, the shield covers the body entirely, or all but a narrow margin. The *Ixodinæ* are divided into two groups: (i) the *Ixodæ*, and (ii) the *Rhipicephalæ*. The former have a long proboscis reaching nearly to the end of the palpi or even a little longer than the palpi. The palpi are longer than broad. The *Rhipicephalæ* have short palpi, nearly or quite as broad as long, more or less conical or subtriangular. They were called *Conipalpi* by Canestrini.

SYNOPSIS OF GENERA.

[A. *Argantinæ:* Rostrum concealed in adult, partly exposed in larvæ and nymphs. No dorsal and ventral shields.
Body flat with thin edges, finely shagreened and punctate *Argas*.
Body with numerous small round granules and with thick sides ... ... *Ornithodorus*.

[1] Some ticks require only one (*R. decoloratus*), others two (*R. evertsi*), and some three hosts (*R. appendiculatus*) in order to reach maturity.

[B. *Ixodinæ:* Rostrum terminal. Body with dorsal shield over some part of it.

I. Rostrum and palpi longer than broad (*Ixodæ*).

α. A groove around anus in front.

Palpi caniculated in both sexes ... ... *Ixodes.*

Palpiclaviform, not caniculated in the male; legs very long ... ... *Eschatocephalus.*

Palpi claviform, not caniculated in the male; *anal groove absent in the female* ... ... *Ceratixodes.*

β. A groove around the anus behind.

No eyes; adanal shields ... ... *Aponomma.*

Eyes present.

Males with no adanal shields ... ... *Amblyomma.*

Males with adanal shields ... ... *Hyalomma.*

II. Labium and palpi short; palpi not, or very little, longer than broad (*Rhipicephalæ*).

α. No eyes.

Rostrum rectangular; no ventral shields in the male ... *Hæmaphysalis.*

β. Eyes present.

No adanal shields, but usually with greatly developed coxæ on fourth pair of legs. Capitulum quadrangular *Dermacentor.*

Capitulum hexagonal ... ... *Rhipicentor.*

Adanal shields in male. Stigmata comma-shaped ... *Rhipicephalus.*

Stigmata oval or round; legs normal ... ... *Boophilus.*

Segments of legs expanded ... ... *Margaropus.*

[The genus Ceratixodes of Neumann, 1902, occurs on birds.

[The genus Eschatocephalus of Frauenfeld, 1853, of which seven species are known, is mostly parasitic on bats, and is found in holes, caves, and church towers.

[The genus Aponomma of Neumann, 1899, is exotic, and almost entirely confined to snakes and saurians.

[The following are synonyms of the different genera:—

Argas, Latreille, 1796 (*Rhynchoprion*, Hermann, 1804).

Ixodes, Latreille, 1795 (*Acarus*, Linnæus, 1758; *Cynorhæstes*, Hermann, 1804; *Crotonus*, Dumeril, 1822).

Ceratixodes, Neumann, 1902 (*Ixodes*, Cambridge, 1879; *Hyalomma*, Cambridge, 1879).

Eschatocephalus, Frauenfeld, 1853 (*Sarconyssus*, Kolenati, 1857).

Amblyomma, Koch, 1844 (*Ixodes*, Latreille, 1795).

Hæmaphysalis, Koch, 1844 (*Rhipistoma*, Koch, 1844; *Gonixodes*, Dugès, 1888; *Opitodon*, Canestrini, 1897).

Rhipicephalus, Koch, 1844 (*Acarus*, Linnæus, 1758; *Ixodes*, Latreille, 1795; *Phanloixodes*, Berlese, 1889; *Boophilus*, Curtice, 1890).

Dermacentor, Koch, 1844 (*Ixodes*, Latreille, 1795; *Pseudixodes*, Haller, 1882).—F. V. T.]

Genus. Ixodes, Latreille.

Ixodes reduvius, L., 1758.[1]

Syn.: *Acarus reduvius* and *ricinus*, L.; *Ixodes ricinus*, Latreille, 1806.

The males are oval; their length 1·2 to 2 mm.; they are brownish-red or black in colour; the females are yellowish-red, 4 mm. long;

[1] *Ixodes reduvius* and *I. ricinus* are synonymous. [The above should read *Ixodes ricinus*, Latreille, 1806.—F. V. T.]

when gorged they are lead-coloured, and may attain 12 mm. in length by 6 to 7 mm. in breadth.

The dog tick (fig. 360) lives in thickets on leaves, etc., and attacks sheep and oxen, and more rarely dogs, horses, and human beings, into the skin of which the female bores with the rostrum in order to suck blood ; the bite is not dangerous, and sometimes is not even felt. Inflammation, however, is set up if the creatures are forcibly removed from the wound, as the rostrum as a rule is torn off in the process. If left alone or smeared over with some grease—vaseline, oil, butter, etc.—the creatures drop off spontaneously. Sometimes the entire tick bores itself into the skin ; they also appear to be permanent inmates of kennels.

[The species *I. reduvius* is the same as *I. ricinus*, Latreille. The male is 2·35 to 2·80 mm. long; the body is dark brown, almost black, with a pale, almost white, margin; there are also traces of reddish mottling. Coxæ of the first pair of legs with a short spine. Rostrum much shorter than that of the female ; shield oval ; anal shield small, about one-third the length of ventral shield. The adult female varies from 2·80 to 3·5 mm. when not distended, but when gorged may reach 10 mm. long. The shield and legs are dark blackish-brown, body deep orange-red with four dark longitudinal lines, paler beneath and light grey in front. When distending it is pale red to grey or white; when fully gorged olive-green, or dark red to black, with irregular yellow streaks on the back and sides just before egg-laying. Sexual orifice opposite fourth pair of legs. The nymph varies from 1·60 to 1·70 mm. long when fasting; the body is olive-white, opaque, with four distinct brown posterior markings and similar anterior ones, leaving a pale centre to the shield. When fully gorged it is 3 mm. long. As the nymph distends, it changes from opaque white to blue-black, and finally black. The little larva is 0·80 to 1·50 mm. long, transparent with olive-green intestinal markings; as it becomes inflated it changes to blue-black, and then black. There are no eyes. It is widely distributed, and chiefly attacks sheep; sometimes it occurs on dogs and also attacks

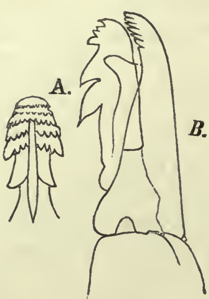


FIG. 359.—A., the rostrum of *Ixodes ricinus* (male) ; B., the terminal joint of the maxillary palpi of the female. Enlarged. (After Pagenstecher.)

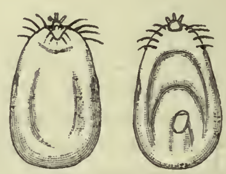


FIG. 360.—Female of *Ixodes ricinus*, gorged full, dorsal and ventral surfaces. 2/1. (After Pagenstecher.)

man. Mégnin records it from horses in the nymph stage. Amongst its other numerous hosts are goats, cattle, deer, hedgehogs, moles, bats, birds, and lizards. It is usually known as the grass tick and bottle-nosed tick. This species occurs in Europe, Asia, North Africa, and North America.

[*Synonyms.*—Considerable confusion exists over the name of this and other common ticks, owing to the same species having been described under a great many names. Observers have taken the same species on different animals and in various stages to be distinct, and have described them accordingly.

[The name *Ixodes reduvius*, Leach, does not stand, as Leach was describing quite a different parasite. The name *I. ricinus*, Latreille, 1806, is now substituted by Neumann and Wheler.

[The synonyms given by Wheler are as follow: *Reduvius*, Charleton, 1668; *Ricinus caninus*, Ray, 1710; *Acarus ricinoides*, de Geer, 1778; *Acarus ricinus*, Linnæus, 1788; *Cynorhæstes reduvius*, Hermann, 1804; *Cynorhæstes ricinus*, Hermann, 1804; *Ixodes megathyreus*, Leach, 1815; *Ixodes bipunctatus*, Risso, 1826; *Cynorhæstes hermanni*, Risso, 1826; *Crotonus ricinus*, Dumeril, 1829; *Ixodes trabeatus*, Audouin, 1832; *Ixodes plumbeus*, Dugés, 1834; *Ixodes reduvius*, Hahn, 1834; *Ixodes fuscus*, Koch, 1835 (?); *Ixodes lacertæ*, Koch, 1835 (?); *Ixodes pustularum*, Lucas, 1866; *Ixodes fodiens*, Murray, 1877; *Ixodes rufus*, *Ixodes sulcatus*, and *Ixodes sciuri*, Koch.—F. V. T.]

Ixodes holocyclus, Neumann, 1899.

[Under the name *I. holocyclus*, Cleland (*Journ. Trop. Med. and Hyg.*, 1913, xvi, No. 3, pp. 43-45) says that: "This tick is common in man where there is dense scrub and tropical jungle along the east coast of Australia at certain times of the year. It may cause severe symptoms in children resulting in death." He records a child being attacked in 1884 which died, and another case from which 200 ticks were removed, the symptoms being weak heart, collapse, syncope, but the patient recovered under treatment; again, in the same journal (pp. 188, 189), the case of a 4½-year-old girl who was bitten showed widespread muscular paralysis, and other cases resembling conium poison.

[Taylor (*Rep. Ent. Aust. Inst. Trop. Med.*, 1911, p. 21, 1913) refers to this species as the scrub tick of New South Wales. The partially fed female has a dark reddish-yellow scutum and is almost as broad as long, punctations very numerous, equal and confluent in places, long white hairs on the lower half of each coxa. He records it as attacking man commonly, mentioning Kamerunga, Cairns district, Queensland, and Sydney, N.S.W., as localities.—F. V. T.]

Ixodes hexagonus, Leach, 1815.

Syn. : *Ixodes sexpunctatus*, Koch, 1897 ; *I. vulpis*, Pagenstecher, 1861.

Lives in the same manner as the foregoing; especially attacks hounds, but also other mammals and even birds. The difference consists in the shape of the legs, the shorter rostrum, and the larger size of the male. It also occasionally attacks man, but is usually confused with the previously mentioned species.

[The synonyms of this species are as follow : *Ixodes autumnalis*, Leach, 1815; *I. erinacei*, Audouin, 1832; *I. reduvius*, Audouin, 1832; *I. crenulatus*, Koch; *I. erinaceus*, Murray, 1877; *I. ricinus*, Mégnin, 1880. Two other synonyms are given above by Braun.

[The female when fully replete is 11 mm. long, when fasting 3·86 mm.; the shield is heart-shaped and punctate, body finely hairy; palpi short and broad; labium shorter, and tarsi of all the legs more truncate than in *I. ricinus*. The colour of the distended body is drab and somewhat waxy; rostrum, shield and legs light testaceous. The male varies from 3·5 to 4·0 mm. long, and is reddish-brown in colour with lighter legs; the shield is punctate and leaves a narrow margin around the body; the body is elliptical, almost as large in front as behind. There is a spine on the coxæ of the first pair of legs, which is shorter than in the male *I. ricinus* and longer than in the female. The genital orifice is opposite the interval between the second and third pair of legs. The fasting *nymph* is 1·76 mm. long, light bluish-grey, margined and transparent, with four large posterior intestinal marks joined together behind the shield and smaller ones extending to the front and sides. When fully distended it is uniformly brownish-white; shield, legs and rostrum pale testaceous. The *larva* varies from 0·88 mm. when fasting to 1·76 mm. when gorged. Its body is light, but gradually becomes darker, with similar intestinal marks to *ricinus*.

[This tick is very common, especially on ferrets, stoats and hedgehogs. It is also found on sheep, cattle, etc. The males do not generally occur in company with the females on the host. Pairing probably takes place on the ground.—F. V. T.]

Genus. Amblyomma, Koch.

Amblyomma cayennense, Koch, 1844.

Syn. : *Amblyomma mixtum*, Koch, 1844 ; *Ixodes herreræ*, Dugés, 1887 ; *Amblyomma sculptum*, Berlese, 1888.

Characterized by the possession of eyes. The male measures 3·8 mm. in length by 3 mm. in breadth; the female 4 mm. in length by 3 mm. in breadth, but when full of blood may become 13 mm.

[1] Neumann, G. L., "Rev. de la fam. des Ixodides," *III Mém. Soc. Zool. France*, 1899, xii, p. 129.

in length and 11 mm. in breadth. They are common in the whole of Central America (Carrapatas), and attack mammals, amphibious animals and man.[1]

[This species was described by Fabricius. It occurs in Cayenne, Guiana, in Southern Texas, Florida, California, Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Bermuda, Cuba, Jamaica, Trinidad, Colombia, Venezuela, French Guiana, Brazil, Paraguay and the Argentine. It is called the silver tick. It frequently attacks man. Schwarz and Bishopp (*Bull.* 105, U.S. Dept. Agric., p. 158) heard of one man whose legs were well covered with suppurating sores and who was ill from the attack of these ticks and the wounds produced by scratching, and records other cases of their swarming on man. Newstead (*Ann. Trop. Med. and Par.*, 1909, iii, No. 4, p. 442) records it as the worst pest to man in Jamaica.—F. V. T.]

Amblyomma americana, Linnæus.

The so-called long star tick, from the silvery spot on the apex of the scutum of the female. It will attack any mammal and even birds and also man. It occurs in North America, and also in Brazil, Guiana and Guatemala. Its punctures frequently end in suppuration. In the Eastern and Southern States man is more frequently attacked by this species than any other. Moss-gatherers in Louisiana are badly attacked by it.[2] It also attacks the milkers in dairies. Attempts to transmit Texas fever failed with this species.

Amblyomma maculatum, Koch.

The so-called Gulf Coast tick, of the Gulf Coast, occurs on birds, mammals and man, especially cattle, and attacks the ears.

Genus. Hyalomma, Koch.

Hyalomma ægyptium, L., 1758.

Syn.: *Acarus ægyptius*, L., 1758; *Ixodes camelinus*, Fischer, 1823.

A species frequently found in Africa, particularly in Egypt and Algeria, and which also occurs in France and Italy, as well as in Asia. Male 8 mm. in length, 4·5 mm. in breadth. Female up to 24 mm. in length and 15 mm. in breadth. It infests large and small animals as well as human beings.[3]

[This is one of the largest ticks, nearly reaching the size of the bont tick. It is known in Africa as the bont leg-tick; all farm stock

---

[1] Neumann, G. L., *loc. cit.*, p. 205.

[2] Morgan, "Ticks and Texas Fever," *Louisiana State Bull.* 55, pp. 134, 135, pl. 59.

[3] Neumann, G. L., *loc. cit.*, p. 285; Ronsisvalle, "Sui fenomeni morb. prodotti nel uomo da un Ixodide denominato *Hyal. æg.*," *Boll. Acc. Gioenia sci. nat.*, 1891, xvii.

is attacked, but sheep and goats suffer most. Only one generation appears to occur each year. The male is almost black with a pale marginal stripe; the replete female brown with irregular light blue stripes. It is abundant in parts of South Africa.]

Genus. **Hæmaphysalis**, Koch.

Hæmaphysalis punctata, Canestrini and Fanzago, 1877—1878.

Syn.: *Hæmaphysalis sulcata*, Canestrini and Fanzago, 1877—1878; *Rhicocephalus expositicius*, Koch, 1877; *Hæmaphysalis peregrinus*, Cambridge, 1889; *Herpetobia sulcata*, Canestrini, 1890.

[This species does not appear to be common. It occurs on sheep, goats, horses and cattle. I have seen a female taken from man in Britain. The female when fasting is 3·44 mm. long, when gorged 12 mm. long. Colour, reddish-brown, leaden-grey when gorged; dorsal shield deeply indented in front; rostrum, shield and legs brownish; body finely punctate, both above and below; sexual opening opposite the coxæ of the second pair of legs in both sexes. Palpi a little longer than the labium; first segment short and narrow, second and third widened on the dorsal face. Coxæ with a short, broad blunt spine; tarsi short, terminated with a spur on the first pair. The male is 3·10 mm. long, Body rather narrow, yellowish to reddish-brown; dorsal shield nearly covers the whole body; numerous punctures over the whole surface. Eleven indentations on the posterior margin of the body; peritremes lighter in colour, large and comma-shaped. The three anterior pairs of legs with a short spine on the haunches, the fourth with a very long one directed backwards. The nymph varies from 2·5 to 3·0 mm., is oval, and light yellow to dark red in colour. Dorsal shield rounded with few punctations. No spur on tarsi, and sexual orifice nearly obsolete. Larva short and oval. Length 1·20 mm.—F. V. T.]

Genus. **Dermacentor**, Koch.

Dermacentor reticulatus, Fabricius, 1794.

Syn.: *Acarus reticulatus*, Fabr., 1794; *Ixodes reticulatus*, Latreille, 1806; *I. marmoratus*, Risso, 1826.

This tick is provided with eyes, but it is distinguished from Ixodes and analogous genera by the lack of the abdominal plastron in the male, which measures 5 to 6 mm. in length by 3·5 mm. in breadth. The female may attain 16 mm. in length and 10 mm. in breadth. It is found in the South of Europe, in Asia, and in America; it attacks chiefly oxen, sheep and goats, and occasionally man.[1]

[1] Neumann, G. L., "Rev. de la fam. des Ixodides," *Mém. Soc. Zool. France*, 1897, x, p. 360.

[This tick sometimes causes much annoyance to human beings. It was once most troublesome at Revelstoke. Specimens have recently been found on fowls, turkeys and pheasants in Kent.

[Other synonyms are as follow: *Cynorhæstes pictus*, Hermann, 1804; *Crotonus variegatus*, Dumeril, 1829; *I. pictus*, Gervais, 1844; *Dermacentor albicollis*, Koch, 1844—1847; *D. pardalinus*, Koch, 1844—1847; *D. ferrugineus*, Koch, 1844—1847; *Ixodes holsatus*, Kolenati, 1857; *Pseudixodes-holsatus*, Haller, 1882; *Hæmaphysalis marmorata*, Berlese, 1887.

[The *female* when fasting is 3·86 mm. long by 2 mm. wide. The body is depressed, larger behind and reddish-brown in colour. The shield is very large and extends to the level of the third pair of legs, with a few large and many small punctations, milky white, variegated with reddish-brown. Sexual orifice opposite the coxæ of the second pair of legs. Coxæ of the front legs are deeply bifid, the others with a moderate spine. When gorged light brown, and may reach 16 mm. When depositing eggs the female is mottled with dark brown above and below. The *male* is like the female. The shield is reddish-brown, variegated with a milky white pattern. Coxæ of the fourth pair of legs three times the size of the third. There is a sharp backwardly pointing spine on the second palpal segment, also seen (but smaller) in the female. Length 4·20 mm.

[According to Mr. Wheler this is a very variable species both in size and colour. It occurs in England on sheep, but not commonly. It has probably been introduced into Britain. Besides the animals mentioned above it is also found on deer.—F. V. T.]

Dermacentor venustus, Banks.

[The Rocky Mountain tick fever tick. This species has been wrongly called *Dermatocentor reticulatus* var. *occidentalis*. The correct name of the carrier of Rocky Mountain tick fever is *Dermacentor venustus*, Banks (Hooker, Bishopp and Wood, *Bull.* 106, U.S. Dept. Agric., Div. Ent., p. 165).

[The female is from 13·8 by 10 by 6·4 mm. to 16·5 by 11·4 by 6·9 mm. when gorged; the male from 2·1 by 1·5 mm. to 6 by 3·7 by 1·4 mm. The male reddish-brown; scutum with an extensive pattern of white lines, usually but little white on the mid-posterior region, legs slightly lighter than scutum, joints tipped with white. Female with scutum mostly covered with white, abdomen reddish-brown, legs as in male. The nymph when unengorged reddish-brown, when gorged dark bluish-grey; the larva is yellowish-brown when unengorged, slate blue when engorged. The ova light brown, shiny and smooth.

[The chief wild hosts are the brown bear, coyote, woodchuck, rabbit, wild cat, badger and mountain goat for the larvæ; practically all small mammals act as hosts for larvæ and nymphæ, whilst the adults are seldom found on other than large domestic animals; horses and cattle are preferred. It occurs in British Columbia, southward to Northern New Mexico, and from the foothills of the Rocky Mountains in Colorado to the base of the Cascade Range in Oregon and California; abundant in Western Montana, Idaho, Eastern Washington, Oregon, North Utah, West Wyoming and North-west Colorado.

[Of great importance in the Bitter Root Valley of Montana, where a number of cases of fever occur each year, with a mortality of about 70 per cent. In British Columbia this tick causes tick paralysis in man and sheep. Only the adults seem to attack man and animals there (Hadwen and Nuttall, *Parasitology*, 1913, vi, No. 3, pp. 288-297 and 298-301) according to the *Canadian Medical Association Journal*, December, 1912. The symptoms are unlike spotted fever. For full details of this tick *vide Bulls.* 105 and 106, U.S. Dept. Agric.]

Dermacentor occidentalis, Neumann.

This tick only occurs in the Pacific Coast region of the United States. Owing to the fact that it frequently attacks man as well as occurring in great abundance in Oregon and California, it is of considerable economic importance. It is spoken of as the wood tick, and in the regions where found is the most common tick to attack man. Hooker, Bishopp and Wood (*Bull.* 106, U.S. Dept. Agric., Div. Ent., 1912, p. 189) state that a number of cases have been brought to their notice where the bite of this tick has caused considerable local inflammation, which in some cases required physicians' attention. It has been supposed to be connected with Rocky Mountain spotted fever, but it is doubtful if it is concerned in its transmission. The engorged female is steel grey, the dorsum with an olive-green surface colour, which covers the grey except in small spots, giving a mottled appearance. The unengorged males and females are reddish-brown, scutum covered with a whitish bloom, interrupted by many red punctures. The female is 9 by 6·1 by 3·3 mm. to 11·8 by 7·6 by 5·6 mm.; the male 2·8 by 1·6 mm. to 4·2 by 2·3 mm. The larvæ are bluish-grey when engorged, reddish-brown when unengorged. The nymph is light brown, sides of scutum darker, and the intestines dark brown. It is confined to the Coast Range and Sierra Nevada Mountains in California and Oregon and the small mountain range to the south-west.

Dermacentor variabilis, Say.

The American dog tick has also been found on man, but it is of little economic importance as it is easily removed from its host.

Genus. Margaropus, Karsch.

Margaropus annulatus australis, Fuller.

The so-called Australian cattle tick. Newstead[1] reports this as a great pest to man in Jamaica in its larval stage. Its chief hosts are cattle, horses, goats, sheep, dogs and rabbits.

Margaropus microplus, Canestrini.

Recorded by Aragão (*Mem. Inst. Oswaldo Cruz*, 1911, iii, fasc. 2, p. 163) as occurring in larval stage on man in Brazil.

Genus. Rhipicephalus, Koch.

Rhipicephalus sanguineus, Latreille, 1804.

Syn.: *Ixodes sanguineus*, Latr., 1804; *I. rufus*, Koch, 1844; *Rhipicephalus limbatus*, Koch, 1844; *Rh. siculus*, Koch, 1844; *Rh. stigmaticus*, Gerstäcker, 1873.

Spread over almost the entire tropical and sub-tropical regions, occurring in Europe in the South of France and in Italy; it infests dogs and more rarely sheep; oxen, cats, foxes and human beings are also attacked.[2]

Neumann's Table of Species of Argas.

1	Body elliptical (sides curved)	2.
	Body oblong (sides straight), ending anteriorly in a point ...	7.
2	Body transversely oval	*vespertilionis*.
	Body elongate oval	3.
3	Margin of body striated	4.
	Margin of body formed by quadrangular areolæ	PERSICUS.
4	Body flat, integument plainly wrinkled	5.
	Body tumid, elongate; integument finely wrinkled; coxæ of fourth pair of legs near anterior third of body	*hermanii*.
5	Body oval, narrowed anteriorly...	REFLEXUS.
	Body elliptical, blunt, hardly narrowed anteriorly	6.
6	Body twice as long as broad	*cucumerinus*.
	Body hardly longer than broad	*transgariepinus*.
7	Dorsal integument with large polygonal depressions; tarsi appearing bifid	BRUMPTII.
	Dorsal integument almost smooth; tarsi not appearing bifid	*æqualis*.

The *Argantinæ* are distinguished from the *Ixodinæ* by the head, which in the former is situated on the inferior aspect of the cephalothorax, while in the *Ixodinæ* it projects freely; also by the very short proboscis, the small club-like palpi, the lack of suckers on the legs, as well as by the scutellum, which covers the entire back and is bent up round the borders. Two genera are distinguished: Argas, Latreille, 1796 (Rhynchoprion, Hermann, 1804), and Ornithodorus, Koch, 1844. The species live on mammals, but more especially on birds.

[1] *Ann. Trop. Med. and Par.*, 1909, iii, No. 4. [2] Neumann, G. L., *loc. cit.*, 1897, p. 385.

Genus. **Argas**, Latreille.

Argas reflexus, Fabricius, 1794.

Syn.: *Acarus reflexus*, Fabricius, 1794; *A. marginatus*, Fabricius, 1794; *Rhynchoprion columbæ*, Hermann, 1804.

The European marginated tick, *Argas reflexus* (length of male 4 mm., breadth 3 mm., length of female 6 to 8 mm., breadth 4 mm.), is of a yellowish colour and has yellowish-white legs. The ingested blood shows red or brown through the intestine, which is provided with blind sacs. It lives in dovecots. It remains hidden during the day and at night crawls on to the sleeping pigeons to suck their blood. It has been observed in France, England, Italy, Germany, and Russia. Persons sleeping near infected dovecots, or in apartments formed from pigeon-lofts, are also attacked, even when the room in question has not been used for sheltering pigeons for years, as "marginated ticks" can live in a fasting condition for a very long time. The bite sometimes gives rise to serious symptoms, such as general erythema and sudden œdema.

FIG. 361.—*Argas reflexus*: from the dorsal surface, the intestine showing through the integuments. (After Pagenstecher.)

[This pest more often feeds on the blood of man than is imagined. Blanchard states that he has received them from men's clothes in Strasburg. Boschulte, of Westphalia, records these parasites in a bedroom inhabited by children and connected with a pigeon-house. The children were bitten during sleep on the hands and feet. The result of the bite was intense itching along the nerves, the bite only being marked by a red spot. In a girl of 14 or 15, vesicles were formed similar to those produced by burns, and in an old man an ulcer formed. Others record painful punctures and persistent œdema produced by this pigeon pest. It was once abundant in Canterbury Cathedral, and often caused much annoyance, I am told, to the worshippers; the ticks falling down from the roof, where they were living, derived from the numerous pigeons that breed in the towers. This Acarus has enormous powers of vitality, living without food for months at a time.—F. V. T.]

Argas persicus, Fischer de Waldheim, 1824.

Of oval form and brownish-red colour. The male measures 4 to 5 mm. in length by 3 mm. in breadth; the female 7 to 10 mm. in length by 5 to 6 mm. in breadth. It frequents the entire north-west and north-east of Persia (the gerib-gez or malleh of the Persians, the miana bug of travellers). It lives concealed in houses and attacks man at night to suck his blood. Its bite is much dreaded, but the serious results may probably be attributed to unsuitable treatment of the wound or its invasion by bacteria.

[This tick, sometimes called the tampan and wandlius in South Africa, is mainly a fowl parasite. Fowls and ducks frequently die under its attack, particularly young ones, death being due to loss of blood. This tick remains attached to its host during its larval stage for about five days; it then leaves and moults in concealment. In its subsequent stages it visits its host by night and remains for about an hour only, during which time it distends itself fully with blood. As a nymph it moults twice, not once as do the cattle ticks. This tick and other Argas become larger with each moult, but retain their same general appearance. The female visits the host every now and then, and, between, deposits eggs in sheltered crevices. About fifty to 120 are deposited at once. Four weeks seems a necessary period to intervene between visits to the host, and the interval may be extended to upwards of a year according to Lounsbury.[1]

[It is found in the Sudan, where Balfour has found granules derived from the segmentation of spirilla in their digestive tract. Fantham and Hindl have confirmed this. It has been assumed that these granules carry infection.

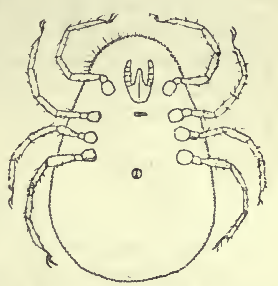


FIG. 362.—*Argas persicus:* ventral aspect. 7/1. (After Mégnin.)

[This so-called Persian tick, the miana, which is such a scourge to travellers in Persia, appears to infest the huts of natives in that country. It has been sent me from Quetta, where it has invaded houses to such an extent the natives cannot live in them. The virulence of its bite is probably due to the tick transmitting fever germs from natives, probably inured, to strangers, who would be susceptible.—F. V. T.]

Argas brumpti, Neumann.

[Found in Somaliland, by Brumpt, and in the Sudan. This tick attacks man as well as wild animals and produces a painful swelling according to King,[2] but as pointed out by that naturalist it probably relies on other than human food.—F. V. T.]

[1] "Report of Government Entomologist, Cape of Good Hope, for 1899," 1900, p. 33.

[2] "Fourth Report Wellcome Res. Labs.," 1911, p. 128.

Argas chinche, Gervais, 1844.

This Acarus, a native of the temperate parts of Colombia, is very troublesome to man. It is probably identical with *A. americanus*, Packard, which infests domestic fowls and turkeys, and occasionally also cattle, and is differentiated from *A. reflexus* by the sculpturing of the cuticle.

Genus. Ornithodorus, Koch.

Neumann's Synopsis of the Genus Ornithodorus is as follows:—

1	Hypostome unarmed; integument in nymph stage and partly in adult spinulose ...	MÉGNINI.
	Hypostome armed with recurved teeth; integument not spinulose ...	2.
2	Camerostome with movable lateral flaps ...	TALAJE.
	Camerostome without movable lateral flaps ...	3.
3	Anterior border of distal segments of legs with tubercles or festoons ...	4.
	Anterior border of segments of legs without tubercles or festoons ...	8.
4	Body not much contracted anteriorly ...	5.
	Body pointed anteriorly ...	7.
5	Tubercles of distal segments of legs higher than broad, distant	6.
	Festoons of distal segments of legs as broad as high, contiguous ...	*pavimentosus*.
6	Eyes present ...	SAVIGNYI.
	No eyes ...	MOUBATA.
7	Eyes present ...	*coriaceus*.
	No eyes ...	TURICATA.
8	Integument with fine radiating wrinkles ...	*lahorensis*.
	Integument granular ...	9.
9	Tarsi appearing bifid at apex ...	*furcosus*.
	Tarsi not appearing bifid at apex ...	10.
10	Tarsi of first pair of legs with three dorsal tubercles, of other legs with one ...	*canestrinii*.
	Tarsi without dorsal tubercles or with only one ...	11.
11	Tarsi of last three pairs of legs with pronounced dorsal protuberance ...	*tholozanii*.
	Tarsi of legs with indistinct dorsal protuberance ...	*erraticus*.

Ornithodorus moubata, Murray, 1877.

An abundant African tick which is one of the carriers of the spirillum of African relapsing fever and can also carry *Filaria perstans* (Christy). Its body is oval, yellowish-brown when young, greenish-brown when mature The integument is covered with mamillose tubercles. No eyes and the stout legs granular above, the tibiæ and tarsi fringed with tubercles on the upper side. Pocock[1] records it from

[1] "A System of Medicine," Allbutt and Rolleston, i, pt. 2, p. 195.

Uganda and German East Africa, Congo and Angola, to Namaqualand and the Transvaal in the south. It is called *bibo* in Uganda, *moubata* in Angola, and *tampan* on the Lower Zambesi. It feeds on animals and birds as well as man. Its bite is very painful. This tick is found in native huts, living in cracks and crevices and in the thatch roofs.

The female tick infected with the spirillum transmits the infection to the eggs and the next generation. They appear to be able to live without food a long time, and probably live for years. They lay their eggs in masses on the ground or in crevices, and when they hatch they are in the nymph stage with four pairs of legs. *O. moubata* also occurs in Madagascar with recurrent fever (Lamoureux, *Bull. Soc. Path. exot.*, 1913, vi, No. 3, pp. 146-149).

Ornithodorus savignyi, Audouin, 1827.

At one time considered the same as the preceding species, but can be easily separated by the presence of two pairs of eyes. It is widely spread over Africa and has been found in South India and at Aden. In the Sudan it occurs in large numbers. King[1] records that a few miles N.N.E. of Khartoum 370 specimens were collected in two hours under a single tree by a well. It is found in Somaliland, where relapsing fever occurs and no *O. moubata*, which it probably replaces as a transmitter (Drake-Brockman, "Rep. Col. Office," April 6 and April 16, 1913). It also occurs in Tunis, where the natives call it "tobbiah" (Weiss, *Arch. de l'Inst. Pasteur de Tunis*, 1912, pt. 4, p. 226).

Ornithodorus coriaceus, Koch.

Found in Mexico, Paraguay and California. Attacks man.

Ornithodorus talaje, Guerin, 1849.

An eyeless species with somewhat elongate pentagonal body found in Mexico and South America, called the "chinche." A variety of it (*coniceps*) is found at Venice, etc., and another variety on various islands in the Indian Ocean and South Atlantic. Its bite is very painful to man.

Ornithodorus turicata, Dugès, 1876.

Without eyes. Indigenous in Central America; attacks human beings and pigs. The bite is painful and is often followed by serious consequences.

[So virulent is this species that pigs put in an infested sty often die in a night. This "turicatas" of Mexico often reaches 6 mm. in length.—F. V. T.]

---

[1] "Fourth Report Wellcome Res. Labs.," 1911, B, p. 129.

Ornithodorus tholozani, Laboulbène and Mégnin, 1882.

Syn.: *Argas tholozani*, Lab. and Még., 1882.

Without eyes. Males 4 to 6 mm. in length and 2 to 4 mm. in breadth; females 8 to 10 mm. in length and 4 to 5 mm. in breadth. It especially attacks sheep. Native of Persia and Asia Minor.

[This species is reputed as being very dangerous to man. It is locally know as the kéné, or sheep-bug. In its fully gorged state it is deep violet.—F. V. T.]

Ornithodorus mégnini, Dugès, 1883.

Syn.: *Argas mégnini*, Dugès, 1883.

Length 8·5 mm., breadth 5·5 mm. Native of Mexico.

[Another synonym for this species is *Rhynchoprion spinosum*, Marx. The adult males and females are grey to dark brown, the male somewhat the smaller; female 5 by 3·5 by 2·5 mm. to 10 by 6 by 3·5 mm. The larvæ at the seed tick stage are dark grey, turning to pink, then to a whitish grey when engorged. The nymph when young is blood-red in front, rest pearly white; later they turn reddish-brown.

[Intense pain may be caused by its presence in and around the ears.

[Two specimens in the nymphal state were taken from the ears of a visitor to Cambridge by Dr. J. Christian Simpson. They were supposed to have entered the ears when the gentleman was camping out in Arizona (*Lancet*, 1901, i, No. 4,052, p. 1198, fig. 3).

[This species attacks the horse, ass, dog, cats and oxen, generally around the ears, and also attacks man. It is well known in the United States as infesting the ears of children (*New York Ent. Soc. Journ.*, 1893, pp. 49-52).

[It occurs in Texas, Arizona, New Mexico and California as well as Mexico, Brazil, and possibly many parts of South America; and recently Bedford ("Sec. Report Div. Vet. Res., S. African Union," 1912, pp. 343, 344) has shown it to occur at Vryburg and Fauresmith, in the Transvaal, on stock. It also occurs in the Sudan.—F. V. T.]

Other Literature on *Ixodidæ*.

(1) "Pénétration de l'*Ixodes ricinus* sous la peau de l'homme," *Compt. rend. Soc. de Biol.*, 1891, xliii, ser. 9, iii, pp. 689-691, R. Blanchard.

(2) "Notas sobre Ixodidas brazileiros," *Mem. Inst. Oswaldo Cruz*, 1911, iii, fasc. 2, pp. 145-195, pls. 11 and 12, Dr. H. de Beaurepaire Aragão. Table of Brazilian Species.

(3) "Contribuicão para a sistematica e biolojia dos Ixodidas," *Mem. Inst. Oswaldo Cruz*, 1912, iv, fasc. 1, pp. 96-120, pls. 2 and 3, Dr. H. de Beaurepaire Aragão.

Family. **Tyroglyphidæ.**

Very small mites without eyes and without tracheæ, with smooth skin.

The males usually have a suctorial pore on either side of the anus, which is used during copulation, or suckers may be found in both sexes near the sexual orifice. The mouth parts form a cone with chelate cheliceræ, and three-jointed pedipalpi; the legs are usually short, have five segments with a terminal claw and suckers, or either one or other of these organs. The numerous species and genera live free and from choice in slowly decomposing vegetable and animal matter (cheese, cereals, flour, sugar, preserves, dried anatomical preparations, bacon, dried fruits and fungi), also in the corners of dwellings, etc.; they incidentally get into or on to man, or are found in chamber utensils and in spittoons; actual parasites are rarely found amongst them.

[The chief genera are Tyroglyphus, Rhizoglyphus, Glyciphagus, Aleurobius and Histiogaster. The first three have typical characters referred to, but are distinguished from each other by the two former having the hairs on the dorsum smooth, whilst in Glyciphagus they are hairy, plumose, or feathered. Rhizoglyphus can be told from Tyroglyphus by having claws on the tarsi without any suckers; Tyroglyphus has both claws and suckers. The larvæ are hexapod and may become adult in the usual way by repeated moults, or they enter the so-called hypopial stage. In this the eight-legged nymph becomes quiescent, and during this stage it fixes itself to some insect or other animal by a patch of suckers on the lower surface of the hind end of the body, and is so carried from place to place. The hypopus does not feed and has a hard shell and short legs. When it has reached a new home it moults and development proceeds in the normal way. Canestrini and Kramer treat the *Tyroglyphidæ* as a sub-family of the *Sarcoptidæ*, calling them sub-family *Tyroglyphinæ*, the other sub-families being *Sarcoptinæ*, *Canestriniinæ* and *Analsinæ*.—F. V. T.]

Sub-family. **Tyroglyphinæ.**

Genus. **Aleurobius,** Canestrini.

Aleurobius (Tyroglyphus) farinæ, de Geer (part), Koch.

The male measures 0·33 mm. in length by 0·16 mm. in breadth; the female 0·6 mm. in length by 0·3 mm. in breadth. These mites possess five pairs of suctorial organs of a light colour; the legs are reddish. Moniez observed them in Lille on the skin of labourers who had been unloading Russian corn. A few of the species generally mentioned under the designation of *Tyroglyphus siro* are probably the common flour-mite, which also occurs on dry cheese.

[The *farinæ* of de Geer is an Aleurobius described by him in 1778 ("Mém. Hist. Ins.," vii, t. 5, f. 15, p. 97) as *Acarus farinæ*.—F. V. T.]

Genus. **Tyroglyphus,** Latreille.

Tyroglyphus siro, L., 1756.

(Defined by Gervais, 1844.)

Male 0·5 mm. in length by 0·25 mm. in breadth; female 0·53 mm. in length by 0·28 mm. in breadth; the males have two suckers on the tarsi of the fourth pair of legs. Penis straight, colour whitish or reddish.

Tyroglyphus longior, Gervais, 1844.

White or yellowish, with two black spots on the abdomen. Male 0·55 mm. in length, 0·28 mm. in breadth; penis bent. Female 0·61 mm. in length and 0·28 mm. in breadth.

T. siro and *T. longior* live on dry cheese, in flour, on dried fruits, etc., and have been occasionally observed in the stools, urine, or pus of human beings, and also on their skin. The so-called vanillismus is to be attributed to these species.

[*T. siro* and *T. farinæ* of Schrank (non Geer) are the same. They are described under other names, such as *Acarus lactis*, Linn.; *A. favorum*, Herm., etc.; *A. lactis* in milk, *farinæ* in flour, and *siro* in cheese; and as *A. dysenteriæ*, Linnæus ("Syst. Nat.," ed. 12, pp. 1024-1767).]

FIG. 363.—*Tyroglyphus farinæ*: male. Enlarged. (After Berlese.)

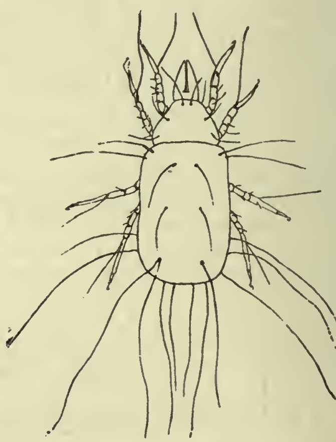


FIG. 364. — *Tyroglyphus longior*, Gerv. (After Fum. and Robin.)

It is to these species that a case of dysentery was referred. Rolander, who studied under Linnæus, was attacked by what was called dysentery. The complaint soon gave way to treatment, but eight days after it returned, soon disappeared, but again came a third time. All the time Rolander had been living like the other inmates of the house, who all escaped. Linnæus, aware that Bartholemy had attributed dysentery to insects which he said he had seen, advised his student to examine his stool. The result was that innumerable mites were found to be present. Their presence was easily accounted for by the fact that they were found in numbers in a cup made of juniper wood from which the student alone drank of a night, and they were found to be of the same species. What this species is we do not know. Linnæus called it *Acarus dysenteriæ*, but it was the same as his *Acarus siro*. No records have occurred since. It cannot be, as Latreille supposed, the cheese mite, for they have been eaten by millions since, and it is strange no such case has occurred again.

[**Tyroglyphus minor** var. **Castellani**, Hirst,

causes the copra itch in persons employed in the copra mills in Ceylon. The skin of the hands, arms, legs and even body becomes covered with pruriginous papules, papulo-pustules and pustules near the head. The eruption begins as a rule on the hands. The mites live in the copra dust. They produce dermatitis. Castellani produced the disease experimentally by rubbing copra dust containing mites on the skin of healthy people. Beta-naphthol ointment (5 to 10 per cent.) proved useful in treatment (*Journ. Trop. Med. and Hyg.*, December 16, 1912, Castellani and Hirst).—F. V. T.]

Genus. **Glyciphagus**, Hering, 1838.

Glyciphagus prunorum, Her., and **G. domesticus**, de Geer.

The Glyciphagi are differentiated from the Tyroglyphi in that the chitinous hairs on the body are fringed or feathered, and that they lack a furrow dividing the cephalothorax from the abdomen. They live under similar conditions to the Tyroglyphi and are occasionally found on man or in fæces.

[Sugar merchants and grocers are frequently troubled by swarms of *G. domesticus*, which leave the stores when being handled, and especially shopmen, who handle sugar kept in small stores for some time. These are the Acari that cause that irritating temporary affection known as "grocer's itch."—F. V. T.]

Glyciphagus cursor, Gervais.

Under this name Signor Moriggia figures a horny excrescence of great length growing from a woman's hand, and containing in its cavities quantities of Acarus. This species is really *G. domesticus*, de Geer. *G. domesticus* has also been described by Gervais (*Ann. Sci. Nat.*, 1841, ser. 2, xv, p. 8) as *G. hippopodes*.

Glyciphagus buski, Murray.[1]

[This is a mite found by Busk and named after him by Murray. It was taken from beneath the cuticle of the sole of the foot of a negro in the Seamen's Hospital Ship on the Thames in 1841, in large sores of a peculiar character confined to the soles of the

[1] Cooper and Busk's *Micros. Journ.*, 1842, and "Economic Entomology," Murray, p. 280.

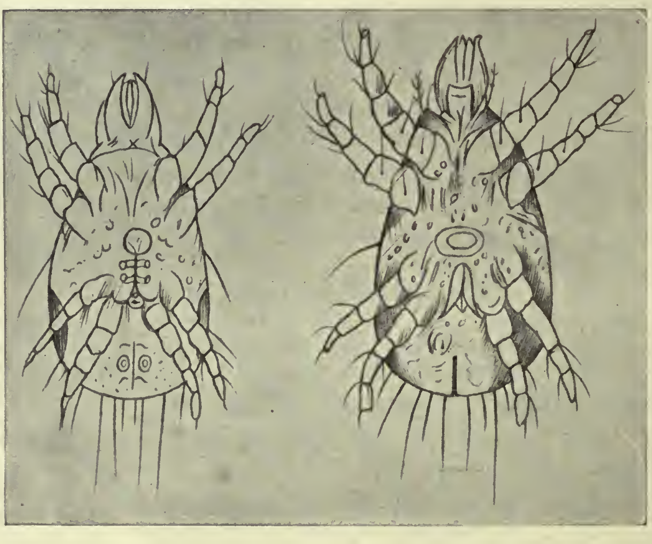
feet. It appeared that the disease was caused by its burrowing beneath the thick cuticle. The disease was attributed to the wearing of a pair of shoes which had been lent to another negro whose feet had been similarly affected for nearly a year. The negro to whom the shoes were lent came from Sierra Leone. Mr. Busk stated that some water brought by Dr. Stranger from the River Sinoe, on the coast of Africa, contained one nearly perfect specimen, and fragments of others very similar to if not identical with this Acarus. Mr. Busk adds that he had been informed by Staff-Assistant Surgeon P. D. Murray that at Sierra Leone there is a native pustular disease called craw-craw—a species of itch breaking into open sores.

[From Busk's original figure I see no reason to doubt that this is a Glyciphagus.—F. V. T.]

Genus. **Rhizoglyphus,** Claparède, 1869.

Rhizoglyphus parasiticus, Dalgetty, 1901.

The *Rhizoglyphii* are to be recognized by their short legs, which are beset with spines, and by the tarsi, which terminate in a claw. They live on plants, roots and bulbs, especially the bulbs of lilies.



a. *b.*

FIG. 365.—*Rhizoglyphus parasiticus.* *a.*, male; *b.*, female. Enlarged. (After Dalgetty.)

This species has been observed on the feet of Indian coolies working in the tea plantations; they produce a skin disease which always commences with blebs between the toes, and which almost always extends to the malleoli, but not beyond. The

Acari have an elliptical body, which is grey, but varies from greenish-yellow to greenish-brown when the stomach is full. Eyes are absent. The legs are composed of five segments and terminate with a claw. The males measure 0·18 mm. in length by 0·08 mm. in breadth, and possess genital and anal pores; the females measure 0·2 mm. in length by 0·09 mm. in breadth.[1] [This is also known as coolie itch and is common in Indian tea plantations.—F. V. T.]

Genus. **Histiogaster,** Berlese, 1883.

Histiogaster (entomophagus?) spermaticus, Trouessart, 1900.

The genus Histiogaster, which also approaches the *Tyroglyphinæ*, is characterized by the circumstance that the males possess suctorial pores used in copulation, as well as leaf-shaped appendages at the posterior end of the body. They feed on vegetables, especially on small fungi.

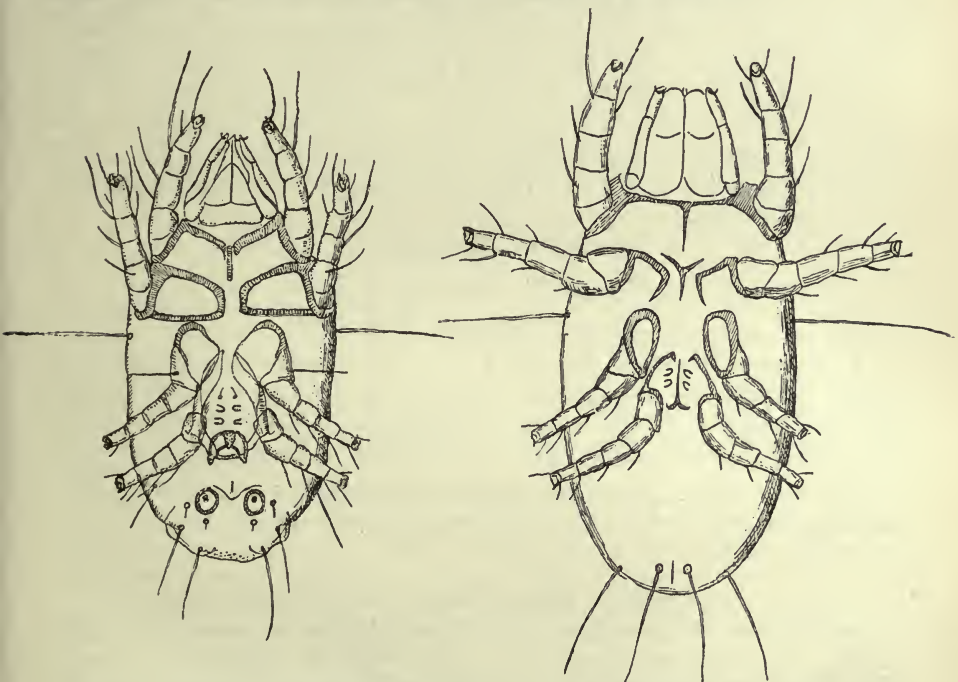


FIG. 366.—*Histiogaster* (*entomophagus ?*) *spermaticus:* on left, male; on right, female—both from the abdominal aspect. 200/1. (After E. Trouessart.)

This species has been described by Trouessart,[2] who found numerous specimens, some adult, others in the developmental stage (larvæ, nymphs), and ova, in the fluid removed by puncture from

[1] Dalgetty, A. B., "Water-itch; or Sore Feet of Coolies," *Journ. Trop. Med.*, 1901, iv, p. 73.

[2] Trouessart, E. R., *Comft. rend. Soc. Biol.*, Paris, 1900, lii, pp. 742-744, 893, 894; *Arch. de Par.*, 1902, v, pp. 449-459.

a cyst of the right testis. The males measure 0·25 mm., the females 0·32 mm., and the larvæ 0·1 mm. in length. The author is of opinion that the animal—perhaps a fertilized female—was introduced by a catheter, and, as a matter of fact, it was afterwards found that the patient had once had the catheter passed in India while suffering from pernicious fever.

It would here rather appear to be the case of a facultative parasitism of an otherwise free-living species. *Histiogaster entomophagus*, Laboulbène, is found occasionally in collections of insects feeding on larger species containing much fat; the species also occurs on dry cantharides; it appears to belong to the region of South Europe, where, however, it is widely spread.

[Entomophagus occurs all over Europe and in America. It has been described under the following names: *Acarus malus*, Shimer, 1868 (*Trans. Illinois Hort. Soc.*); *Dermaleichus mali*, Riley, 1873 (*Rep. Ins. Missouri*, v, p. 87); *Tyroglyphus mali*, Murray, 1877 ("Eco. Ent. Apt.," p. 275); *T. corticalis*, Michael, 1885 (*Trans. Roy. Micros. Soc.*, ser. 2, v, 3, p. 27, figs. 1 to 14); *Histiogaster corticalis*, Canestrini, 1888 (*Prosp. Acarof.*, iii, p. 397); *H. aleurophagus*, Sicherin, 1894, Canestrini, *Prosp. Acarof.*, vi, p. 815. Trouessart's species is evidently distinct. —F. V. T.]

Genus. **Cheyletus.**

Cheyletus mericourti, Lab.

Acaropsis mericourti, Moq. Tand.

[This mite has been described from three specimens found in pus which flowed from an abscess in the ear of a naval officer, produced by inflammation of the auditory passage. Where the mites came from we do not know, as they were found near the Bank of Newfoundland. This genus of Acari has enormous mandibles and a peculiar tracheal system; two ungues and appendages to the tarsi.—F. V. T.]

Family. **Sarcoptidæ** (Itch Mites).

Small mites without eyes and tracheæ, and with delicate, transversely striated cuticle. The mouth parts form a cone, over which the shield-shaped upper lip protrudes; the cheliceræ are chelate; the pedipalpi (or maxillary palpi) have three joints; the legs are short and compact, and composed of five segments; the terminal joints have pedunculated suckers (ambulacra) or a long bristle. The larvæ are six-legged. They live on or under the skin of birds and mammals, on which they produce the skin disease known as scabies, or itch.

[The *Sarcoptidæ* attack the hairs, feathers or epidermis of birds, animals and man, living as permanent parasites. The punctures they produce are followed by the formation of more or less thick crusts or scabs, beneath which the mites live and breed (so called scab, mange and itch). Most are oviparous, some ovoviviparous. The eggs are minute, ovoid, with a thin semi-transparent shell. They incubate in a few days, varying from two to ten or eleven, as a rule. Generally sarcoptic diseases lie dormant in winter and revive in spring and summer in man ; but in animals with long wool, such as sheep, they are most active during winter, although revival of active reproduction takes place in spring.

[Speaking generally, for the *Sarcoptidæ* there are three distinct stages in the development of the male, four in the female, as follows:—

[(1) The larva. In this stage only three pairs of legs occur.

[(2) The nymph, in which a fourth pair of legs appear, and which thus approaches the adult ; but so far no sexual organs occur. Nymphs are of two sizes—the smaller being future males, the larger females.

[(3) The next stage in the female is the age of *puberty*, the female now being provided with a vulvo-anal slit ; this so-called *pubescent female* is fertilized by the male. The male then dies. But the female again casts her skin and enters another stage—

[(4) The ovigerous female—the egg-laying female—which has differently modified legs.

[The rate at which these Acari breed is very great. Gerlach has found that roughly, in each Sarcopt gallery, a female produces fifteen individuals—ten females and five males—and that the progeny reproduce again in fifteen days. The table given below thus shows that one pair may produce the enormous number of 1,500,000 descendants in three months :—

First generation after 15 days	...	10	females	...	5	males
Second ,, ,, 30 ,,	...	100	,,	...	50	,,
Third ,, ,, 45 ,,	...	1,000	,,	...	500	,,
Fourth ,, ,, 60 ,,	...	10,000	,,	...	5,000	,,
Fifth ,, ,, 75 ,,	...	100,000	,,	...	50,000	,,
Sixth ,, ,, 90 ,,	...	1,000,000	,,	...	500,000	,,

= *1,500,000 individuals.*

[These *Acarinæ* are divided into three distinct sub-families, namely the *Cytolichinæ*, *Sarcoptinæ*, *Canestriniinæ*.

[The *Sarcoptinæ* alone interest us here, and of the nine genera the three following are the most important :—

[(1) Sarcoptes, Latreille ; Eusarcoptes.

[(2) Psoroptes, Gerv. ; Dermatodectes, Gerlach ; Dermatocoptes, Fürstenberg.

[(3) Chorioptes, Gerv. ; Symbiotes, Gerlach ; Dermatophagus, Fürst. ; Sarcodermatocedes, Del.

[The following are the main characters of these three genera :—

[*Sarcoptes*—round or slightly oval ; the two posterior pairs of legs being nearly or quite concealed beneath the body; the tarsi end in simple long pedicles, with ambulatory suckers.

[*Psoroptes*—oval; the legs are all visible outside the margin of the body ; the ambulatory suckers are carried on long triangulated stalks ; the male has copulatory suckers and abdominal prolongations.

[*Chorioptes*—oval ; legs long, thick, all visible ; ambulatory suckers very wide, carried at the end of simple, short pedicles.

[Sarcoptes make channels or furrows beneath the epidermis, and in these the female lays her eggs. This form of acariasis is thus difficult to cure. It is the cause of human itch (*vide Sarcoptes scabiei*).

[Psoroptes do not make sub-epidermic galleries ; they live and breed in colonies beneath crusts or scabs formed by the changes they produce in their host's skin. Sheep scab is a common type of disease produced by Psoroptes. This genus is of little importance as a parasite to man.

[Chorioptes live as Psoroptes ; they also do not affect man. Otodectes, Can., affecting cats and dogs, and others occur, but do not affect man as far as we know at present ("Demodicidae und Sarcoptidae," von Professor G. Canestrini und P. Kramer, *Das Tierreich*, 1899).—F. V. T.]

Sub-family. **Sarcoptinæ.**

Genus. **Sarcoptes,** Latreille.

Sarcoptes scabiei, de Geer, 1778.

Syn.: *Acarus scabiei*, de Geer, 1778; *A. psoricus*, Pallas, 1760; *A. siro*, L., 1778; *Sarcoptes exulcerans*, ? Linn., 1758, Nitsch, 1818; *S. hominis*, Raspail, 1834, and Hering, 1838; *S. galei*, Owen, 1853; *S. communis*, Delaf. et Bourg., 1862; *S. scabiei* var. *hominis*, Mégnin, 1880.

The body is oval or nearly circular and whitish in colour, with transverse rows of striæ partly interrupted on the back. There are transverse rows of small bristles on the dorsal surface, and groups of trichomæ on the front, sides and back. There are chitinous hairs at the base of the legs; the two first pairs are provided with pedunculated ambulacra in both sexes, the two posterior pairs terminate each with a long bristle in the female; in the male the third pair of legs terminate in a bristle, the fourth pair with a pedunculated ambulacrum. The anus is situated at the posterior border of the dorsal surface.

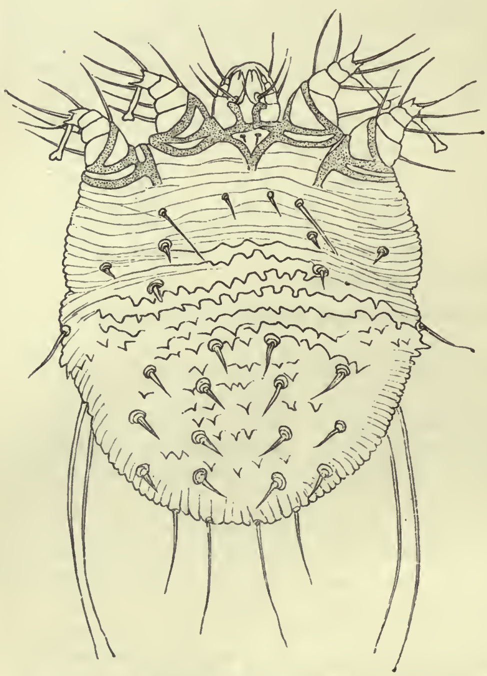


FIG. 367.—*Sarcoptes scabiei*: female, dorsal aspect. 200/1. (After Fürstenberg.)

At one time numerous species were differentiated, according to the form of the Acarus, the number, position and size of the hairs and spines, even according to the hosts, etc. All these characteristics, however, fluctuate so considerably that absolute differentiation is impossible; the supposed species may be regarded in the same light as Mégnin did, as varieties. It is also hardly possible to distinguish the mite of human scabies (*S. hominis*) from that of a number of domestic animals (*S. squamiferus*). It is best, therefore, to accept one single species (*S. scabiei*), which may give rise to different races or castes by living in the skin of man and mammals, but can pass from one host to the other.

[Canestrini and Kramer, in their monograph of the *Sarcoptidæ*, enumerate eighteen distinct species of this genus, from the dog, goat, camel, horse, ferret, lion, wolf, sheep, pig, etc., and two species parasites of man (*scabiei* and *scabiei-crustosæ*). There is no doubt that they are distinct species.—F. V. T.]

The *S. scabiei* of man (*S. scabiei* var. *hominis*) (length of male 0·2 to 0·3 mm., and breadth 0·145 to 0·190 mm.; length of female 0·33 to 0·45 mm., and breadth 0·25 to 0·35 mm.) lives in the tunnels that it excavates in the epidermis, and attacks by preference places with thin skin, such as between the fingers, in the bend of the elbows and knees, in the inguinal region, on the penis, on the mammæ, but may also affect other parts. The tunnels, which vary from a few millimetres to a centimetre and more long, do not run straight, but are somewhat tortuous; the female is found at the terminal end. The tunnels contain the excrement and oval eggs (0·14 mm. in length) of the parasite; the males are rarely met with, as they die off after copulation; the females die after depositing their eggs. The six-legged larvæ hatch out after four to eight days, and after about a fortnight, during which time they change their skins three times and undergo metamorphosis, they begin themselves to burrow. Transmission from person to person rarely is effected through linen, but by direct contact (as in coitus); transmission can be artificially effected on horses, dogs and monkeys, but not on cats.

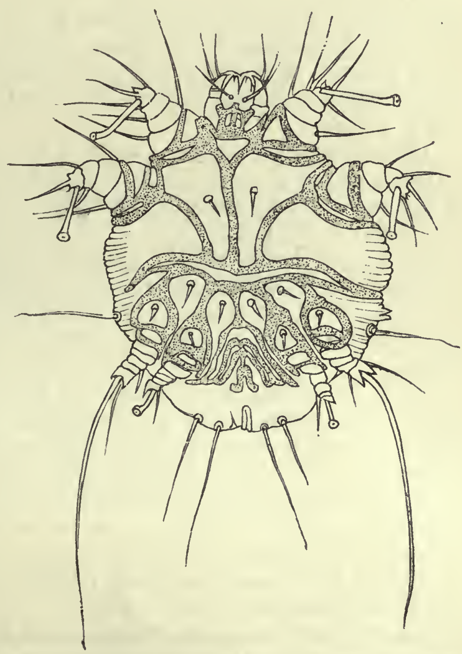


FIG. 368.—*Sarcoptes scabiei*: male, ventral aspect. 200/1. (After Fürstenberg.)

The smaller *S. scabiei-crustosæ*, Fürstenberg, is the cause of the itch that occurs chiefly in Norway; it is not certain whether this is a distinct species of itch mite.

[This is quite a distinct species, which is recorded from Germany and France. Mégnin (*Parasitology*, 1880, p. 165) described this as *S. scabiei* var. *lupi*. The female is 140 μ long, 340 μ broad; the male is 170 μ long by 150 μ broad. In *Science* (March 3, 1893, p. 125) is recorded that at the Indiana Academy of Science Dr. Robert Hessler referred to "a case of that extremely rare and almost extinct form of itch known as 'Norway itch,' the *scabies norvegica* of Hebra, 1852. The afflicted man was covered with thick, creamy white, leathery scales; some of these scales measured over an inch in diameter and $\frac{1}{10}$ in. thick. A constant shedding of scales went on, a handful being gathered daily. They were found full of mites and eggs and riddled with passages. Under treatment the mites were killed and the skin became normal. Dr. Hessler made a calculation of the number of eggs and mites, amounting to ova and shells 7,004,000, mites in all stages 2,009,000.—F. V. T.]

The following forms may be transmitted from DOMESTIC ANIMALS to MAN:—

(1) *S. scabiei* var. *equi.* Male, 0·2 to 0·23 mm. long, 0·16 to 0·17 mm. broad. Female, 0·40 to 0·42 mm. long, 0·28 to 0·32 mm. broad. The horse is the normal host.

(2) *S. scabiei* var. *ovis.* Male, 0·22 mm. long, 0·16 mm. broad. Females, 0·32 to 0·44 mm. long, 0·24 to 0·36 mm. broad. This mite lives on sheep, and passes over to goats and human beings; it may also be artificially transferred to horses, oxen and dogs.[1]

(3) *S. scabiei* var. *capræ.* Male, 0·24 mm. long, 0·188 mm. broad. Female, 0·345 mm. long, 0·342 mm. broad. On goats, passing from them to horse, ox, sheep, pig and man. On the latter, in contradistinction to the varieties (1) and (2), it produces a severe affection.

(4) *S. scabiei* var. *cameli.* Frequently observed in man, chiefly in Africa. A few cases have been observed in Europe; the affection induced by it is severe.

(5) *S. scabiei* var. *aucheniæ.* Male, 0·245 mm. long, 0·182 mm. broad. Female, 0·34 mm. long, 0·264 mm. broad. It lives on the llama, and may be transmitted to man.

(6) *S. scabiei* var. *suis.* Male, 0·25 to 0·35 mm. long, 0·19 to 0·3 mm. broad. Female, 0·4 to 0·5 mm. long, 0·3 to 0·39 mm. broad. In the domestic pig and wild boar; occasionally also in man. The settlement, however, is usually of short duration.

(7) *S. scabiei* var. *canis.* Male, 0·19 to 0·23 mm. long, 0·14 to 0·17 mm. broad. Female, 0·29 to 0·38 mm. long, 0·23 to 0·28 mm. broad. In the house-dog, and also, not unusually, in human beings.

(8) and (9) *S. scabiei* var. *vulpis* and *S. scabiei* var. *leonis* of the fox and lion have likewise been observed on man.

These are all distinct species and should read as follows: *S. canis*, Gerl.; *S. ovis*, Mégn.; *S. equi*, Gerl.; *S. dromedarii*, Gerv. (*cameli*, Mégn.); *S. auchenicæ*, Raill.; *S. suis*, Gerl.; *S. vulpis*, Fürst.; *S. leonis*, Can.

Sarcoptes minor, Fürstenberg, 1861.

Anus situated on the back, legs short, pedunculated ambulacra broad; living on cats (*S. minor* var. *cati*) and rabbits (*S. minor* var. *cuniculi*). In cats this mite usually lives in the cervical region, and thence spreads to the ears and head; it usually causes the death of the infected animals; it is easily transferable from cat to cat, is difficult to transmit to rabbits, but once settled on them can easily

[1] [This mite produces the so-called "black muzzle" of sheep.—F. V. T.]

infect other rabbits. On the other hand, the transmission of the itch mite of the rabbit to the cat does not succeed. In man *S. minor* induces an eruption that disappears after about a fortnight.

[*S. minor*, Fürstenberg, 1861 ("Krätzm.," viii, p. 218), comes in Railliet's sub-genus NOTOEDRES, 1893 ("Zool.," ed. 2, p. 660). Canestrini raised this to generic rank in 1894 (*Prosp. Acarof.*, vi, p. 724).

[There are three species: (1) *N. notoedres*, Mégnin = *Sarcoptes alepis*, Railliet and Lucet (*Compt. rend. Soc. de Biol.*, 1893, xlv, p. 404), and *Sarcoptes notoedres* var. *muris*, Mégnin (*Parasitology*, 1880, pp. 172-174). This occurs on the black and brown rats and the water-vole.

[(2) *N. cati*, Hering, 1838 (*N. acta. ac. Leop.*, ii, 18, xliv, p. 605, figs. 9 and 10), = *Sarcoptes minor*, Fürstenberg ("Krätzm.," 1861, viii, p. 215). Found on the cat in Germany, France, Italy, and Britain.

[(3) *N. cuniculi*, Gerlach, 1857, "Krätzm.," iii, figs. 20, 21. It lives on the rabbit and is found in Germany and France.—F. V. T.]

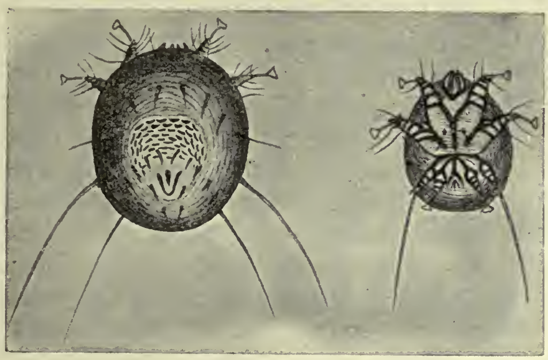


FIG. 369.—*Sarcoptes minor* var. *cati*: on the left, female (lying on its abdomen); on the right, male (lying on its back). (After Railliet.)

The itch mites of domestic animals, which belong to the genera Psoroptes (= Dermatodectes = Dermatocoptes) and Chorioptes (Symbiotes = Dermatophagus), as a rule do not infest and live on man, even when artificially transmitted. It is, however, possible for this to occur. Moniez ("Traité de par.," 1896, p. 559) mentions that a species of Chorioptes—probably *Ch. bovis*—had been found on man, as had also *Demodex folliculorum*. This author also includes *Dermatophagoides scheremetewskyi*, Bogdanoff (*Bull. soc. imp. d. natural.*, *Moscou*, 1864, xxxvii, p. 341), which has repeatedly been found on man in Moscow and Leipzig (Zürn, *Ber. d. med. Ges.*, *Leipzig*, 1877, p. 38), as *Chorioptes bovis*.

OTHER REFERENCES TO *Scabies crustosæ* AND *norvegica*, ETC.

(1) "Ein Fall von *Scabies crustosa norvegica*," *Würzb. med. Zeitschr.*, l, pp. 134-139, pl. 3, H. Bamberger.

(2) "Ueber die Krätzmilbe (*Acarus scabiei*)," *Notiz. a. d. Geb. d. Nat. u. Heilk.*, Weimar (1913), xlii (11), Oct., pp. 161-166 (1834), de Blainville.

(3) "Rapport sur le ciron de la gale (*Acarus scabiei*)," *Ann. de Mus. d'Hist. nat.*, 1831; *Parasitology*, iv, pp. 213-232, de Blainville.

Family. **Demodicidæ** (Mites of the Hair-follicles).

Small *Acarina*, elongated in worm-like fashion, with annulated abdomen, and without eyes or tracheæ. The mouth parts consist of a suctorial proboscis and three-jointed palpi; the legs are short, and have three segments with small terminal ungues. The anus is situated on the anterior border of the abdomen; oviparous; the larvæ have six stumpy legs. These mites live in the hair-follicles of mammals.

Genus. **Demodex,** Owen.

Demodex folliculorum, Simon, 1842.

Syn.: *Acarus folliculorum*, Sim., 1843; *Demodex folliculorum*, Owen, 1843; *Macrogaster platypus*, Miescher, 1843; *Simonea folliculorum*, P. Gervais, 1844; *Steatozoon folliculorum*, Wilson, 1847.

As in *Sarcoptes scabiei*, numerous varieties of this species are known; the form parasitic on man lives in the hair-follicles, the meibomian and sebaceous glands, and hardly ever causes inconvenience; the male measures 0·3 mm. in length and the female about 0·4 mm. in length. The eggs 0·06 to 0·08 mm. in length, 0·04 to 0·05 mm. in breadth, and are thin-shelled. The creatures are always attached with the head end downwards in the parts mentioned; they are most frequent in the sebaceous glands of the face, by the nose, lips and forehead, but they may be present on the abdomen and on other parts of the body. They may occasionally obstruct the excretory gland ducts, thus causing inflammation of the gland (comedones); their agglomeration in the meibomian glands sets up inflammation of the margins of the eyelids. There are generally only a few specimens in a gland. According to some statements Demodex occurs in 50 per cent. of mankind and even in children; they survive the death of their hosts by several days.

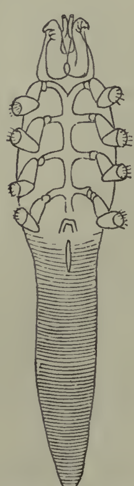


FIG. 370.—*Demodex folliculorum* of the dog. (After Mégnin.)

The variety living in the dog (*D. folliculorum* var. *canis*) is smaller than the variety living in man, and produces a skin disease resembling scabies in these animals. According to Zürn they may also live on man; nevertheless, no other investigator has recorded a similar observation, and attempts at artificial infection have proved negative.[1]

[Ten distinct species of Demodex are given by Canestrini and Kramer ("Demodicidae und Sarcoptidae," *Das Tierreich*, 1899, vii). The species are certainly distinct.

[The species living on the dog (*D. canis*, Leydig, 1844) is cosmopolitan. According to the *British Medical Journal* (February 22, 1913,

[1] [This mite causes what we know in England as red mange in dogs.—F. V. T.]

p. 407), dog mange may be caught by humans. Whitfield and Hobday describe in the *Veterinary Journal* seventeen cases which have come under their observation.—F. V. T.]

Order. **Pentastomida.**

Family. **Linguatulidæ.**

Arachnida greatly altered in consequence of their parasitic manner of life; for a long time they were regarded as helminthes. The body is elongated, vermiform, flattened or cylindrical, and more or less distinctly annulated. The head, thorax, and abdomen are not defined from each other (fig. 371). The elliptical mouth, surrounded by a chitinous ring, is situated at the anterior end, on the ventral surface, and the intestine leading straight through the body opens at the posterior end. Two retractile hooks are at the sides of the mouth (fig. 372); these are usually considered to be the terminal joints of two pairs of legs, but it appears to be more correct to regard them as the remains of the antennæ and palpi (Stiles). According to this opinion, the legs in the adult state are completely degenerated.

The nervous system is reduced to an œsophageal ring. No organs of sense are recognizable except the papillæ at the anterior end. There are neither organs of circulation nor of respiration.[1]

The sexes are distinct. In the small male the sexual orifice is situated ventrally in the anterior part of the body; in the female it is placed near the anus. The *Linguatulidæ* lay eggs, and from each egg, after being conveyed into an intermediate host, a four-legged larva, with rudimentary mouth parts, hatches out. It goes through a series of metamorphoses, and passes through a second larval condition, which, however, possesses the essential characteristics of the fully developed form. Sooner or later it migrates during this stage, and reaches its final host, mammal or reptile, in the nostrils or lungs of which the adult *Linguatulidæ* live.

[As adults they live as internal blood feeders in various birds, reptiles and mammals, especially in the nasal and respiratory passages. The larval stage occurs in another host in an encysted condition; this host is usually an animal preyed upon by the species in which the sexual forms are found. The larvæ bore through the walls of the host's stomach and enter liver and spleen or brain, where they encyst; here they grow until they assume almost the appearance of the adult. These encysted larvæ on being eaten later make their way into the nasal passages and lungs, where they mature. Both adults and larvæ occur in man, as mentioned later.

[Three genera are recognized in this family:—

[(1) *Linguatula.*—Body flat, annulated. Adults live in the nasal sinus.

[(2) *Porocephalus.*—Body cylindrical, elongate, with often deeply cut rings. Adult in respiratory organs of snakes, larvæ in animals and man.

[(3) *Reighardia.*—Cylindrical, but not ringed. Not found in humans.—F. V. T.]

---

[1] What are designated as stigmata in the Linguatulides are the orifices of sebaceous glands.

Genus. Linguatula, Fröhlich.

Linguatula rhinaria, Pilger, 1802.

Syn.: *Tænia rhinaria*, Pilger, 1802; *Polystoma tænioides*, Rud., 1810; *Linguatula tænioides*, Lam., 1816; *Pentastoma tænioides*, Rud., 1819.

The male is white in colour, 18 to 20 mm. in length, anterior portion 3 to 4 mm. in breadth, posterior part 0·5 mm. in breadth. The female is of a yellowish colour, 8, 10, or 13 cm. long, anterior part 8 to 10 mm. and posterior part 2 mm. wide. The brownish eggs can be seen in the median line. The body is elongated, rather flat, and exhibits about ninety rings or segments with crenellated borders. The hooks round the mouth are strongly curved and are articulated to a basilar support. Eggs oval, 0·09 μ in length, 0·07 μ in breadth.

FIG. 371.—*Linguatula rhinaria*: female. Natural size.

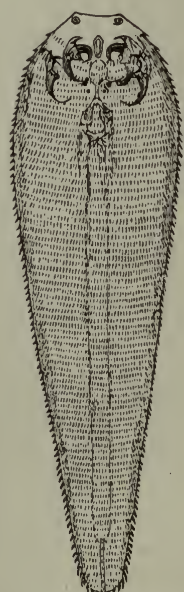


FIG. 372.—Larva of *Linguatula rhinaria* (*Pentastoma denticulatum*). Enlarged. (After Leuckart.)

L. rhinaria, in the adult condition, lives in the nasal cavity and frontal sinus of the dog, wolf, fox, horse, goat, and occasionally of man; it causes severe catarrh, epistaxis and suppuration.

Development.—The ova, which are found in masses in the nasal mucus, already possess an embryo; they are expelled with the nasal secretion, and are swallowed by herbivorous mammals with their food, mostly by hares and rabbits, but also by sheep, goats, oxen, horses, antelopes, fallow deer, pigs, cats, and occasionally also by human beings. The young larvæ hatch out in the stomach; they possess a thickened anterior body with rudimentary mouth parts and two pairs of limbs; the body gradually tapers to a short tail.

The larvæ of the *Linguatulidæ* bore through the intestinal wall and reach the liver, more rarely the mesenteric glands, etc.; they here become encysted and enter a sort of pupal stage in which they lose their limbs; after several moultings and gradual growth the second larval stage, having the appearance of the adult Linguatula, sets in. About five to six months after infection the creatures have become 4 to 6 mm. long, possess eighty to ninety rings, which have a series of fine points on their posterior border; the mouth and intestine are formed, the sexual organs mature and the two pairs of hooks are near the mouth. This larval stage (fig. 372) has been known for a long time, but it was regarded as an independent species of animal, and therefore had a separate name (*Linguatula serrata*, Fr.; *Pentastoma denticulatum*, Rud., etc.).

Later these Linguatula larvæ make an attempt to escape from their hosts, and this, of course, can only be effected by means of an active migration; they leave the cysts, and according to their respective positions in the abdominal or pleural cavities they reach the bronchi

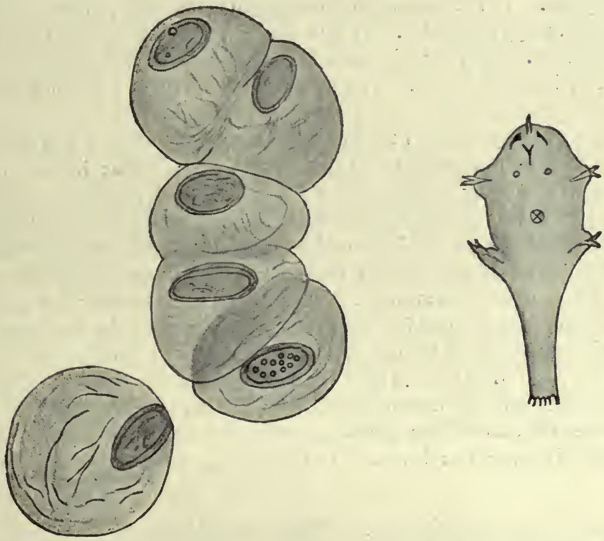


FIG. 373.—*Linguatula rhinaria:* on left, eggs in gelatinous covering. 110/1. On right, first larval stage. 300/1. (After M. Koch.)

or the intestine, and finally pass out; they may be again sniffed up by dogs and settle in their nasal cavities. Still this outward migration does not appear to be necessary for further development. A portion of the larvæ gain access to the nasal cavities directly through the trachea, and thus herbivorous mammals certainly become directly infected. In most cases the infection of dogs, wolves and foxes, that is, of carnivorous mammals, takes place through consuming the bodies of mammals, or parts of them, such as the liver and lungs, which are affected with the second larval form; in any case most larvæ obtain access first to the stomach of their host, from here they make an active migration through the œsophagus to the oral and nasal cavities, in which they settle. It is possible also that the same larvæ which are free in the oral cavity when the food is being eaten migrate into the nasal cavities. After being stationary a fresh skin is formed and the spine-bearing cuticula are thrown off. The male attains its full size in the fourth, and the female in the sixth month. The duration of life is stated to be from fifteen months to several years.

L. rhinaria has been observed in man in the adult as well as in the larval condition (*Pentastoma denticulatum*). Zenker first called attention to the occurrence of the larva in man, having found it nine times in the liver in 168 autopsies. Heschl found it twice in Vienna in twenty autopsies, Virchow found it in Würzburg and Berlin, Wagner in Leipzig (10 per cent.), and Frerichs in Breslau five times in forty-seven autopsies. The parasite is much less frequent in Switzerland. According to Klebs, one case occurs in 900 autopsies, and according to Zaeslin two cases occurred in Basle to 1,914 autopsies. In the Seamen's Hospital in Kronstadt *P. denticulatum* has been found six times in 659 autopsies. It was almost always the liver that contained one or a few specimens. The parasite was very rarely found in the kidney or spleen, or encysted in the intestinal wall. The adult *L. rhinaria* is far more rarely observed in man.

A case reported by Landon that related to a blacksmith of Elbing is particularly interesting. This man accompanied the campaign of 1870; he soon, however, fell ill with pains in the liver, accompanied by icterus and intestinal disorders. Soon after the war, and after the symptoms were reduced to icterus and weakness, bleeding of the nose set in and continued with slight intermissions for seven years; an unpleasant sensation of pressure in the left nasal cavity set in, with inflammatory swelling of the mucous membrane. At last, in the summer of 1878, when the pressure in the nose had considerably increased, a Linguatula was expelled from the nose with a violent attack of sneezing, and lived for three days longer in water. The bleeding of the nose then ceased and the patient soon recovered. There can be no doubt that the first illness was connected with the invasion in the liver of numerous larvæ of Pentastoma, and disappeared after their encystment; one or a few of these must subsequently have found its way to the nose and settled there.

Genus. **Porocephalus.**

Porocephalus constrictus, v. Siebold, 1852.

Syn.: *Nematoideum hominis*, Diesing, 1851; *Pentastomum constrictum*, v. Sieb., 1852; *Porocephalus constrictus*, Stiles, 1893.

Porocephalus is distinguished from Linguatula by its cylindrical body and by certain internal structures. *Porocephalus constrictus* is at present only known in its larval stage. It is milk white in colour with golden-yellow hooklets. Number of rings, twenty-three. Length 13 mm., breadth 2·2 mm. There are no prickles on the posterior border of the annulations of the body.

This species was first discovered by Pruner encysted in the livers of two negroes in Cairo. Bilharz reported two further cases in which the parasites were encysted in the liver and in the mucosa of the intestine; a few other observations have been made by Fenger, Aitken, Giard and Chalmas. Aitken's report deals with soldiers of the British Colonies in Africa. The parasites were discovered in the liver as well as in the lung, and appear to have been the cause of death in one case (pneumonia, peritonitis).

Pruner has found the same parasite also in the liver of the giraffe.

It has recently been assumed that *Porocephalus constrictus* is the larva of *Pentastoma moniliforme*, Diesing, 1835, that attains a length of 70 mm. and lives in the lungs of African Pythonides. The larva is known to have been ejected from monkeys (*Cercopithecus albogularis*, *Cynocephalus maimon*), from the giraffe (*Camelopardalis giraffa*), from a species of hyæna (*Proteles cristatus*), and should be expected to occur frequently in smaller mammals which have been swallowed by African serpents of enormous size.

[The three species of *Pentastomidæ*, or tongue worms, found in man are *Linguatula serrata*, Frölich; *Porocephalus armillatus*, Wyman; and *Pentastoma moniliformis*, Diesing.

[(1) *Linguatula serrata* has been referred to under a great number of names.[1] It is a frequent parasite in dogs, oxen and sheep; as an adult in the dog and also in the fox and wolf. The nymphal stage is found in rats, hares, rabbits, the horse, oxen, sheep, goats, pigs, camels, deer, the African and long-eared hedgehogs, porcupine, guinea-pig and peccary. In man it is found in both adult and nymphal stages. Sambon says the nymphal stage is of frequent occurrence, but is usually overlooked. Zenker, who first found it in man, obtained it in nine out of 160 *post-mortems*, usually encysted in the liver. It is then said to be harmless. Landon, in 1878, found the adult in man, the patient suffering from epistaxis for about seven years; in the end during a fit of sneezing the living parasite was ejected through the nostril. This case is of particular interest as it appears to suggest that this Acarid may now and then pass its entire development in the same host, or at any rate may actively migrate from the liver to the nasal cavities after a period of encystment in the liver or elsewhere, which has also been observed in herbivorous animals (*vide* also p. 526).

[It is recorded from man in Central America (Darling, *Bull. Soc. Path. exot.*, 1912, v, p. 118; and again *Arch. Int. Med.*, 1912, v, p. 401), also from Rio de Janeiro (*Mem. Inst. Oswaldo Cruz*, 1913, fasc. ii, p. 125) by Faria and Travassos.

[(2) *Porocephalus armillatus*, Wyman, is also known under a variety

[1] [Synonymy given by Sambon: Adult form, *Ténia lanceolé*, Chabert, 1787; *Ver rhinaire*, Chabert, 1787; *Tænia rhinaris*, Pilger, 1805; *Tænia lanceolata*, Rudolphi, 1805; *Cochlus rhinarius*, Rudolphi, 1805; *Prionoderma rhinaria*, Rudolphi, 1808; *Polystoma tænioides*, Rudolphi, 1809; *Linguatula tænioides*, Lamark, 1816; *Prionoderma lanceolata*, Cuvier, 1817; *Pentastoma tænioides*, Rudolphi, 1819; *Linguatula lanceolata*, de Blainville, 1828; *Linguatula rhinaris*, Railliet, 1885; *Linguatula caprina*, R. Blanchard, 1900. Nymphal form: *Linguatula serrata*, Frölich, 1789; *Tænia capræa*, Abildgaard, 1789; *Tænia caprina*, Gmelin, 1800; *Polystoma serrata*, Goeze, 1800; *Halysis caprina*, Zeder, 1803; *Linguatula denticulata*, Rudolphi, 1805; *Echinorhynchus capreæ*, Braun, 1809; *Tetragulus capriæ*, Bosc, 1810; *Pentastoma denticulatum*, Rudolphi, 1819; *Pentastoma emarginatum*, Rudolphi, 1819; *Pentastoma fera*, Creplin, 1829; *Linguatula ferox*, Gros, 1849.

of names.[1] This species is widely spread over tropical Africa. The adult stage is found in pythons and puff-adders, the nymphal in the chimpanzee, Sykes monkey, mandrill and other monkeys, the lion, leopard, banded ichneumon, Aard wolf, dog, black rat, South African reedbuck and the giraffe. The adult has never been found in man or any mammal. No fewer than sixteen cases of the nymphal form, Sambon tells us, have been found in man, and it is probably much more widespread than at present known. So far it has only been found in the African natives. This species has sixteen to seventeen body rings in the male, eighteen to twenty-two in the female, and the body does not taper as much as in the next species.

[(3) *Pentastoma moniliformis*, Diesing,[2] is an Oriental species, found in India, Indo-China and South China, and the Malay Archipelago. The adult occurs in both the Indian and reticulated pythons. The nymphal stage has been found in monkeys, the tiger, the civet and the Indian otter.

[The nymph has twice been found in man; in one case in the liver of a Filipino, the other in the serous coat of the small intestine of a native of Sumatra.

[This species can be told by the female having twenty-nine to thirty-three body rings, the male twenty-six, and the annulations are more bead-like and less prominent than in the African species.

[In addition to these three, Sambon thinks it probable that others occur in man.—F. V. T.]

OTHER REFERENCES TO *Pentastomidæ*.

(1) "Die Wanderung des *Pentastomum denticulatum* beim Rinde," *Centralbl. f. Bakt. u. Parasitenk.*, Jan. 2, 1889, v (1), pp. 1-5, V. Bates.

(2) "Il *Pentastoma moniliforme*, Dies., nella pantera," *Med.-vet. Torino*, 1877, 4 s., vi (12), pp. 529-532, R. Bassi.

(3) "On the Organization and Development of Linguatula (Pentastoma), accompanied with the description of a new species from the abdominal cavity of the mandrill," *Ann. and Mag. Nat. Hist.*, 1848, 2 s. ii (7), 2, pp. 69-70, v. Beneden.

(4) "De la *Linguatula ferox* (*Pentastoma denticulatum* aut *serratum*)," *Bull. Acad. roy. d. Sci. d. Belg.*, 1855, xxii, pt. 1 (1), pp. 4-10, v. Beneden.

---

[1] Adult form as *Linguatula armillata*, Wyman, 1847; *Pentastomum polyzonum*, Harley, 1856; *Pentastomum armillatum*, Leuckart, 1860; *Pentastomum armillatum*, Diesing, 1864; *Porocephalus armillatus*, Stiles, 1893; *Porocephalus polyzonus*, Stiles, 1893; *Porocephalus moniliformis*, Neumann (in part), 1899. Nymphal form: *Linguatula diesingii*, van Beneden, 1849; *Pentastomum euryzonum*, Diesing, 1850; *Nematoideum hominis*, Diesing, 1851; *Pentastomum constrictum*, von Siebold, 1852; *Linguatula constricta*, Küchenmeister, 1855; *Pentastoma leonis*, Wedl., 1863; *Pentastoma fornatum*, Cobbold, 1879; *Pentastomum protelis*, Hoyle, 1883; *Porocephalus constrictus*, Stiles, 1893; *Linguatula constrictor*, Galli-Valerio, 1896; *Pentastomum diesingii*, Shipley, 1898.

[2] The synonomy is as follows:—Adult form: *Pentastoma moniliforme*, Diesing, 1835; *Linguatule moniliforme*, Mégnin, 1880; *Porocephalus moniliformis*, Stiles. Nymphal form: *Pentastoma fornatum*, Creplin (in part), 1849; *Pentastoma wedlii*, Cobbold, 1866; *Pentastoma aonycis*, Macalister, 1874; *Porocephalus armillatus*, Stiles (in part), 1908.

(5) "Note sur quelques pentastomes," *Bull. Acad. roy. d. Sci. de Belg.*, 1857, 26, 2 s., ii (5), pp. 29-30, v. Beneden.

(6) "Ueber das *Pentastoma* in de gekrösdrusen den Schafe," *Repert. d. Thierh. Stuttg.*, 1861, xxii, pp. 37-38, Collin.

(7) "Eine Linguatula aus der Mesenterialdrüse des Schafes und Dromedars als zweites ungesche. Stadium von *Pent. taenioides*," *Notiz. u. Tagsber. u. d. Geb. d. Nat. u. Heilk.* Jena, 1862, v, pp. 127, 128, Colin.

B. INSECTA (*Hexapoda*).

Three separate regions can always be distinguished in the body of insects, namely, the head, thorax and abdomen. The HEAD is a roundish unsegmented capsule and possesses four pairs of appendages. The first pair are the various shaped feelers (antennæ), which are placed on the superior surface of the head next to the eyes ; then more ventrally placed a pair of upper jaws (mandibles) without palpi and without articulations ; they are powerful masticatory organs.[1] The first pair of lower jaws (maxillæ) are jointed and bear a palpus (palpus maxillaris) ; the second pair of maxillæ are soldered together and form the lower lip (labium), and likewise carry a palpus labialis on each side. The upper lip (labrum), as well as the other parts (which, however, are only appendages), belong to the mouth, which is really formed of a number of closely united pieces. The mouth parts are modified according to the functions required of them. *Coleoptera*, *Neuroptera*, and *Orthoptera* have biting or masticatory mouth parts which conform with the scheme described above. In the licking mouth parts of the *Hymenoptera* the maxillæ and under lip are considerably elongated, while the mandibles retain their form and are used for triturating the food ; in the *Lepidoptera* nearly all the mouth parts are shortened except the maxillæ, which form a long and sometimes spirally rolled suctorial proboscis ; the *Diptera* and *Rhynchota* have piercing and sucking mouth parts. The mandibles and maxillæ are metamorphosed into needle-like structures, while the suctorial apparatus is formed by the labrum.

The thorax consists of three segments, which are frequently united ; ventrally it carries three pairs of legs, which consist of a definite number of articulated pieces joined together. Their form also changes according to their function, so that legs for running, walking, digging, swimming, jumping, and preying are seen. A pair of wings are respectively attached to the last and last but one thoracic rings, and these may be traced back, not to metamorphosed appendages, but to tracheal branchia. They are composed of chitinous membranes supported by branched structures (veins or ribs). Their size and formation vary ; they are seldom of equal size and form (*Neuroptera*) ; often the posterior wings are larger than the anterior wings, the former then only serving as protective coverings for the latter (*Coleoptera*), or the anterior wings are larger (*Lepidoptera*), or the posterior wings are shortened or are entirely absent (*Diptera*) ; and finally there are insects in which both pairs of wings are lacking.[2]

The abdomen retains its segmentation, but, with the exception of a few groups related to the primitive forms of insects, has no appendages in the imago condition ; the abdomen usually consists of ten segments, on the last of which the anus is situated.

---

[1] [The mandibles are only powerful masticatory organs in biting-mouthed insects (*Mandibulata*) ; in the sucking or piercing-mouthed insects they may be absent, or in the form of needle-like stylets (*Haustellata*).—F. V. T.]

[2] [As in the order *Aptera*, which includes the Thysanura and Collembola, and also exceptions in other orders, as the fleas amongst *Diptera*, the Mutillus and ants amongst *Hymenoptera*.—F. V. T.]

We need only observe the following characters in considering the anatomy of insects :—

The EPIDERMIS consists of the chitinous cuticle, which is separate from the cellular layer beneath (hypodermis); the various appendages are supported by the chitinous layer.

The INTESTINAL CANAL usually consists of the anterior, median and terminal intestine, and as a rule passes straight through the body; salivary glands discharge into the anterior part, and, in some cases, yield a stiffening secretion which serves for spinning webs; numerous or scanty hepatic tubes are appended to the median intestine, while on the border between the median and terminal intestine open four to six long tubes (vasa malpighiana), which act as urinary organs. Finally the end portion of the intestine carries various glands (anal and rectal glands, etc.).

The CENTRAL NERVOUS SYSTEM agrees in structure with that of the Annelids, but is more highly developed. The pharyngeal ring surrounds the front part of the intestine; the sensory nerves originate from its SUPERIOR PHARYNGEAL GANGLIA and are the seat of the higher psychical functions; the INFERIOR PHARYNGEAL GANGLIA govern the mouth parts, and in addition appear to regulate the movements (cerebellum) of the vertebrates.

The chain of GANGLIA lying on the ventral side of the abdomen consists primitively of pairs of ganglia corresponding with the twelve segments, which are connected by longitudinal and transverse commissures. But many changes in the ganglia may be seen in insects caused by partial or entire amalgamation of single ganglia, so that in a few cases only one abdominal ganglion is present. In conclusion, a definite INTESTINAL NERVOUS SYSTEM is always present.

Of the organs of sense the FACETTED EYES, situated at the sides of the head, deserve special mention, as do also the ORGANS OF TOUCH and SMELL, situated on the antennæ, and the ORGANS OF HEARING and taste, or finer sensations, situated at the mouth and in the buccal cavity.

The sounds emitted by insects are, as a rule, produced by the friction or beating of certain chitinous parts, but sounds are also produced in breathing (flies).

The ORGANS OF RESPIRATION, the so-called tracheæ, are highly developed; there are openings (stigmata) at the sides of the body which draw in air by means of the active participation of the muscles of the body. The number of stigmata varies between two and ten pairs; the tracheæ themselves branch off from the trunks in the most varied manner, and carry air to the internal organs.

The colourless BLOOD circulates between the tissues and organs, and is kept circulating by the contraction of a chambered dorsal vessel provided with ostia, and which terminates in a short aorta opening at the anterior end.

Insects are SEXUALLY DISTINCT; their sexual glands are in pairs and have a tubular structure, but the testicular tubules are united together by a capsule into an oval testicle; exceptionally, also, the excretory canals are double, as also the sexual orifices; usually the paired canals unite into a single oviduct or spermatic duct which terminates at the posterior end of the body after receiving the products of various glands.

As to the HISTORY OF THE DEVELOPMENT of insects, all that is necessary to mention here is that the young hatched from eggs only exceptionally (as in *Apterygota*) resemble the adult parent (insecta ametabola); as a rule they differ from them not only in the shape of the body, but also more or less by their manner of life, and only attain the form of the parent through METAMORPHOSIS. This is a gradual process (insecta hemimetabola) in the *Rhynchota* and *Orthoptera*, or a sudden one with a stage of inanition (insecta metabola) in the other orders. This stage of rest or inanition, the PUPA, concludes the larval life (caterpillar, maggot, etc.) ; during the pupal stage no nourishment at all is taken, but the internal organs undergo changes ; in some forms the rest is not absolute, as voluntary local movements may take place (pupæ of gnats).

The insects are divided into numerous orders according to the form of the mouth parts, the structure of the wings, as well as the manner of the development ; with the exception of the lowest group (*Apterygota*), which is most nearly related to the ancestors of the insects, and which has no wings and undergoes no metamorphosis, all the remaining orders, which are termed *Pterygota*, have wings on the thorax, though there are, of course, a few species and families of this group which have lost their wings.

The *Pterygota* include—

(1) *Orthoptera.*—Biting mouth parts, anterior wings leathery, posterior wings thin, folded longitudinally ; metamorphosis incomplete (grasshoppers, crickets, cockroaches).

(2) *Pseudoneuroptera.*—Biting mouth parts, wings of equal size, thin, not folded up (dragon-flies, hair and feather lice, termites).

(3) *Rhynchota* or *Hemiptera.*—Mouth parts formed for puncturing and sucking ; wings alike, or the anterior wings may be thickened, parchment-like at their base (plant lice, cicadæ, bugs and true lice).

(4) *Neuroptera.*—Biting mouth parts ; wings alike, thin ; metamorphosis complete (ant-lions, lace-wing flies, etc.).

(5) *Trichoptera.*—Licking mouth parts ; anterior wings narrow, posterior wings longitudinally folded, both ornamented with little hairs ; the larvæ are worm-like in form, live in water, and breathe through tracheal gills (may flies, etc.).

(6) *Lepidoptera.*—Suctorial mouth parts ; wings covered with scales (butterflies).

(7) *Coleoptera.*—Biting mouth parts ; anterior wings thickened and differ in colour, appearance and function from the thin, folded posterior wings (beetles).

(8) *Hymenoptera.*—Mouth parts for licking and biting ; the wings alike, membranous (ichneumon flies, ants, wasps, bees, humble bees).

(9) *Diptera.*—Mouth parts formed for puncturing, sucking or licking ; posterior wings degenerated (gnats, flies, gadflies, fleas).

(10) *Strepsiptera.*—Anterior wings shortened ; the female without wings and living parasitically (fan-wings).

The parasites of man occur amongst the *Rhynchota*, *Coleoptera*, and amongst the *Diptera*.

[The most usual and recent classification of the *Hexapoda* is the following :—

(1) *Aptera.*—Wingless insects ; scarcely any metamorphosis.

(2) *Neuroptera.*—Four membranous wings, frequently with much network ; the front pair not much, if at all, harder than the under pair ; the latter with but little or no fan-like action in closing ; mandibulate ; metamorphosis variable, but rarely complete.

(3) *Orthoptera.*—Four wings ; front pair coriaceous or leather-like, usually smaller than the other pair, which are of more delicate texture and contract in repose like a fan ; mandibulate ; metamorphosis complete.

(4) *Thysanoptera.*—Four very narrow fringed wings ; mouth imperfectly suctorial ; metamorphosis slight.

(5) *Hemiptera.*—Four wings ; the front pair either all transparent or with the basal half leathery; mouth suctorial; metamorphosis slight.

(6) *Diptera.*—Two membranous wings only; mouth suctorial, very varied; metamorphosis complete.
(7) *Lepidoptera.*—Four large wings covered with scales; mouth suctorial, metamorphosis great.
(8) *Hymenoptera.*—Four membranous wings; front pair larger than hind, which do not fold up in repose; mandibulate, sometimes with a tubular proboscis; metamorphosis complete.
(9) *Coleoptera.*—Four wings, the front pair hard and horny (elytra), meeting in a line over the back and covering the delicate hind pair; mandibulate; metamorphosis complete.

[There are two other well-known arrangements, namely, Packard's and Brauer's, of recent date, but the one given here, which is based on Linnæus' grouping by Dr. Sharp, is by far the simplest.—F. V. T.]

Order. **Rhyncota.**[1]

The lower lip forms a long thin tube that can be turned back (rostrum), and within which lie the setaceous mandibles and maxillæ; the first thoracic segment is not united with the two posterior ones; the anterior wings are usually leathery as far as the centre.

(*a*) RHYNCOTA APTERA PARASITICA.

Family. **Pediculidæ** (Lice).

The lower lip is transformed into a projecting rostrum provided with barbed hooklets in which the hollow extensile sucker (maxillæ and mandibles) is situated; no wings; no metamorphosis; only simple eyes; the antennæ are five-jointed, the feet possess hook-like terminal structures; the barrel-shaped eggs (nits) are deposited on the hair of the host.

[The lice or *Pediculidæ* are also known as *Anoplura* and *Siphunculata*.

[They have been split up into a number of families and sub-families and a number of genera, but as far as this work is concerned it is best to retain the single family *Pediculidæ*.

[Only the three species mentioned here are common parasites of man, but now and then horse and cattle and sheep lice, *Hæmatopinus*, may cause transitory annoyance.—F. V. T.]

Genus. **Pediculus,** Linnæus.

Pediculus capitis, de Geer, 1778.

Male 1 to 1·5 mm. in length, female 1·8 to 2·0 mm. in length. The colour varies from light grey to black according to the colour of the hair of the human race upon which they are parasitic. The abdomen has eight segments, of which the six central ones are

[1] [Usually known as *Hemiptera*. There are two sub-orders, *Heteroptera* and *Homoptera*. The former have the base of the front wings coriaceous; the latter have all four wings membranous. The *Homoptera* are Aphides or plant lice and scale insects (*Coccidæ*), none of which attack man. Recently an interesting case has been reported to me where certain Aphides had been passed in human urine. One species was *Rhopalosiphum dianthi*, the other found in the urine was the hop aphis (*Phorodon humuli*). I cannot believe, however, that they had been actually passed, in spite of the case being reported by a medical man.—F. V. T.]

each provided with a pair of stigmata. The thorax is as broad as the abdomen. Eggs 0·6 mm. in length; about fifty are deposited by a female head louse. The young can propagate when eighteen days old.

The head louse lives especially in the hairy parts of the head of human beings; more rarely it is found on other hairy parts of the body. It is spread over the entire surface of the globe, and was present in America before the arrival of Europeans. Quite exceptionally it is said that it bores itself deep into the epidermis and can live in ulcers.

FIG. 374.—Mouth parts of *Pediculus vestimenti*. Enlarged. (After Denny.)

[The eggs are pear-shaped and are attached to the hairs near the roots by means of a clasping collar. They hatch in about seven days. The young are like the adults and mature in a month. Its general colour varies with that of its host. In West Africans nearly black, in Hindoos dark and smoky, on Chinese and Japanese yellow, on Hottentots orange, on South American Indians dark brown (Murray).—F. V. T.]

FIG. 375.—Ovum of the head louse. 70/1.

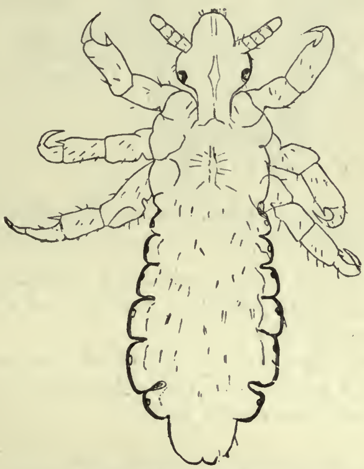


FIG. 376.—Head louse, male. 15/1.

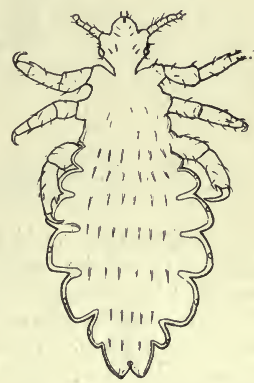


FIG. 377.—*Pediculus vestimenti*, Burm.: adult female. 15/1.

Pediculus vestimenti, Nitzsch, 1818.

The head in front is somewhat rounded. Antennæ longer than in the head louse; 2 to 3·5 to 4 mm. in length; whitish-grey; the abdomen is broader than the thorax; stigmata as in *P. capitis*. Eggs 0·7 to 0·9 mm. in length; about seventy are deposited.

P. vestimenti lives on the neck, throat and trunk of persons, and the clothing next the body, in which also the eggs are deposited. The louse of so-called pedicular disease (*P. tabescentium*) is, according to Landois' researches, only the usual *P. vestimenti;* moreover, many cases of phthiriasis are attributable to mites or fly maggots.

[This parasite has often been a great pest amongst soldiers during long campaigns, especially amongst the Russians during the Crimean War. *Vide* also notes in Addenda (p. 615) under "Body, Head and Clothes Lice."—F. V. T.]

Genus. **Phthirius**, Leach.

Phthirius inguinalis, Redi, 1668.

Syn. : *Pediculus pubis*, L.

Male 0·8 to 1·0 mm. in length ; female 1·12 mm. in length ; colour greyish-white ; form subquadrate ; the two posterior pairs of legs are strong ; the abdomen has nine segments and six pairs of stigmata ; and still another pair of stigmata is situated between the two anterior limbs. Eggs pear-shaped, 0·8 to 0·9 mm. in length, 0·4 to 0·5 mm. in breadth, and are deposited in rows of about ten on the hairs.

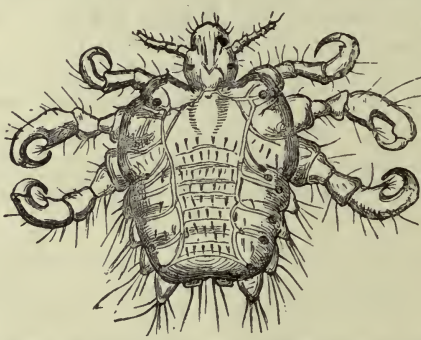


FIG. 378.—*Phthirius inguinalis*, Leach : they are distinguished by the larger tracheal trunks originating from the stigmata. Enlarged.

Pediculus pubis, which is found almost exclusively in the Caucasian race, lives on hairy parts of the body, but hardly ever on the skin of the head ; the pubic region is its favourite place of abode.

[This species reproduces more rapidly than other lice, and is communicated much more freely. The eggs are often laid singly attached to the hairs near their apex. It is known as the "crab louse."—F. V. T.]

(*b*) RHYNCOTA HEMIPTERA.

Family. **Acanthiadæ.**

Body flattened, antennæ four-jointed, rostrum three-jointed, wings atrophied.

[This family, the *Cimicidæ*, includes the bed bugs ; the proboscis, which lies in a groove, is of three segments ; the front wings are shown by two small elytra, there is no trace of hind wings. Two species are known commonly to attack man.—F. V. T.]

Genus. **Cimex**, Linnæus.

Cimex lectularius, Linnæus.

Syn. : *Acanthia lectularia*, Fabricius, 1794.

It measures 4 to 5 mm. in length, 3 mm. in breadth ; brownish-red ; eight abdominal segments. The female deposits fifty whitish eggs at a time (1·12 mm. in length) three or four times a year ; the entire development up to complete maturity takes about eleven months. [They will breed all the year round, but less so in cold weather.—F. V. T.]

The bed bugs live in the cracks and fissures of human habitations, under carpets, behind pictures, in furniture, bedsteads, etc. ; hidden during the day, they attack persons at night to suck their blood. The alkaline secretion of the salivary glands dropped into the wound around the separate bites causes the so-called "wheals."

The bed bugs were known in bygone days by the Greeks (*κάριο*) and the Romans (cimex). They were first mentioned from Strasburg in the eleventh century, and in England about 1500.

[This is the common bed bug of northern latitudes and must not be confused with the tropical bed bug (*C. rotundatus*). The bed bug can migrate from one house to another; this especially takes place when a house is uninhabited. They escape from windows and pass along walls, water-pipes and gutters, and so reach adjoining houses. This noxious pest accompanies man wherever he goes ; ships and trains become infested, especially the former.

[A characteristic feature in this animal is the peculiar odour it produces, like many others in the same group of insects. This odour comes from a clear, oily volatile liquid secreted by glands in various parts of the body. Although he normal food is man's blood, the bed bug can subsist upon moist wood, dust and dirt that collects in crevices in floors, walls, furniture, etc. The puncturing mouth consists of

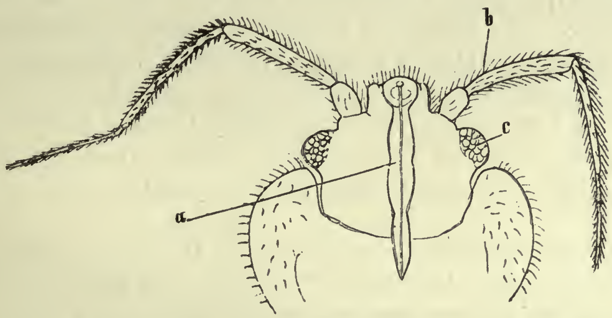


FIG. 379.—Head of the bed bug from the ventral surface. *a*, the rostrum ; *b*, the antenna ; and *c*, the eye. 70/1.

a fleshy under lip, within which lie four thread-like hard filaments which pierce the flesh, the blood being drawn up through the beak.

[The eggs are oval, white, with a projecting rim around one end, with a lid which is pushed off when the young hatch ; they are laid in cracks and crevices in batches of from twelve to fifty. The egg stage lasts from seven to ten days. The larval stage so gradually passes into the adult that one scarcely notices the change; during its growth the skin is cast five times, and at the change the little wing-pads are seen, showing that the adult stage is reached. The young larva is at first pale yellowish-white. It resembles the parent, but has no trace of elytra. Although eleven weeks is said to be necessary for their development, the stages may be gone through much more rapidly ; Howard and Marlatt[1] give seven weeks in some instances. It seems pretty certain that these Cimex only take one meal of blood between each moult and another preceding egg laying.—F. V. T.]

[1] "Household Insects," Howard and Marlatt, *Bull.* 4 (N.S.), U.S. Dept. Agric., 1896, p. 37.

Cimex rotundatus, Signoret, 1852.

[This bug is common in warm climates; it is an abundant insect in India, and King has found it in the Sudan, where *C. lectularius* is, however, the common species. It is usually known as the tropical bed bug. Signoret's bug can be told from the other common species by the shape of the pronotum. In *C. rotundatus* it is uniformly convex, whilst in *C. lectularius* the lateral edges are flat and sometimes even concave. The abdomen of *rotundatus* is also rather more elongate.

[This species is of considerable importance, as according to Patton it may act partly as the intermediary host of the piroplasma of kala-azar.

[Wenyon found at Bagdad that *Cimex* sp. would take up Leishmania from Oriental sore, and that the parasite developed into flagellate form. Patton came to the conclusion that the bed bug transmitted Oriental sore in Cambay, India, but Wenyon contests this view (*vide Journ. Lond. School Trop. Med.*, 1912, ii, pt. 1, pp. 13-26). Franchini (*Bull. Soc. Path. exot.*, 1912, v, No. 10, pp. 817-819) was unable to connect Cimex with this disease. At present nothing seems proved. Besides their possible connection with kala-azar, it has been shown by Howard and Clark (*Journ. Exp. Med.*, 1912, xvi, No. 6, pp. 850-859) that they can carry the virus of poliomyelitis.

[This bed bug was originally described from the Island of Réunion in 1852 by Signoret. A similar insect was described from Burma by Fieber, in 1861, as *C. macrocephalus*. This is the same as Signoret's species.

[The distribution given by Patton[1] is as follows: India, Burma, Assam, Malay, Aden, Islands of Mauritius and Réunion. Patton in this paper refers to an erroneous statement made in a recent edition of this book (the last English edition). As I have personally kept *lectularius* in moist dirt, wood and refuse for over two years, the statement as far as I am concerned is not erroneous. Moreover, since his doubting this fact the same experiment has been twice repeated with the same results. What they did and do persist on I cannot say.—F. V. T.]

Cimex columbarius, Jenyns.

[This is common in parts of Europe in pigeon nests, and also amongst poultry (*vide Report Econ. Zool.* for year ending September 30, 1913, pp. 142-144, Theobald). It occurs in Britain on the latter and will attack man. I have personally been badly bitten whilst collecting them. It is rounder and has shorter antennæ than

---

[1] *Indian Med. Gaz.*, February, 1907, xlii, No. 2.

C. lectularius. Jenyns also described a more pubescent species from swallows as *C. hirundinis.* I have recently received an account of the swallow bug invading a house in Kent and causing much annoyance. —F. V. T.]

Cimex ciliatus, Eversmann, 1841.

3·3 mm. in length, yellowish-red, thickly covered with hair; indigenous in Russia (Kasan).

[From a single specimen seen it is evidently distinct.—F. V. T.]

Family. **Reduviidæ.**

Head long, narrowed behind into a neck; eyes large, prominent; rostrum thick and curved; antennæ moderately long, slender at the tip; legs long and stiff; carnivorous.

Amongst the *Reduviidæ* one genus is of particular importance, namely the genus Conorhinus, which has a long head and the first segment of the beak very much shorter than the second, and the posterior tibiæ longer than the femora.

These large bugs have a wide distribution, the Oriental region, North and South America, and the West Indies, Madagascar and West and Central Africa.

These large bugs may cause very nasty wounds by their bites, but beyond that it has recently been shown that one interposes in the life-cycle of a trypanosome, namely—

Genus. **Conorhinus**, Lap.

Conorhinus megistus, Burm.

This large bug has recently been shown by Chagas to be the agent in the development of the trypanosome (*T. cruzii*) which is the cause of the well-known disease in many parts of Brazil called *Barbeiro* (Barbier). This insect is about 1 in. long, black, with four red spots on the pronotum, and six red lateral lines on the abdomen, black legs, head and beak. The insect is figured in a coloured plate (No. 9) in *Mem. Inst. Oswaldo Cruz*, 1909, i, fasc. 2, pp. 158-218.

A further account is given by Neiva.[1]

Conorhinus sanguisuga, Lec. (Blood-sucking Cone-nose).

This bug is also known as the Texas or Mexican bed bug, also as the big bed bug. It is particularly troublesome in the Mississippi Valley in bedrooms. The bite is very severe and results in more pronounced swelling and inflammation than that of the Cimex.

[1] *Mem. Inst. Oswaldo Cruz*, 1910, 2, fasc. 2, pp. 206-212.

Normally this genus feeds upon the blood of mammals and insects. Its fondness for human blood appears to be quite a new habit, and appears limited to the mature insect only. It is nearly an inch long, flat, head very narrow and long, the rostrum short and thick. In colour it is dark brown with pink markings. They are fully winged when adult, and they fly with ease, entering houses on the wing, especially being attracted by lights in windows; they also run swiftly. Like the bed bug they conceal themselves during the day and come out at night and bite the sleeper. The effect of the bite is very varied, but as a rule a sore, itching wound, accompanied by burning pain and swellings, which may extend over a good deal of the body, occur. A specific poison is undoubtedly injected into the puncture; but no doubt serious results are also due to the beak being contaminated through the insects feeding upon foul carrion. Mr. Lembert, when bitten by a *Conorhinus* sp. (?) on the Pacific slope, exhibited the following symptoms: an itching sensation extending up the leg, large blotches manifesting themselves on the upper part of the limb and extending up to the hands and arms; his lips swelled and the itching and swelling extended over the head; there was also much nausea. Similar results are recorded from other regions.[1]

The eggs of the *C. sanguisuga* are at first white, then become yellow, then pink; the young hatch in twenty days. There are two larval and two pupal stages, the latter showing wing-pads. The eggs are laid and the young feed out of doors, chiefly upon insects. It is particularly abundant in April and May indoors.

Conorhinus, *sp. novum* (Monster Bug).

Another species; acts in a very similar way in California, the bite being very poisonous.

Conorhinus rubrofasciatus, de Geer[2] (Malay Bug).

This large bug attacks man in Malaysia and elsewhere. It is recorded as inflicting "a very nasty sting, which is done by the huge proboscis." Acute pain and inflammation follow in a few minutes. In one case the whole leg became swollen. This species occurs over the whole Oriental region, in Madagascar and Sierra Leone. It is dark brown in colour with dusky yellow or brick-red markings on the pronotum and elytra. Donovan suggests that it may be connected with the kala-azar piroplasma.

---

[1] "Household Insects," p. 42.

[2] [*First Report Econ. Zool.*, 1903, p. 130.—F. V. T.]

Conorhinus renggeri, Herr-Schäff (Great Black Bug of Pampas).

This large black bug is mentioned by Darwin,[1] who states as follows: "At night I experienced an attack (for it deserves no less a name) of the benchuca, a species of Reduvius, the great black bug of the Pampas. It is most disgusting to feel soft wingless insects, about an inch long, crawling over one's body. Before sucking they are quite thin, but afterwards they become round and bloated with blood, and in this state are easily crushed. One which I caught at Iquique (for they are found in Chili and Peru) was very empty. When placed on a table, and though surrounded by people, if a finger was presented the bold insect would immediately protrude its sucker, make a charge and, if allowed, draw blood. No pain was caused by the wound. It was curious to watch its body during the action of sucking, as in less than ten minutes it changed from being flat as a wafer to a globular form. This one feast, for which the benchuca was indebted to one of the officers, kept it fat during four whole months, but after the first fortnight it was quite ready to have another suck." Mr. Kirby[2] also refers to this species.

Conorhinus variegatus (Variegated Cone-nose).

Occurs in Florida in houses, and chases bugs (Cimex) and flies; not definitely known to bite man.

Conorhinus nigrovarius.

This species occurs in South America. It is one of the forms known as bichuque. Its bite makes a troublesome swelling.

Conorhinus protractus

also attacks man in Utah.[3] It has been called the "big bed bug."

Genus. Reduvius, etc.

Reduvius personatus, Linné.

Syn.: *Reduvius personatus*, Leconte, 1855[4]

European, but also found in the United States. The bite causes intense pain. It bites when caught or handled, but does not seem to do so voluntarily. Swelling and irritation result which may last a week, and may even cause death.[4] In 1899 it was very abundant

[1] Charles Darwin, "A Naturalist's Voyage" (Voyage of the *Beagle*), 1888, p. 330.
[2] "Text-book of Entomology," 1885, p. 205.
[3] "The Big Bed Bug of the Far West," *Bull.* 18 (N.S.), *U.S. Dept. Agric.*, 1898, p. 101.
[4] "Insects to which the name 'Kissing-bug' became applied during the summer of 1899," *Bull.* 22 (N.S.), *U.S. Dept. Agric.*, 1900, p. 24.

at Washington and elsewhere; other species occurred, and so no definite opinion existed as to the actual biter, but some people took *R. personatus* actually biting. It was first described as a parasite of man in America by Walsh and Riley.[1]

A popular name for this bug is the wheel or masked bug—a black insect, three-fourths of an inch long. The larva of this bug is carnivorous and covers its body with dust so as to conceal itself from its prey. The adult is active on the wing.

Coriscus subcoleoptratus, Kirby, 1837.

Syn.: *Nabicula subcoleoptrata*, Kirby, 1837; *Nabis subcoleoptratus*, Reuter, 1872; *Coriscus subcoleoptratus*, Stål, 1873.

Northern United States. Howard was bitten by one between the fingers—the pain was intense, like a needle prick, but the swelling was small. No other case known.

Rasahus biguttatus, Say, 1831.

Syn.: *Pirates biguttatus*, Stål, 1862; *Callisphodrus biguttatus*, Stål, 1866; *Rasahus biguttatus*, Stål, 1872.

Common in southern United States, and found in Cuba, Panama and Pará, etc. Known as the two-spotted corsair on account of the great spot on the hemielytra. Frequently found in houses, where it chases the bed bug. It also bites man frequently. From 1869 Walsh and Riley placed it amongst the parasites of man. In the United States Davidson[3] is of opinion that all cases attributed to spider bites are due to this insect.

Melanolestes morio, Erichson, 1848 (Non-walker).

Syn.: *Pirates morio*, Erichson, 1848; *Melanolestes morio*, Stål, 1866; *Pirates picipes*, Herrich-Schäffer, 1848; *Melanolestes picipes*, Howard, 1900.

Guiana and Mexico and eastern and southern United States. Length 20 mm., hides under stones and logs during daylight, and flies at night. Attracted by lights into houses. Very abundant in 1899 at Washington. Howard cites cases where it was proved to bite man.

Melanolestes abdominalis, Herrich-Schäffer, 1848.

Syn.: *Pirates abdominalis*, Herrich-Schäffer; *Melanolestes abdominalis*, Uhler, 1875.

Allied to the former; some say similar, but can be told by the shorter wings on the female. It occurs in the same localities as *M. morio*.

---

[1] *American Entomologist*, 1869, i, pp. 84-88.

[2] R. Blanchard, "Sur la Piqûre de quelques Hémiptères," *Arch. de Par.*, 1902, p. 145.

[3] "So-called Spider-bites and their Treatment," *Therap. Gaz.*, February 19, 1875.

Phonergates bicoloripes.

This reduvid attacks man in Africa.

Family. Aradidæ.

Broad and very flat bugs, with antennæ of four segments and the beak of three; scutellum short, no cuneus to elytra and the tarsi of two segments. They normally live under the bark of trees, etc., and are found in most parts of the world.

Dysodius lunatus, Fabr. (Pito Bug).

A large species which is found in South America, frequenting houses, and bites very severely.

The Ochindundu.

The bug is described by Wellman (*Journ. Trop. Med.*, April 2, 1906, p. 97) as not only feeding on ticks, such as *Ornithodorus moubata*, but as also attacking man. It is called by the Angola Bantus the ochindundu. It is black in colour; the first two pairs of legs are of a bright red hue. It has curious paddle-like structures on the front four legs, which seem to be designed for securely holding the ticks. It infects native kraals for the sake of preying on ticks. The natives also state that it inflicts a bite which far exceeds in painfulness that of the tick. They compare the bite with that of a poisonous snake.

Family. Lygæidæ.

Scutellum short; antennæ four-jointed; ocelli present; membranous part of hemielytra with never more than five nervures. Nearly all vegetable feeders. A few are recorded here as biting man.

Lyctocoris campestris, Fabricius.

Syn.: *Acanthia campestris*, Fabr. (*Lyctocoris domesticus*).

Rare in habitations, lives on human blood. Found by Blanchard in a bed at an hotel at Liverpool. The bite is undoubtedly worse than that of Cimex; cosmopolitan. In colour it is ferruginous, shining, legs testaceous; hemielytra slightly shorter and narrower than the abdomen; membranous portion transparent, the apex broadly fuscous. Length 3·8 to 4·8 mm.

Rhodinus prolixus, Stål, 1859.

Sometimes attacks man, and the bite is very painful. It is 25 mm. long and 8 mm. broad, and occurs in Colombia. It is found also in Cayenne and Venezuela. This like other species is known in South America as bichuque or benchuca.

[A few other unimportant species are also recorded as biting man, such as *Harpactor cruentas*, in the South of France; *Eulyes amœna*, from Borneo and Java; *Arilus carinatus*, Forster, from Brazil. The latter appears to be the same as the *Acanthia serratus*, Fabricius.—F. V. T.]

Order. **Orthoptera.**

[The only *Orthoptera* recorded as doing actual harm to man are certain wingless locusts found in Africa. The cysticercus stage of a small tapeworm found in rats and man has been found in an earwig (Alcock).

[The strange *Hemimeridæ* found in West Africa, resembling wingless cockroaches, are parasitic on rats (*Cricetomys*). *Phasmidæ*, or stick insects, are said to be able to eject a fluid which may cause blindness if it comes in contact with the eyes.

Locusts Injurious to Man.

[A wingless locust—*Enyaliopsis durandi*, Luc—is recorded by Wiggins[1] as injurious to man in Uganda. "The bite of this insect," it is said, "gives rise to a very nasty eruption, which may extend over the whole body, with high temperature and general malaise. The skin at the site of the bite sloughs away, and generally leaves a large deep cavity, which heals very slowly."

[An allied species—*E. petersi*, Schaum—emits a clear yellow fluid, but according to Marshall this does no harm.[2] Stannus writes that "for some years I have been cognizant of the fact that among the natives of Nyasaland an allied if not the same species is held to cause skin lesions by the emission of a fluid on the bare skin surface of the body. I have seen cases of ulcers on various parts of the body, for which the 'nantundua' was assigned as the cause." He then describes the destruction of the superficial layers of the skin which he observed after the yellow fluid had been on the skin twelve hours.—F. V. T.]

Order. **Coleoptera.**

The larvæ of beetles, similarly to those of some other *Arthropoda* (myriapods and the larvæ of gnats), have sometimes been observed in man as purely accidental guests. In one case or another, such accounts may have originated through a mistake of the observer. Thus English doctors report the presence of the larvæ of *Blaps mortisaga* in the stools of human beings, Sandberg of the larva of *Agrypnus murinus* in his ten year old son, and Blanchard mentions the larva of a beetle that was vomited by a child. All these cases, however, do not represent actual parasitism, although there are beetles living parasitically.[3]

Silvanus surinamensis, Linnæus (Saw-toothed Grain Beetle).

[Taschenberg records this beetle as having invaded some sleeping apartments adjoining a brewery where stores were kept, and annoying the sleepers at night by nipping them when in their beds.

---

[1] *Bull. Ent. Res.*, 1910, i, pt. 3, p. 227.

[2] *Ibid.*, 1911, ii, pt. 2, p. 180.

[3] [Dr. Daniels has sent me a small coleopterous larva found in an abscess on a man in British Guiana.—F. V. T.]

[This beetle is common in many parts of the world amongst groceries, corn, meal, seeds, dried fruits, etc. It is about $\frac{1}{10}$ in. long, much flattened and chocolate-brown in colour. The thorax has two shallow grooves and bears six minute teeth on each side. The jaws are strong, but the bite cannot be very serious.—F. V. T.]

Order. **Diptera** or **Siphonaptera.**

Aphaniptera (Fleas).

Wingless, the thoracic rings distinct and free ; antennæ of three segments ; legs very powerful ; abdomen with nine segments. [Ten segments are present, but only nine are visible.—F. V. T.] The mandibles transformed into serrated puncturing organs, which are situated in the split sheath of the rostrum ; the maxillæ are laminated and have palpi, and more or less conceal the other parts.

The importance of fleas lies mainly in the fact that they act as plague carriers. About 150 species have already been described. The only ones of importance for this work are those found on man and those on rats and mice. The two families in which these are found are known as *Pulicidæ* and *Sarcopsyllidæ*.

The eggs of fleas are laid on the ground, on rugs, etc., and in birds' and rodents' nests. They hatch rapidly in warm weather and in warm climates, varying from two to five days ; in cold countries they may take two or three weeks to incubate.

The larva is a footless creature, pearly white in colour, the head sometimes being darkened, composed of fourteen segments including the head, and although apodal can move with considerable agility. It lives amongst dust and dirt, and feeds upon any organic matter it can find. In about two weeks it is said to become mature, and then spins a cocoon in which pupation takes place.

The cocoons of the common human flea and the fowl flea become covered with dust and dirt. The period of pupal life seems varied, for I have had the fowl flea hatch out in ten days, and others in three weeks at the same time of year.

The adults are a blood suckers and cause considerable irritation as well as acting as disease carriers, and in the *Sarcopsyllidæ* the females attach themselves permanently to their hosts, embedding themselves under the skin, where they become pregnant. Some kinds harbour the cystic stage of tapeworms, and the rat trypanosome passes certain stages in the rat flea. Most fleas have definite hosts, but some, like the rat and fowl fleas, attack man.

The fleas which can carry the bacillus of plague are *Xenopsylla cheopis*, *Pulex irritans*, *Ceratophyllus fasciatus* and *Hoplopsyllus anomalus*.

The two families, *Pulicidæ* and *Sarcopsyllidæ*, can be distinguished as follows :

Thoracic segments much foreshortened, coxæ and femora of hind legs very slightly enlarged ... ... *Sarcopsyllidæ*.
Thoracic segments normal, coxæ and femora of all the legs much enlarged ... ... *Pulicidæ*.

Family. **Sarcopsyllidæ** (Jiggers).

The members of this family are not confined to one host.

Three genera are known and tabulate as follows :—

α. Hind coxa without a patch of spines on the inside.
  α¹. Hind femur simple ... ... 1. *Dermatophilus*.
  α². Hind femur with a large tooth-like projection near the base ... ... 2. *Hectopsylla*.
β. Hind coxa with a patch of short spines on the inside 3. *Echidnophaga*.

Genus. **Dermatophilus**, Guérin.

Dermatophilus cæcata, Enderl.

The eyes of the female vestigial. Taken on and behind the ears of *Mus rattus* in Brazil.

Dermatophilus penetrans, L., 1758 (Jigger, Chigoe).

Syn.: *Sarcopsylla penetrans.*

About 1 to 1·2 mm. in length; brown in colour. Eyes distinct. The males only occasionally visit man to bite; the fertilized female, on the other hand, bores into the skin with her head, particularly about the toes of the host, and then attains considerable dimensions. The eggs develop on the soil with a metamorphosis similar to that of the common flea.

FIG. 380.—*Dermatophilus penetrans:* young female. Highly magnified. (After Moniez.)

FIG. 381. — *Dermatophilus penetrans:* older female. Enlarged. (After Moniez.)

The sand flea (nigua) particularly infests Central and South America, and, in 1873, was carried by ships from Brazil to the West Coast of Africa. In a comparatively short time it has become disseminated throughout Africa and has also appeared in Madagascar; recently also it has been reported from China.

Besides attacking man, it also settles on mammals, for instance, on dogs, pigs, etc. According to Jullien the wound or little swelling caused by the female has no particular significance, as children infested with ten or eleven sand fleas quietly proceeded with their games. It will be understood, however, that the wound easily affords the opportunity for the setting up of inflammation or even septic processes, as is the case in any kind of wound.

[The jigger is also well known in the West Indies.—F. V. T.]

Genus. **Echidnophaga**, Olliff.

Four species found on rats, etc.

Echidnophaga gallinacea, Westwood (Chigoe of Fowls).

[This flea is a native of tropical Asia and Africa. It lives on the fowl chiefly, attacking the neck and around the eyes. Specimens were sent me from Texas, where they not only attack poultry but also children, the latter somewhat severely. It also occurs on cats, and is found on rats in Africa. It has been introduced into North America.

[Three other species are found on rats, *viz.*: *E. myrmecobii*, Rothsch., from Australia; *E. murina*, Tirah, from Southern Europe; and *E. liopus*, Rothsch., India and Western Australia.—F. V. T.]

Family. Pulicidæ (True Fleas).

ROTHSCHILD'S CLASSIFICATION is as follows:—

SECTION I.—Club of antennæ distinctly segmented only on the hind side.

Key to Genera.

a. No comb on head and thorax.
- *a*¹. The internal incrassation, which extends from the insertion of the mid coxa into the thorax, joins the anterior edge of the mesosternite ... ... *Pulex.*
- *b*¹. This incrassation joins the upper edge of the mesosternite *Xenopsylla.*

b. With a comb on the pronotum only ... ... *Hoplopsyllus.*

. With a comb on the pronotum and at the lower edge of the head ... ... *Ctenocephalus.*

SECTION II.—Club of antennæ distinctly segmented all round.

Key to Genera.

a. Eye developed.
- *a*¹. No comb on head.
  - *a*². Pygidium not projecting backwards; frons with tubercle ... ... *Ceratophyllus.*
  - *b*². Pygidium strongly convex, projecting backwards; frons without tubercle ... ... *Pygiopsylla.*
- *b*¹. Two spines at angle of genæ ... ... *Chiastopsylla.*

b. Eye vestigial or absent.
- *a*¹. Abdomen without comb.
  - *a*². Hind edge of tibiæ with about eight short and several long bristles, which do not form a comb.
    - *a*³. Fifth segment in fore and mid tarsi with five, and in hind tarsus with four bristles ... ... *Neopsylla.*
    - *b*³. Fifth segment in fore and mid tarsi with four, and in hind tarsus with three lateral bristles, there being an additional pair of bristles in all the tarsi on the ventral surface in between the first pair ... ... *Ctenophthalmus.*
  - *b*². Hind edge of tibiæ with about twelve short and three long bristles, the short ones forming a kind of comb *Ctenopsylla.*
- *b*¹. Abdomen with at least one comb ... ... *Hystricopsylla.*

Genus. Pulex, Linn.

Pulex irritans, L., 1758.

Male 2 to 2·5 mm. in length, females about 4 mm.; reddish or dark brown; head without bristles; thoracic and abdominal rings of bristles on the dorsal aspect, and small hairs directed backwards at he posterior margin. The barrel-shaped white eggs are deposited in cracks in the boards, sweepings, spittoons, etc.; they produce legless larvæ consisting of fourteen segments, which, after about eleven days, are transformed into pupæ; after another eleven days the flea emerges.

FIG. 382.—*Pulex irritans.* 14/1.

FIG. 383.—Larva of flea. Enlarged. (After Railliet.)

FIG. 384.—*Pulex serraticeps.* 22/1.

Fleas live in human dwellings all over the world, and periodically pass on to persons to suck their blood. They may deposit their eggs on very uncleanly individuals, and even undergo development, therefore it is possible to find larvæ and pupæ on such persons.

The dog flea, *Pulex serraticeps*, is easily distinguished from the flea of man by the large thick bristles on the posterior margin of the first thoracic ring (fig. 384).

Genus. **Xenopsylla**, Glink.

Xenopsylla cheopis, Rothschild.

This is the common rat flea of tropical countries. Rothschild[1] says: "Although practically cosmopolitan, it cannot apparently flourish in temperate and cold climates."

[1] *Bull. Ent. Res.*, 1911, i, pt. 2, p. 92.

In the male the bristles of the flap-like process of the clasper all slender; in the female the narrow portion of the receptaculum seminis long. Originally discovered in Egypt.

This is apparently the chief plague flea. The Indian Plague Committee have proved that this flea is easily infected when fed on plague rats, and that the bacillus multiplies rapidly in the flea's stomach and that the fleas may remain infective for fifteen days. How the flea infects man does not apparently seem to have been proved, as it does not do so through its bite, but the excrement is highly infective. It is probable that this poisoned fæcal matter gets to the wound caused by the piercing mouth.

Xenopsylla brasiliensis, Baker,

occurs on rats in West Africa and has been introduced into Brazil.

Genus. **Ctenocephalus**, Kolen.

Includes the cat and dog fleas. The dog flea, *C. canis*, Dugès, is found on the dog all over the world, but especially in temperate climates. It also occurs on rats. Man is often badly bitten by this insect and it overruns houses. The eggs are laid on rugs, carpets and dust and dirt and amongst dogs' hair, but are not fastened to it and fall anywhere. The ova may hatch in about fifty hours and the larvæ live for seven days and then spin their cocoons amongst dust and dirt. The pupal stage lasts about eight days.

The cat flea (*C. felis*) is widely distributed over the world, and occurs on many mammals beyond the cat, and is also found on rats.

Genus. **Hoplopsyllus**, Baker.

A genus found in North America related to Pulex, but at once recognized by the prothorax bearing a comb.

Hoplopsyllus anomalus, Baker,

which is found on the ground squirrel (*Citellus beecheyi*) in California, an daccording to Rothschild once found on the rat, has been proved to carry the plague bacillus and to play an important part in plague infection in California.

Genus. **Ceratophyllus**, Centis.

Ceratophyllus fasciatus, Bosc.

This flea is also found on the rat in Europe and will attack man. It is a plague carrier. It has eighteen to twenty teeth on the

---

[1] "Report United States Public Health, 1909," xxiv, No. 29.

prothoracic comb and no black spines on the head. The genus Ceratophyllus of Centis has a pronotal comb and three ante-pygidial chætæ on each side. Two other specimens recorded: *C. londiniensis*, Rothsch., and *C. anisus*, Rothsch. The former on rats and mice in London, the latter on *Felis* sp. from Japan and *Mus norvegicus* in California.

Genus. **Ctenopsylla**, Kolen.

This genus contains a very abundant rat and mouse species, *C. musculi*, Dugès, which is widely distributed over the globe.

Genus. **Hystrichopsylla**, Tasch.

Large hairy fleas, with no eyes and one or more combs on the abdomen. In the Mediterranean area one species, *H. tripectinata*, Tirah, is common on rats and mice, and also in the Azores. Several others occur on rats and mice. For information concerning these the reader is referred to Rothschild's papers.

Pulex pallipes is another species found on the rat and man.

Systematic, Anatomical, and Biological Remarks on Mosquitoes.

Mosquitoes come in the *Nematocera*, one of the sub-orders of the *Diptera*, and are divided into numerous families, of which, however, the *Culicidæ* are of most interest to us here. Other families as the *Psychodidæ* and *Chironomidæ* are also of considerable importance, *vide* following pages. The head is small, the facetted eyes are placed laterally, but there are no accessory eyes (ocelli). In front of the eyes are situated the comparatively long antennæ, the differences of which strongly mark the distinction of sex.[1]

The antennæ are composed of fifteen or sixteen segments. In the male they are covered with long whorl-like hairs, while in the female the antennal hairs are short—differences that are perceptible even with the naked eye.[2] The proboscis, which is longer than the antennæ, protrudes from the inferior aspect of the head and is composed of the following parts (figs. 387 and 388): Two grooved half tubes, facing one another, of which the upper one is the upper lip (labrum) and the lower one the lower lip (labium), which represents a pair of coalesced maxillæ. Within the tube formed by the labrum and labium are the mandibles and maxillæ, transformed into instruments for piercing, and a single puncturing organ, the hypopharynx. On the right and left, next to the proboscis, are placed the straight five-jointed palpi, the final joint of which is thickened in the male.[3] In biting, the labrum, which is swollen at its free end, is not introduced into the wound like the

[1] [This is by no means always the case; in the genera Deinocerites, Wyeomyia, Limatus, Theobald, and in Sabethes, Robineau Desvoidy, they are nearly the same in both sexes.—F. V. T.]

[2] [This is not always the case, *vide* previous note.—F. V. T.]

[3] [This is only so in Anophelina and in the genus Theobaldinella, Neveu-Lemaire, Grabhamia, Theobald, Acartomyia, Theobald, etc. In true Culex and many other genera the male palpi are pointed.—F. V. T.]

other mouth parts, but is bent backwards. The labium and hypopharynx push direct into the skin ; the maxillæ and mandibles, however, which are needle-like and serrated at the tips, penetrate with a saw-like movement. [The swollen free end of the labrum really means the *labellæ*, two articulated pieces, supposed by some to be the labial palpi. In most species the mandibles are not serrated at their ends.—F. V. T.] The saliva is introduced into the wound through the lumen of the

(*a*)  (*b*)

FIG. 385.—Head of a male (*a*) and of a female (*b*) Anopheles. Slightly enlarged. (After Giles.)

(*a*)  (*b*)

FIG. 386.—Head of a male (*a*) and of a female (*b*) Culex. (After Giles.)

hypopharynx, while the blood is sucked up by the mosquito in the groove of the labium.

The three thoracic segments are soldered together. The central one carries the membranous wings on the sides of the dorsal surface; the posterior somite carries the small halteres (rudimentary posterior wings). There are three pairs of long slender legs on the lower side.

The abdomen has no limbs, is composed of eight (rarely nine) distinct segments ; the sexual and anal orifices are at the posterior end, the stigmata on the sides. The intestinal canal (fig. 389) is composed of three principal divisions ; the anterior part reaches as far as the front pair of legs, and consists of the œsophagus, which

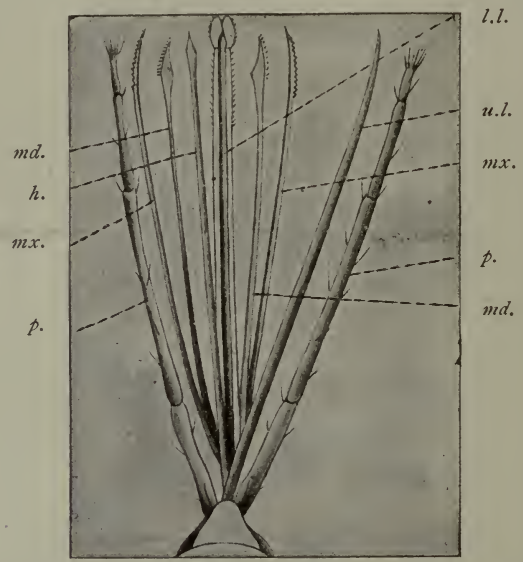


FIG. 387.—Mouth parts of *Anopheles claviger*.[1] *h.*, hypopharynx ; *md.*, mandible ; *mx.*, maxilla ; *u.l.*, upper lip ; *l.l.*, lower lip ; *p.*, palpi. (After Grassi.)

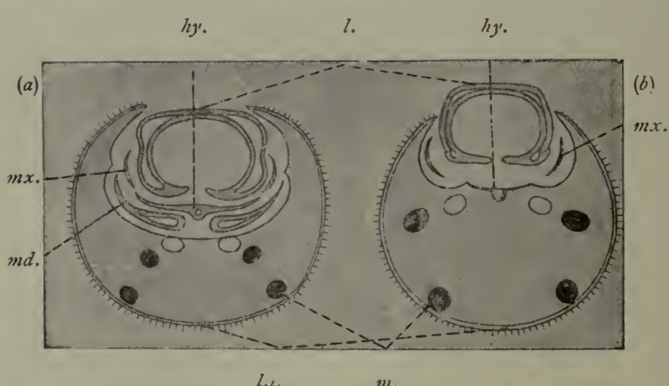


FIG. 388.—*Anopheles maculipennis* : transverse section through the proboscis of a female (*a*) and a male (*b*). *hy.*, hypopharynx, with duct of the salivary gland ; *m.*, muscles; *md.*, mandibles ; *mx.*, maxillæ ; *l.*, labium ; *l.l.*, labrum. (After Nuttall and Shipley.)

is provided with two small lateral diverticula. [At the commencement of the œsophagus are one or more diverticula, which vary in size ; they contain air, food

[1] [This should read *Anopheles maculipennis*, Meig. ; there was no type of *A. claviger*. —F. V. T.]

and bacteria.—F. V. T.] The mid gut reaches as far as the fifth and sixth abdominal ring; in front it is thin, and has numerous small supra-œsophageal ganglia; the posterior part is, however, more dilated. Four or five Malpighian tubes, the excretory organs, discharge at the place where the mid gut passes into the terminal gut.

The pair of salivary glands have one common excretory duct leading into the hypopharynx.

These glandular bodies are situated in the thorax ; each consists of three slightly serpentine tubules, the dorsal and ventral tubes being long, the central one shorter. The above-named characteristics apply to both genera Culex and Anopheles, but in the genus Culex is smaller, Anopheles larger. [In Anopheles the ends of the ducts in the lobules are dilated, whilst in most of the genera the ducts are the same size all along. The lobules may bifurcate, and in Psorophora there are five lobules.—F. V. T.] The legs of the genus Culex are about the same length as the whole body; in Anopheles they are double that length.[1] In Anopheles the palpi and proboscis are of equal length ; in Culex the condition is different, according to sex. In the male the palpi are longer than the proboscis ; in the female considerably shorter and the number of segments diminished. The venation of the wings exhibits furthur points of differentiation, as also their adornment, though this last sign is not by any means always conclusive; most species of the genus Culex have unspotted wings, whilst those of Anopheles are usually spotted. More important is the fact that in Culex the

FIG. 389.—Longitudinal section of an Anopheles, showing alimentary canal. In the forepart of the thorax is the salivary gland consisting of three tubules ; ventrally, the suctorial stomach extending into the abdominal cavity ; the stomach, and at the posterior end of the abdomen the Malpighian vessels. (After Grassi.)

abdomen is decorated with small scales, similar to those on butterflies, whereas there are small bristles on the abdomen of Anopheles. [This cannot be said to be a character by which an Anopheline may be told from a Culicine, for in such common Anopheline genera as Cellia and Neocellia we get plenty of scales on the abdomen.—F. V. T.] An experienced observer can, however, separate the two genera by the difference in size and their manner of resting. When settled they either touch the resting place with all the legs or only with the four anterior legs. In consequence of the different length of the legs, the body of Culex approaches the resting place more closely ; moreover, Culex holds the abdomen parallel or at an acute angle to the resting surface, whereas Anopheles carries the abdomen directed upwards (at an angle of about 145°) and holds the head down. Both genera, however, usually only rest on the four anterior legs, and then, as has long been known, Culex carries the third pair directed towards the dorsum, while those of Anopheles hang down.

In regard to the differentiation of the species, I must refer you to the special literature, and content myself by observing that about 150 species of Culex and about fifty species of Anopheles have been described, of which fifty about four are

[1] [This is certainly not always the case.—F. V. T.]

found in Europe. [The number of known Anophelines now is more—100 species—of other Culicidæ over 700.—F. V. T.] According to our present knowledge it appears that the entire genus Anopheles can transmit malaria to man; this observation has been confirmed in *Anopheles claviger*, Fabr.; *A. maculipennis*, Meig.; *A. bifurcatus*, L.; *A. superpictus*, Grassi; *A. pseudopictus*, Gr., all of which are found in Italy,[1] Germany, etc., as well as in the tropics. Moreover, in *A. costalis*, Loew; *A. funestus*, Giles (Africa); *A. quadrimaculatus*, Say (North America), and *A. rossii*, Giles; the latter is perhaps identical with *A. superpictus*, Gr., as well as with *A. culicifacies* (India). [*Anopheles maculipennis* and *A. claviger* are the same. Certainly neither *maculipennis* nor *bifurcatus* has been found in the tropics. *Anopheles quadrimaculatus*, Say, is the same as *A. maculipennis*. There is no

FIG. 390.—*Anopheles maculipennis*, Meigen. Enlarged. (After Grassi.)

evidence that *all* Anophelines carry malaria, but there is much to show that certain species only are capable of so doing. A list of known carriers is given later.—F. V. T.]

Everyone is aware that mosquitoes swarm at sunset in fine weather, and then seek out human beings and other warm-blooded animals to take food. In this regard, however, the sexes differ, for it is almost without exception that the females only suck blood, while the males subsist on the juices of plants (blossoms or fruits).[2]

[1] Compare Ficalbi, E., "Venti spec. di zanzare (*Culicidæ*) ital. . . .," *Bull. Soc. ent. ital.*, 1899, xxxi; abstracted in *Centralbl. f. Bakt., Par. u. Infektionsk.*, 1900, xxviii, p. 397.

[2] Both males and females may be kept alive in captivity for a long time if given fruits, or even only sugar and water.

After sucking, and when night has fallen, the mosquitoes find a place of refuge, for which purpose they utilize the grasses or foliage of trees and bushes, or inhabited or uninhabited rooms of houses, also cellars, stables, verandahs, etc., where they also pass the day.

[Some mosquitoes bite in the daytime—Stegoymia and some Anophelines; some bite right into the night, as *Culex fatigans* and *C. pipiens*.—F. V. T.]

The period required for digestion varies according to the temperature. It takes two days in summer, and may take up to ten days or more in cool weather. After digestion is complete more food is taken up, this being necessary [in some species only—F. V. T.] for the maturing of the sexual products in the female.

It is still unknown under what circumstances copulation takes place;[1] in any

FIG. 391.—Larva of *Anopheles maculipennis*, Fabr. Enlarged. (After Grassi.)

FIG. 392.—Larva of Culex. Enlarged. (After Grassi.)

case, sooner or later the females are fecundated, and when the ova have become mature, and the season is not too far advanced, they seek a suitable place in which to deposit them.[2] These are larger or smaller, permanent or temporary, collections of standing water, pools, puddles, lakes, pits, water in rain-water barrels, basins, etc. Nevertheless, certain kinds prefer certain waters; thus *Anopheles* (*claviger*) *maculipennis* and several of the Culices seek stagnant water overgrown with swamp vegetation and decomposing vegetable matter; *A. bifurcatus* and certain Culices, clear water with some vegetation (such as fountains and the lakes in gardens and parks); *Culex pipiens* has a preference for rain-water barrels, even though the water be dirty and evil-smelling. [I have found the larvæ of *Anopheles bifurcatus* living in great numbers in ponds and lakes completely overgrown with floating water-weeds, and those of *Culex pipiens* in liquid manure.

[1] The act of copulation in many species is now known. The female Culex has three receptaculæ seminalis, while the female Anopheles has one receptaculum seminis.

[2] It is certain that the females perish immediately after depositing the ova; but this does not always hold good, as a part of them survive for a few days. The males die soon after copulation.

Sexual Organs of the Mosquito.—The female has a pair of ovaries, opening into a single tube by the ovarian tubes; into the single tube opens a duct coming from the spermathecæ, and also a mucous gland. The spermathecæ store up the male cells. The male organs consist of two testes joined by ducts (vasa deferentia) to the ejaculatory duct formed by their union. Each vas deferens is joined by a short tube with the sac-like vesicula seminalis.—F. V. T.]

There is also a difference in the manner in which Culex and Anopheles deposit their ova. Culex deposits two to three hundred eggs in compact heaps that float on the water, and in which the eggs stand perpendicularly one next the other; whereas *Anopheles maculipennis* deposits only three or four up to twenty eggs, united in groups that float horizontally on the water; the eggs of *A. bifurcatus*, again, are arranged in star-like groups. The eggs are about 0·75 mm. in length, and assume a dark hue soon after being laid. The development only occupies a few days. The young larvæ grow rapidly, changing their integument several times;

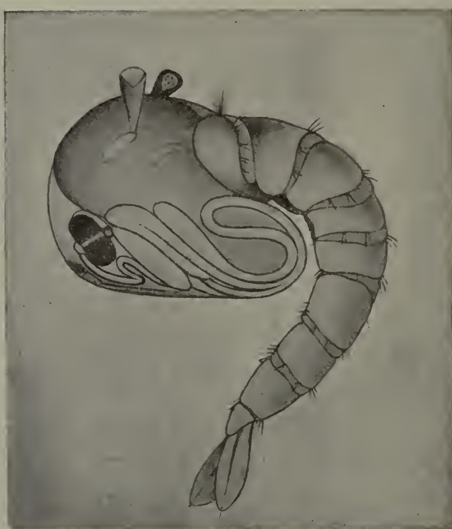


FIG. 393.—Pupa of *Anopheles maculipennis*, Meig. Enlarged. (After Grassi.)

the larvæ also differ in the various genera, though they have a general resemblance (figs. 391 and 392).

The long legless larva has a flattened head, a fairly broad, rectangular, or trapeziform thorax, on which there are bristles, and an abdomen distinctly segmented, and on the segments of which there are also lateral bristles. The situation of the stigmata marks the difference between the two genera. Though in both genera the stigmata are at the posterior end and on the dorsal surface, they are in Anopheles close to the surface of the body; in Culex, however, they are on the free end of a long tube (siphon).

The position of the larva in the water also differs. The larva of Anopheles lies almost horizontally beneath the surface of the water, the posterior border of the penultimate abdominal segment, upon which the stigmata are situated, being on the surface; whereas the larva of Culex hangs head downwards perpendicularly in the water, the point of the siphon only touching the surface.

In about a fortnight the larva is fully grown and becomes a pupa. The pupa (fig. 393), which moves in jerky movements, remains in the water, but partakes of no food. In shape it somewhat resembles a tadpole, that is to say, it consists of a bulky anterior portion, on the surface of which the head, with its appendages, is recognizable, and a more slender segmented abdomen. Above, on the thorax, there are two small trumpet-shaped breathing tubes for the conveyance of air to the tracheal system. After three or four days the perfect mosquito hatches out, remains a short time on the surface of the water until its chitinous integument is hardened, and then flies away.

The females that are fertilized in the autumn hibernate in sheltered spots in the open air, or in houses, cellars, under stairs, in stables, barns, etc., and are the progenitors of the first generation of the following year.

In accordance with the climate of a country, or the kind of weather of a year, the conditions in regard to the manner of life and the duration of the development of the mosquito vary. At all events, the life-history of the mosquito elucidates many points relating to malaria which were hitherto not understood.

[The length of the egg, larval and pupal life varies so much that it is not possible to give an account of any value here. Frequently the eggs may incubate in two days, whilst I have had *Stegomyia fasciata* eggs from Cuba that have hatched out under abnormal circumstances more than two months after they were laid ("Mono. Culicid.," iii, p. 6). Some larvæ, as *Anopheles bifurcatus*, live for months during the winter. Some mosquitoes therefore hibernate as larvæ. The larvæ and pupæ of the different genera present very marked characters, mainly in regard to the structure of the siphons. Specific differences may be found in the frontal hairs of Anopheline larvæ and in the number and arrangement of a group of spines at the base of the siphon in Culicines.—F. V. T.]

Culicidæ or Mosquitoes.

The importance of these insects to man is very great. They not only produce painful bites, which may become inflamed and give rise to a considerable amount of œdema, but they are more important on account of the part they play in the distribution of various diseases. *Culicidæ* may not only carry disease germs, but act as intermediate hosts for certain parasites, such as some of the *Anophelina* for malarial parasites, Culex for Filariæ, and Stegomyia for yellow fever, etc. ; the last-named is in any case the distributor of that fatal disease. It is therefore very necessary to know the life-history, habits and characters of these pests.

Mosquitoes exist in almost all parts of the world from the Arctic circle to the tropics ; temperate regions suffer from them less than the two extremes, but even there they form not only a source of great annoyance but of danger as malaria and possibly now and again yellow fever carriers. A few years ago comparatively few species were known, now some 800 odd have been described. Their number will probably not stop far short of 1,000, in spite of the fact that many have been described under different names, yet really the same species. Some are purely domestic, others entirely sylvan ; the former, as we might expect, often have a very wide distribution, having been taken from place to place in boats and trains. The more rapid transport becomes, the greater becomes the possibility of this wide distribution of many species increasing, and the spread of other species from their natural home to foreign parts by sea and then by trains further inland.

All *Culicidæ* are aquatic in their larval and pupal stages. Almost all small collections of water, both natural and artificial, may form breeding grounds for these pests. Some even breed in pitcher plants and many in bromelias. The

FIG. 394.—Heads of Culex and Anopheles: (1) Culex male; (2) Culex female; (3) Anopheles male; (4) Anopheles female. (After Daniels.)

favourite resorts for the larvæ of Anophelina are small natural collections of water, such as puddles, ditches and small pools around swamps; certain species (*A. maculipennis*, etc.) live in rain barrels as well. They may also occur in the sluggish water at the edges of rivers or even in mid river, where the flow is checked by masses of water weeds (*Myzomyia funesta*, etc.). The Stegomyias prefer artificial collections of water, but also occur in natural pools. The yellow fever species (*S. fasciata*) prefers small collections, such as in barrels, pots, jars, etc. Culex occur in all manner of places—rain barrels, tanks, cisterns, ponds and ditches. Some of the South American species of Culex, Wyeomyia, Joblotia, etc., breed in the collections of water at the base of bromelia leaves.[1] Very few Culicid larvæ live in salt water except in Australia, where Dr. Bancroft has found them in salt water of specific gravity 1·040 (*Mucidus alternans* and *Culex annulirostris*). Other salt water mosquitoes are known in America. The food of the larvæ is very varied; the majority appear to feed upon confervæ, small crustacea and insects; some are

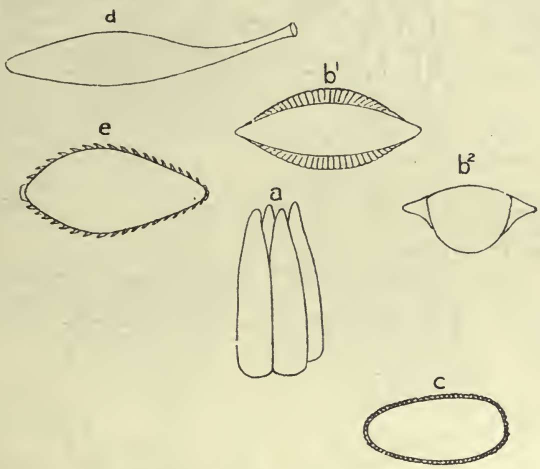


FIG. 395.—*a*, eggs of Culex; *b*[1] *b*[2], eggs of Anopheles; *c*, egg of Stegomyia; *d*, egg of Tæniorhynchus; *e*, egg of Psorophora.

cannibals, readily devouring others of their own kind. The larger larvæ of Megarhinus, Psorophora, Toxorhynchites and Mucidus are extremely ravenous and devour one another.

There are two main types of larvæ, the Anopheline and Culicine; in the former there is no respiratory siphon, in the latter the siphon is long or moderately long. The head offers certain marked peculiarities which are of specific value; this especially applies to the *Anophelina*, in which the frontal hairs are of great service in distinguishing the larvæ,[2] whilst in Culex the number and position of the spines at the base of and on the siphon are characteristic. The position assumed by the larvæ in the water also varies in the different groups; most of the Anophelines lie horizontally, most of the *Culicina* and *Ædeomyina* hang head downwards. The

[1] "Wald Mosquitoes und Wald Malaria," Dr. Lutz, *Centralbl. f. Bakt.*, *Par.*, *u. Infektionsk.*, i Abt. Orig., xxxiii, No. 4.

[2] Informati n sent me by Dr. Grabham shows this statement to be not quite correct, as the frontal hairs may vary in different stages of the same larva. This he has shown in *Cellia albipes*, Theob., and I have noticed it in a Nyssorhynchus from Africa.

pupæ also vary, but not to the same extent; the chief differences to be noticed are in the form of the two respiratory trumpets.

The eggs, which may be laid separately (*Anopheles maculipennis*, *Stegomyia*

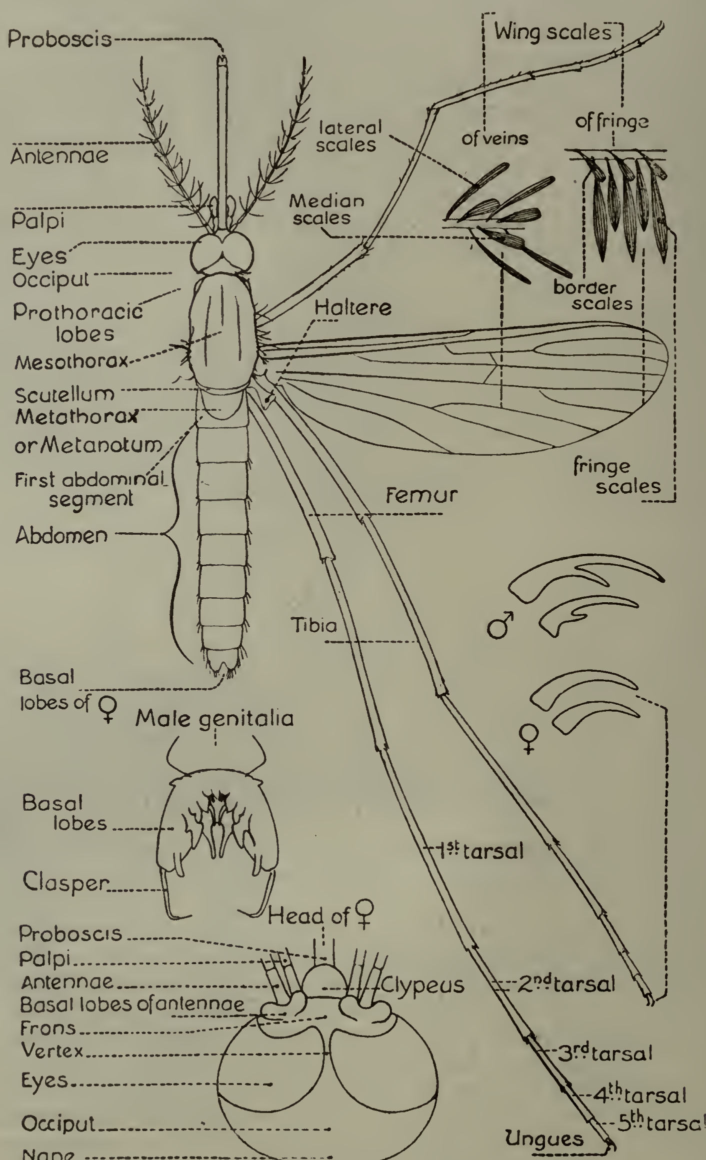


FIG. 396.—Diagram showing the structure of a typical mosquito. (Theobald.)

fasciata, *Joblotia nivipes*, etc.), or in rafts (*Culex pipiens*, *C. fatigans*) or in chains (*Pseudotæniorhynchus fasciolatus*), present a great variety of forms. The most peculiar are shown in fig. 395 (Tæniorhynchus, Culex, Stegomyia, Anopheles, Psorophora).

As in all insects, they differ very materially in each species of one genus. Those best known are the Anopheline eggs.

The eggs always float on the surface of the water; immersion soon destroys them, but many may occur in mud and can resist desiccation.

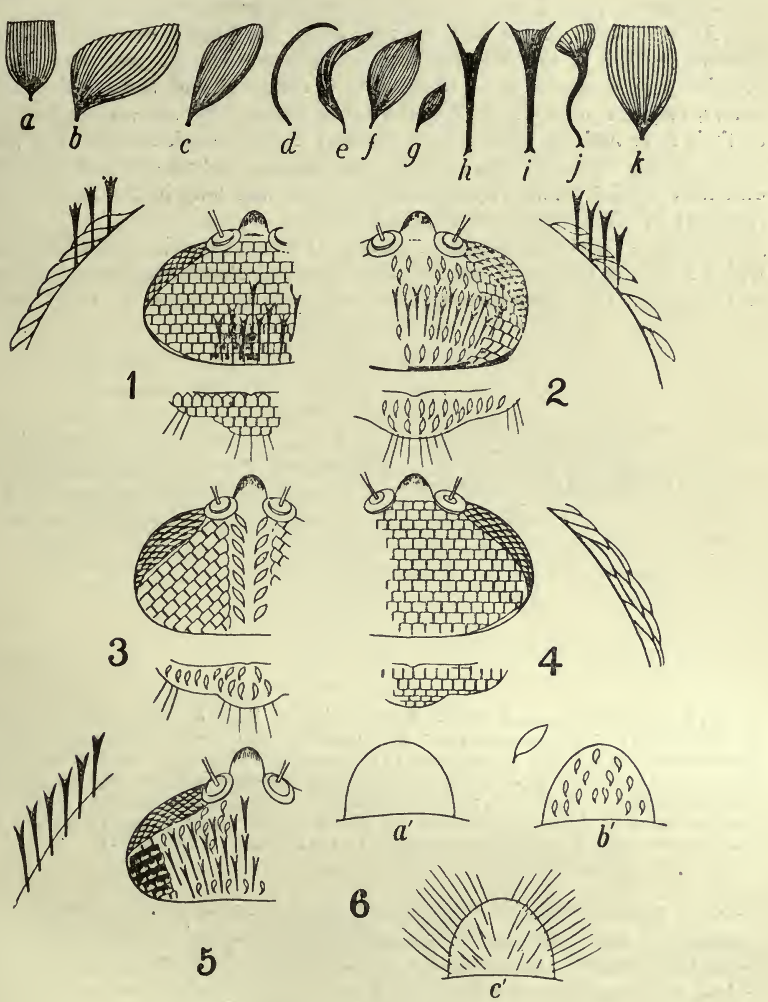


FIG. 397.—Types of scales, *a* to *k*; head and scutellar ornamentation, 1 to 5; forms of clypeus, 6. (Theobald.) 1, head and scutellum of Stegomyia, etc.; 2, of Culex and Mansonia; 3, of Howardina, Ædes, etc.; 4, of Megarhinus and Toxorhynchites, etc.; 5, of Cellia and some other Anophelines; 6, *a′*, clypeus of Culex; *b′*, of Stegomyia; *c′*, of Joblotia.

Characters of Adult Culicidæ.—The chief characters by which true mosquitoes, or *Culicidæ*, are known are the following:—

(1) Wings always with the veins covered with scales; the longitudinal veins,

usually six in number (in one genus seven); the costal vein carried round the border of the wing.

(2) Head, thorax and abdomen usually, but not always (Anopheles, etc.), covered with scales.

(3) Mouth parts formed into a long piercing proboscis.

As a rule the males may be told from the females by their antennæ being plumose, whilst in the females they are pilose (*vide* fig. 394), but this does not invariably hold good, for in Deinocerites, Theobald, and Sabethes, Desvoidy, and others, they are pilose in both sexes. The labial palpi are very variable in regard to their form and the number of segments; in the *Anophelina* they are long in both sexes, as long or nearly so as the proboscis, more or less clubbed in the males; in *Culicina*, *Joblotina* and *Heptaphlebomyia*, they are long in the males, short in the females; in *Ædeomyina*, short in both sexes.

Scales.—The most important structural peculiarities in *Culicidæ* are the scales, which form the chief and most readily observed characters for separating genera and species. The importance of scale structure has been recently ignored by some

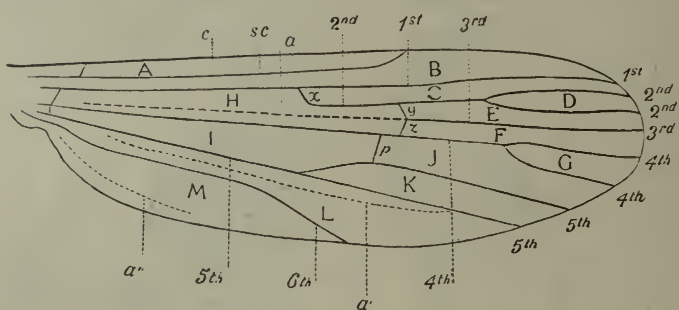


FIG. 398.—Neuration of Wing. *Explanation of Wing, Veins and Cells.*—A, costal cell; B, sub-costal cell; C, marginal cell; D, first sub-marginal cell (= first fork cell); E, second sub-marginal cell; F, first posterior cell; G, second posterior cell (= second fork cell); H, first basal cell; I, second basal cell; J, third posterior cell; K, anal cell; L, anxiliary cell; M, spurious cell; *c*, costal vein; *1st*—*6th*, first to sixth longitudinal veins; *a*, *a′* and *a″*, incrassations (*a′* called by Austen the sixth vein, *a″* the eighth vein); y, supernumerary cross vein; z, mid cross vein; *p*, posterior cross vein; *s.c.*, sub-costal. (Theobald.)

workers, who are probably right academically, but as a means of separating groups, and so more easily running down a species, the practical man is strongly advised to follow this method. As to what a genus is, is purely a matter of personal opinion. If one examines any recent standard work on entomology one will find a species being placed in varied genera by the varied authorities.

The head, thorax, abdomen and wings are in nearly all cases clothed with squamæ of varied form, of which the following are the main types (fig. 397):—

(1) Flat, spade-shaped scales (*a*).
(2) Narrow curved scales (*e*).
(3) Hair-like curved scales (*d*).
(4) Spindle-shaped scales (*f*).
(5) Small spindle-shaped scales (*g*).
(6) Upright forked scales (*h*) and (*i*).
(7) Twisted upright scales (*j*).
(8) Inflated or pyriform scales (*k*).

(9) Mansonia scales (*b*).
(10) Small broad asymmetrical scales (*c*).

Various other varieties are found on the wings, such as:—

(1) Narrow linear lateral scales.
(2) Narrow lanceolate scales.
(3) Broad lanceolate scales.
(4) Elongated, broad, truncated scales (= Pseudotæniorhynchus-like scales).
(5) Pyriform scales.
(6) Asymmetrical broad or Tæniorhynchus scales.
(7) Flat spade-like scales.[1]

The wings have a series of scales along the middle line of the veins, and also lateral scales to all or nearly all the veins. The wing is also fringed by a series of scales (fig. 396), which, however, are of little systematic importance; the so-called "border scales" (b.s.) vary, however, to some extent, and are useful characters in separating some of the Tæniorhynchus.

THE CLASSIFICATION OF *Culicidæ*.

SECTION A.—Proboscis formed for piercing; metanotum nude. Scutellum simple.

I. Wings with six-scaled longitudinal veins.

A. Palpi long in the male.

a. Palpi long in both sexes, clavate in ♂ *Anophelina*.

I. First submarginal cell as long or longer than the second posterior cell. Antennal segments without dense lateral scale tufts.

Thorax and abdomen with hair-like scales	Prothoracic lobes simple; no flat head scales	Wing scales lanceolate ...	*Anopheles*, Meigen.
		Wing scales mostly long and narrow ...	*Myzomyia*, Blanchard.
		Wing scales as above, but fourth long vein near base of third and outstanding scales on prothoracic lobe	*Neomyzomyia*, Theobald.
		Wing scales partly large and inflated	*Cyclolepppteron*, Theobald.
	Prothoracic lobes mammillated; some flat head scales. Basal lobe of ♂ genitalia of two segments		*Stethomyia*, Theobald.
Prothoracic lobes with dense outstanding scales			*Feltinella*, Theobald.
Thorax with some narrow curved scales; abdomen hairy			*Pyretophorus*, Blanchard.
Wing scales small and lanceolate. Wing scales broad and lanceolate			*Myzorhynchella*, Theobald.

[1] Heart-shaped scales occur on the wings of Etiorleptiomyia.

Thorax with hair-like curved scales, some narrow curved ones in front; abdomen with apical lateral scale tufts, scaly venter; no ventral tuft	*Arribalzagia*, Theobald.
Thorax with hair-like curved scales; abdominal scales on venter only, with a distinct ventral apical tuft	*Myzorhynchus*, Blanchard.
Much as above, but abdomen with long spine-like dense lateral tufts	*Chrystia*, Theobald.
Thorax with very long hair-like curved scales; abdomen pilose, except last two segments which are scaly; dense scale tufts on third femora; wings with broadish, blunt, lanceolate scales	*Lophoscelomyia*, Theobald.
Thorax and abdomen with scales { Abdominal scales as lateral dorsal patches of small flat scales; thoracic scales narrow and curved, or spindle-shaped	*Nyssorhynchus*, Blanchard.
Thorax and abdomen with scales { Abdomen nearly completely covered with irregular scales and with lateral tufts ...	*Cellia*, Theobald.
Thorax and abdomen with scales { No lateral scale tufts	*Neocellia*, Theobald.
Thoracic scales hair-like except a few narrow curved ones in front; abdominal scales long, broad and irregular	*Kerteszia*, Theobald.
Thorax with hair-like curved scales and some broad straight scales, others spatulate on sides. Abdomen covered with fine hairs except last three segments, which are scaly. Tufts of scales on hind femora. Wing scales lanceolate	*Manguinhosia*, Cruz.
Antennal segments with many dense scaly tufts	*Chagasia*, Cruz.
Antennæ with outstanding scales on second segment, more appressed ones on the first. At least one segment of abdomen with long flat more or less spatulate scales ...	*Calvertina*, Ludlow.
II. First submarginal cell very small	*Bironella*, Theobald.
With a distinct cylindrical tubercle projecting obliquely from the prothoracic region	*Dactylomyia*, Newstead and Carter.[1]
Scutellum trilobed.	

[1] The following genera of Anophelites have been founded by James* :—

(1) Abdomen with hairs but no scales. Thorax with dorsum with long narrow curved scales, which form on the anterior promontory a thick bunch projecting over the neck. Prothoracic lobes with a tuft of rather broad true scales, upright forked scales of head of usual broad expanding type: Patagiamyia, James. Includes Gigas, Giles, and Lindesayi, Giles. Both seem to me typical Anopheles.

(2) Abdomen as above. Thorax very similar. Prothoracic lobes with hairs, no scales. Upright

* *Records of Indian Museum*, 1910, iv, No. 5, p. 98.

First submarginal cell much smaller than the second posterior cell ; proboscis long and bent	*Megarhininæ.*
Palpi long in both sexes	*Megarhinus*, Rob. Desvoidy.
Last segment of ♂ palpi blunt. Last segment of ♂ palpi long and pointed ...	*Ankylorhynchus*, Lutz.
β. Palpi short in the female	*Toxorhynchites*, Theobald.
First submarginal cell longer than the second posterior cell	*Culicinæ.*
Legs more or less densely scaly ; head not entirely clothed with flat scales ; all the legs densely scaly.	
Wings with large pyriform scales	*Mucidus*, Theobald.
Wings with narrow scales	*Psorophora*, Rob. Desvoidy.
Hind legs only densely scaled	*Janthinosoma*, Arribalzaga.
Head entirely clothed with flat scales.	
Legs uniformly scaled with flat scales.	
Head and scutellar scales all flat and broad.	
Palpi of ♀ short, of ♂ thickened apically and tufted	*Stegomyia*, Theobald.
Palpi of ♀ longer than in Stegomyia and in ♂ long and thin, acuminate, simple ...	*Desvoidea*, Blanchard.
Head scales mostly flat, but a median line of narrow curved ones ; scutellar scales flat on mid lobe, narrow curved on lateral lobes and palpi longer than proboscis ...	*Macleayia*, Theobald.
Head scales mostly flat, irregular, narrow curved ones behind ; mid lobe scutellum with flat scales, lateral with narrow curved ; ♂ palpi shorter than proboscis	*Catageiomyia*, Theobald.
Head scales mostly flat, but a few narrow curved ones in middle in front ; scutellar scales all flat	*Scutomyia*, Theobald.
Head scales all flat ; scutellar scales all narrow curved	*Skusea*, Theobald.

forked scales of head rod-shaped : Neostethopheles, James. Includes Atkenii, James ; Immaculatus, Theobald ; Culiciformis, James and Liston. These seem to me to be true Anopheles.

(3) Abdomen with hairs and scales on dorsum of each segment ; ventrally there are six scaly tufts on the apices of six segments. Thorax with scales and a tuft of outstanding ones on prothoracic lobes : Christophersia, James. Type Halli, James. Very close to if not identical with Cellia.

(4) Head with narrow curved scales lying rather flat upon head and flat lateral scales, upright forked ones behind. Central lobe of scutellum with tuft of narrow curved scales, lateral lobes with large flat oval scales ; male palpi longer than proboscis, two large apical segments with long projecting hairs : Leslieomyia, Christophers. Type *Leslieomyia tæniorhynchoides*, Christophers, from Amritsar, India.

(5) Abdomen with first six or seven segments with hairs only, eighth and seventh (?) with scales, also genital processes. Thorax with hairs and narrow curved scales sharp pointed, blunt-ended broad scales on each side of anterior third. No tufts of scales on prothoracic lobes. Head usual type of upright forked scales : Nyssomyzomyia, James. Type Rossii, Giles.

Head with flat scales, except a small median area of narrow curved ones; scutellar scales all narrow curved ... ... *Howardina*, Theobald.

Head with all flat scales except a thin line of narrow curved ones behind; scutellar scales all narrow curved ... ... *Danielsia*, Theobald.

Head with small flat scales over most of surface, with median line and line around eyes of narrow curved ones; scutellar scales bluntly spindle or club-shaped ... *Hulecoetomyia*, Theobald.

Head and scutellar scales narrow curved.

Wing scales long, narrowly lanceolate, collected in spots; palpi clubbed in ♂; five-jointed and rather long in ♀ ... ... *Theobaldia*, Neveu-Lemaire.

Wing scales (lateral) long and narrow, and ♀ palpi three-jointed, ♂ not clubbed and hairy ... ... *Culex*, Linnæus.

Wing scales at apex of veins dense and rather broad, femora swollen; small dark species ... ... *Melanoconion*, Theobald.

Wings with short, thick, median scales and short, broadish lateral ones on some of the veins; scales mottled; fork-cells rather short ... ... *Grabhamia*, Theobald.

Wings with dense, broadish, elongated, truncated scales ... ... *Pseudotæniorhynchus*, Theobald.

Wings with broad, short, asymmetrical scales ... ... *Tæniorhynchus*, Arribalzaga.

Head covered with rather broad, flat, spindle-shaped scales; scutellum with small flat scales to mid lobe ... ... *Gilesia*, Theobald.

Head clothed with flat, irregularly disposed scales all over, with patches of narrow curved ones; ♂ palpi clubbed ... ... *Acartomyia*, Theobald.

Abdomen with projecting flat lateral scales with deeply dentate apices; wings not ornamented ... ... *Lasioconops*, Theobald.

Wings ornamented; scutellum with flat and narrow curved scales ... ... *Finlaya*, Theobald.

γ. Palpi short in ♂ and ♀ ... ... *Ædeomyina*.

Wings unornamented.

Antennæ pilose in ♂ and ♀; second joint very long ... ... *Deinocerites*, Theobald.

Antennæ plumose in the ♂.

Head clothed with narrow curved and flat scales.

Mid-lobe of scutellum with six border-bristles.

Scutellum with narrow curved scales.

Palpi in ♀ four-jointed, in ♂ two-jointed ... *Ædes*, Meigen.

Mid-lobe of scutellum with four border bristles.

Scutellum with flat scales.
Head clothed with flat scales only.
Fork-cells normal length.
Mid-lobe of scutellum with four border-bristles.
Palpi of ♀ two-jointed ... ... *Verallina*, Theobald.
Palpi of ♀ five-jointed, metallic ... ... *Hæmagogus*, Williston.
Fork cells very small or small.
Scutellar scales flat.
First submarginal cell longer than the second posterior cell; no flat scales on mesothorax ... ... *Ficalbia*, Theobald.
First submarginal cell smaller than the second posterior cell; flat scales on mesothorax... ... ... *Uranotænia*, Arribalzaga.
Scutellar scales narrow curved.
First submarginal cell as in Uranotænia ... *Mimomyia*, Theobald.
Wings ornamented with Mansonia-like scales *Ædeomyia*, Theobald.

SECTION B.—Metanotum ornamented with chætæ, squamæ or both.
α. With chætæ only.
Proboscis longer than whole body; lateral wing scales Tæniorhynchus-like ... ... *Phoniomyia*, Theobald.
Proboscis as long as whole body in ♀; frons drawn out into a prominence; wing scales rather broad and long ... ... *Binotia*, Blanchard = *Runchiomyia*, Theobald.
Proboscis not as long as the whole body; lateral vein scales narrow ... ... *Wyeomyia*, Theobald.
Proboscis not as long as whole body, swollen apically; wing scales long and broad ... *Dendriomyia*, Theobald.
β. Metanotum with squamæ and chætæ.
Palpi short in ♂ and ♀.
Proboscis straight in ♀ and ♂; legs with scaly paddles ... ... *Sabethes*, Rob. Desvoidy.
Venation like Sabethes.
Legs simple ... ... *Sabethoides*, Theobald.
Venation like Culex ... ... *Goeldia*, Theobald.
Proboscis in ♂ elbowed, with two scaly tufts *Limatus*, Theobald.
Palpi long in ♂, short in ♀ ... ... *Joblotina*, Blanchard.
II. Wings with seven-scaled longitudinal veins: Culex type ... ... *Heptaphlebomyia*, Theobald.

SECTION C.—Proboscis short, not formed for piercing ... ... *Corethrina.*
Metatarsus longer than first tarsal joint ... *Corethra*, Linnæus.
Metatarsus shorter than first tarsal joint ... *Mochlonyx*, Ruthe.[1]

---

[1] Many other genera have been created; these will be found in my catalogue of *Culicidæ* in my "Monograph of the Mosquitoes of the World," 1901-10, 5 vols., in my "Novæ Culicidæ," family *Culicidæ*, Genera Insectorum, etc.

NOTES ON THE DIFFERENT GENERA.

Sub-family. **Anophelina.**

The following Anophelines have been recorded as malaria carriers :—

**Anopheles maculipennis*, Meigen.
Anopheles bifurcatus, Linnæus.
**Myzomyia funesta*, Giles.
Myzomyia lutzii, Theobald.
**Myzomyia rossii*, Giles.
Myzomyia listonii, Liston.
Myzomyia culicifacies, Giles.
Pyretophorus superpictus, Grassi.
**Pyretophorus costalis*, Loew.
Pyretophorus chaudoyei, Theobald.
**Cellia argyrotarsis*, Robineau Desvoidy.
Myzorhynchus pseudopictus, Grassi.
Myzorhynchus barbirostris, Van der Wulp.
Myzorhynchus sinensis, Wiedemann.
Myzorhynchus paludis, Theobald.
Myzorhynchus mauritianus, Grandpré.
Neocellia stephensii, Liston.
Neocellia willmori, James.
Nyssorhynchus theobaldii, Giles.
Nyssorhynchus fuliginosus, Giles.
Nyssorhynchus annulipes, Walker.

Those marked with an asterisk (*) also carry the larvæ of *Filaria bancrofti*, as also do *Myzorhynchus minutus*, Theobald, and *Myzorhynchus nigerrimus*, Giles.

Genus. **Anopheles,** Meigen.

"Syst. Beschr. Europ. zwei. Ins. I," 1818, ii, p. 2, Meigen ; "Mono. Culicid.," 1903, i, p. 191 ; iii, p. 17 ; and 1910, v, p. 3, Theobald.

This genus contains a few large species found either in temperate climates or in hills and mountains of warm climates. The type is the European and North American *A. maculipennis*.

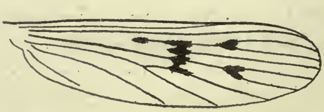


FIG. 399.—Wing of *Anopheles maculipennis*, Meigen.

A. maculipennis, Meigen. This species and *A. bifurcatus* are malaria carriers. True Anopheles only occur in Europe, North America, the North of Africa and in the mountains of India, and one has been found by Bancroft similar to *A. bifurcatus* in Queensland. They are easily told by the absence of scales on thorax and abdomen, and by the rather densely scaled wings with lanceolate scales.

Genus. **Myzomyia**, Blanchard; **Grassia**, Theobald.

Comp. rend. heb. Soc. Biol., No. 23, p. 795, Blanchard; "Mono. Culicid.," 1910, iii, p. 24; v, p. 16, Theobald.

This genus occurs in Asia, Africa and South America, Europe and East Indies. The type is *M. funesta*, Giles, found in Central and West Africa. Although structurally there is not much difference between this genus and Anopheles, they differ greatly in appearance, and there are usually a few narrow curved thoracic scales projecting over the head, whilst the wing scales are much smaller in proportion, and the wings more uniformly spotted, always so along the costa. *Funesta* and *lutzii* are undoubtedly malaria bearers and also *rossii.*

Genus. **Neomyzomyia**, Theobald.

"Mono. Culicid.,"1910, v, p. 29.

A single species only occurs in this genus, *N. elegans*, James, from India. In this genus, which is near to Myzomyia, the fourth long vein is very near the base of the third, and there are outstanding scales on the prothoracic lobes, and there is a marked tuft of dense scales at the posterior angles of the head.

Genus. **Cycloleppteron**, Theobald.

"Mono. Culicid.," 1903, ii, p. 312; 1903, iii, p. 58; 1910, v, p. 33.

Two common species only occur in this genus, *C. grabhamii*, Theob., from Jamaica, and *C. mediopunctatus*, Theob. (Lutz., ms.), from South America. The chief character is the presence of large black inflated pyriform scales on the wings. The palpi are densely scaled. Neither have been shown to be malaria bearers.

Genus. **Feltinella**, Theobald.

"Mono. Culicid.," 1907, iv, p. 56.

A single species, so far only found in this genus. The basal lobes of the male genitalia of two segments, the prothoracic lobes with dense outstanding scales.

The species, *F. pallidopalpi*, Theob., occurs in Sierra Leone.

Genus. **Stethomyia**, Theobald.

"Mono. Culicid.," 1903, iii, p. 13; 1907, iv, p. 59; 1910, v, p. 35.

Four species occur in this marked genus—one *S. nimba*, Theob., from British Guiana and Para, another *S. fragalis*, Theob., from the Malay States, *S. culiciformis*, James and Liston, from India, and *S. pallida*, Ludlow, from India.

The former may be a malaria carrier, for Dr. Low says: "Malarial fever is got amongst the Indians and often of a severe type. In that connection it is interesting that in the interior, at a place called Corato, I got an entirely new Anopheles in large numbers." The genus is easily told by its unornamented wings, flat head scales, mammillated prothoracic lobes and long thin legs.

Genus. **Pyretophorus**, Blanchard; **Howardia**, Theobald.

Compt. rend. heb. Soc. Biol., No. 23, p. 705, Blanchard; *Journ. Trop. Med.*, v, p. 181; and "Mono. Culicid.," 1903, iii, p. 13; 1910, v, p. 36, Theobald.

Forty-four species come in this genus, of which *Anopheles costalis*, Loew, is the type.

This genus is found in Africa, India, Europe and in Australia. Three species are proved malaria bearers, namely, *P. costalis*, Loew, *P. chaudoyei*, Theob., and *P. superpictus*, Grassi. Members of this genus can be told by having narrow curved thoracic scales, hairy abdomen, and much-spotted wings.

Genus. **Myzorhynchella**, Theobald.

"Mono. Culicid.," 1907, iv, p. 78.

In this genus the thorax has distinct, narrow curved scales, and the abdomen is hairy, the wing scales broad and lanceolate, and the head with broad scales not closely appressed, but not forked or fimbriated.

Five species are known: *lutzi*, Cruz; *parva*, Chagas; *nigritarsis*, Chagas; *tibiomaculata*, Neiva; *gilesi*, Neiva; and *nigra*, Theobald. They are all recorded from Brazil, and *nigra* also from Mexico.

Genus. **Manguinhosia**, Cruz, in Peryassu.

"Os Culicideos do Brazil," 1908, p. 112.

A single marked species from the Brazils. The thorax has piliform curved scales, and some narrow curved and flattened ones on the sides. Abdomen pilose, except the last three segments which are scaled. No tufts of scales on posterior femora.

Allied to Lophoscelomyia, but at once told by the absence of scale tufts on the hind femora. *M. lutzi*, Cruz, Brazil.

Genus. **Chrystya**, Theobald.

"Rep. Sleeping Sickness, Roy. Soc. Eng.," 1903, vii, p. 34.

A very marked genus in which the hairy abdomen has very long, dense, hair-like, apical, scaly tufts to the segments. A single species only so far known, *C. implexa*, Theobald, from Africa (Uganda, Sudan, etc.).

Genus. **Lophoscelomyia**, Theobald.

Entomologist, 1904, xxxvi, p. 12.

A single species only, from the Federated Malay States. The hind femora have dense, apical scale tufts; the thorax long, hair-like curved scales; abdomen pilose, except the last two segments which are scaly; wings with broad, blunt, lanceolate scales.

Genus. **Arribalzagia**, Theobald.

"Mono. Culicid.," 1903, iii, pp. 13 and 81; and 1910, v, p. 48.

Two species only occur, found in South America. The thorax and abdomen have scales and hairs respectively, as in Pyretophorus, but the abdomen has in addition prominent lateral apical scale tufts to the segments and a scaly venter. Wings with membrane tinged in patches and wing scales bluntly lanceolate and very dense. The type is *A. maculipes*, Theob. found in Trinidad and Brazil; *A. pseudomaculipes*, Cruz, also in Brazil.

Genus. **Myzorhynchus**, Blanchard; **Rossia**, Theobald.

Compt. rend. heb. Soc. Biol., 1902, No. 23, p. 795, Blanchard; *Journ. Trop. Med.*, 1902, p. 181, Theobald; "Mono. Culicid.," 1903, iii, p. 84; 1907, iv, p. 80; 1910, v, p. 49.

A very marked genus of large, dark, densely scaled species, found in Europe, Asia, Africa and Australia. The thorax with hair-like curved scales; the abdomen with ventral and apical scales, and a median ventral apical tuft, and with very densely scaled palpi in the female, and densely scaled proboscis. It seems to be mainly an Asiatic and East Indian genus, but three species occur in Africa and one in Australia. They are mostly sylvan species and bite severely.

Fourteen species are known. Five are malaria carriers (*vide* list, p. 566).

Genus. **Nyssorhynchus,** Blanchard ; **Laverania,** Theobald.

"Mono. Culicid.," 1910, iii, p. 14 ; v, p. 55, Theobald ; *Compt. rend. heb. Soc. Biol.*, No. 23, p. 795, Blanchard.

A group of small, closely allied species found in Asia, Africa and Australia, twelve out of the twenty species coming from India.

The thorax is covered with narrow curved and spindle-shaped scales, abdomen with small, flat or narrow curved dorsal scales, especially on the apical segments or in patches ; the legs are always banded or spotted with white, and the tarsi have as a rule one or more pure white segments. (This banding and spotting is of no generic value, however.)

The species show considerable seasonal variation. The type of the genus is *N. maculatus*, Theobald.

Three are malaria carriers (*vide* list, p. 566).

Genus. **Cellia,** Theobald.

"Mono. Culicid.," 1903, iii, p. 107 ; 1910, v, p. 67.

Very marked Anophelines, with densely scaly abdomens, the scales irregularly disposed on the dorsum and forming dense lateral tufts ; thorax with flat spindle-shaped scales ; palpi densely scaled and also the wings.

The type of the genus is the African *C. pharoensis*, Theob. It is represented in Asia by *C. kochii*, Dönitz ; in West Indies and South America by *C. argyrotarsis*, Desvoidy, and *C. bigotii*, Theob. ; in Africa by *C. squamosa*, Theob., etc.

C. argyrotarsis, Desvoidy, and *C. albimana*, Wiedemann, are undoubtedly malaria bearers.

Genus. **Neocellia,** Theobald.

"Mono. Culicid.," 1907, iv, p. 111.

Allied to Cellia, but has no lateral scale tufts. Three species recorded from India.

Genus. **Kertészia,** Theobald.

"Ann. Mus. Nat., Hung.," 1905, iii, p. 66.

This genus has the thoracic scales hair-like, except a few narrow curved ones in front ; abdominal scales long, broad and irregular.

A single species, *K. boliviensis*, Theob. from Bolivia.

Genus. **Manguinhosia,** Cruz.

The thorax has narrow hair-like curved scales and some broad straight scales ; others spatulate on the sides. Abdomen with fine hairs, except the last three segments which are scaly. Tufts of scales on the hind femora. Wing scales lanceolate.

The type is *M. lutzi*, Cruz, from Brazil.

Genus. **Chagasia**, Cruz.

"Brazil-Medico," 1906, xx, pp. 20, 199.

This genus can at once be told by the antennal segments having many dense scaly tufts. Type, *C. fajardoi*, Lutz, from Brazil.

Genus. **Calvertina**, Ludlow.

Canadian Entomologist, 1909, xli, pp. 22, 234.

The antennæ in this genus have outstanding scales on the second segment, more appressed ones on the first. At least one abdominal segment with long, flat, more or less spatulate scales. Type, *C. lineata*, Ludlow, from Philippine Islands.

Genus. **Birónella**, Theobald.

"Ann. Mus. Nat. Hung.," 1905, iii, p. 69.

At once told by the first submarginal cell being very small. Type, *B. gracilis*, Theob. from New Guinea.

Sub-family. **Megarhininæ**.

Three genera occur in this marked sub-family; they are the largest of all mosquitoes, and are very brilliantly coloured, and many have tail fans. They occur in North and South America, Asia, Africa, and Australia. The long curved proboscis is very marked. They are usually spoken of as elephant mosquitoes; some are vicious blood-suckers at times.

The three genera tabulate as follows:—

α. Palpi long in both sexes.
- β. Last segment of ♀ palp round or blunt as if broken ... ... Genus *Megarhinus*, R. Desvoidy.
- ββ. Last segment of ♀ palp long and pointed ... ... Genus *Ankylorhynchus*, Lutz.

αα. Palpi of female short of male long. Palpi of female not more than one-third length of proboscis ... Genus *Toxorhynchites*, Theobald.

Genus. **Megarhinus**, Robineau Desvoidy.

"Mém. Soc. d'Hist. nat. de Paris," 1827, iii, p. 412; "Mono. Culicid.," 1901, i, p. 215; 1903, iv, p. 163; 1907, iv, p. 128; 1910, v, p. 89.

All large brilliant mosquitoes with long palpi in both sexes and, as a rule, with a caudal fan of scales; the proboscis is long and bent. They are all sylvan species, and are not so far recorded as biting man.

Genus. **Toxorhynchites**, Theobald.

"Mono. Culicid.," 1901, i, p. 244; 1903, iii, p. 119; 1907, iv, p. 140; 1910, v, p. 95.

Differs from the former genus in that the female palpi are short. The palpi may have one, two or three minute terminal segments. Banks's genus Worcesteria has three.

The elephant mosquito of India (*T. immisericors*), Walker, bites very severely. They are sylvan species.

Sub-family. **Culicinæ.**

Genus. **Mucidus,** Theobald.

"Mono. Culicid.," 1901, i, p. 268 ; 1910, v, p. 125.

This genus is so far confined to Australia, West and Central Africa, India, East Indies and Malay Peninsula. They are all large mosquitoes, easily told by the whole body being more or less covered with long twisted scales, giving them a mouldy appearance, and the legs densely scaled with outstanding scales ; the wings with large parti-coloured scales. The Australian *M. alternans*, Walker, occurs in larval form both in fresh and salt water. The adults bite man.

Genus. **Psorophora,** Robineau Desvoidy.

"Mém. de la Soc. d'Hist. nat. de Paris," 1827, iii, p. 412, R. Desvoidy ; "Mono. Culicid.," 1901, i, p. 259 ; 1903, iii, p. 130 ; 1907, iv, p. 158 ; 1910, v, p. 123, Theobald.

This genus is confined to the Americas and the West Indies. Several species exist which can easily be told from Mucidus by the absence of long twisted scales and the narrower wing scales. The legs are densely scaled and the thorax ornamented with flat spindle-shaped scales.

P. ciliata, Robineau Desvoidy, occurs in both North and South America, and bites man.

Genus. **Janthinosoma,** Arribalzaga.

"Dipt. Arg.," 1891, p. 52, Arribalzaga ; "Mono. Culicid.," 1901, i, p. 253 ; 1903, iii, p. 124 ; 1907, iv, p. 152 ; and 1910, v, p. 118, Theobald.

Hind legs only densely scaled ; some of the hind tarsi are always white. The venation is as in Culex. The abdomen is metallic and iridescent. They all bite man and occur only in the Americas and West Indies.

Genus. **Stegomyia,** Theobald.

"Mono. Culicid.," 1901, i, p. 283 ; 1903, iii, p. 130 ; 1907, iv, p. 170 ; 1910, v, p. 151.

This, the most important genus in the *Culicinæ*, can be told by the head and scutellum being clothed with flat scales and the thorax with narrow curved ones.

About forty species are known in this genus, occurring in Southern Europe, Asia, Africa, Australia, the Americas, East and West Indies, and on most oceanic islands. Many of them seem to be vicious blood-suckers. They are mostly black and white mosquitoes, and several seem to go by the name of tiger mosquitoes. The genus contains the yellow fever mosquito (*S. fasciata*, Fabricius), the only one that need be dealt with in detail here. The chief known species tabulate as follows :—

A. Proboscis banded.
- *a.* Legs basally banded.
  - Thorax brown, with scattered creamy-white scales ... ... *annulirostris*, Theobald.
  - Thorax black, with narrow, curved golden scales ... ... *periskelta*, Giles.
- *aa.* Legs with basal and apical banding. Fore legs with no bands ; mid with apical and basal bands on first and second tarsals, hind with basal bands.
  - Thorax white in front, with a brown eye-like spot on each side ... ... *thomsoni*, Theobald.

AA. Proboscis unbanded.

β. Legs basally banded.

γ. Abdomen basally banded.

Thorax with one median silvery-white line	*scutellaris*, Walker.
Thorax as above, but pleuræ with white lines	*pseudoscutellaris*, Theobald.
Thorax similar, but two white spots near where line ends	*gelebinensis*, Theobald.
Thorax with two median yellow lines and lateral curved silvery lines	*fasciata*, Fabr.
Thorax with two short median lines and a white patch on each side	*nigeria*, Theobald.
Thorax with large lateral white spots in front, smaller ones by wings, two narrow median lines and two posterior sub-median white lines...	*lilii*, Theobald.
Thorax with a white W-shaped area in front, a prolongation curved on each side enclosing a brown eye-like spot	*W-alba*, Theobald.
Thorax with white frontal median spot, two large lateral spots, a small one in front of the wings, a narrow median white line and narrow sub-median ones on posterior half. *Last two hind tarsi white*	*weilmannii*, Theobald.
Thorax brown, with broad white line in front extending laterally towards wings, where they swell into a large patch, a white line on each side just past wing roots. *Last two hind tarsi white* ...	*albipes*, Theobald.
Thorax with silvery white spot on each side in front, small one over roots of wings and white over their base. *Last two hind tarsi white*	*pseudonigeria*, Theobald.
Thorax with two lateral white spots, front ones the largest, a small median one near head, two yellow median lines, a short silvery one on each side before the scutellum	*simpsoni*, Theobald.
Thorax with silvery-white scaled area in front and another on each side in front of wings	*argenteomaculata*, Theobald.
Thorax with median yellowish-white line, a silvery patch on each side in front of wings extending as a fine yellow line to the scutellum, and another silvery spot before base of each wing	*poweri*, Theobald.
Thorax with small grey-scaled area in front of wing roots and three short creamy lines behind	*minutissima*, Theobald.

Thorax (?) denuded ; abdomen black ; fifth segment with yellow basal band ; sixth unbanded ; seventh, two median lateral white spots ; eighth, two basal lateral white spots ; second hind tarsal nearly all white ... ... *dubia*, Theobald.

γγ. Abdomen unbanded.
First hind tarsal all white, second basally white, last two dark. Thorax chestnut brown, with a broad patch of white scales on each side in front and a median pale line ... ... *terreus*, Walker.

ββ. Legs with white lines as well as basal bands.
Thorax brown, with white lines ; abdomen with basal bands ... ... *grantii*, Theobald.

βββ. Fore and mid legs with apical bands, hind basal.
Fourth tarsal of hind legs nearly all white *mediopunctata*, Theobald.
Mid metatarsi with basal pale banding, base and apex of hind, also base of first tarsal pale ... ... *assamensis*, Theobald.

ββββ. Legs unbanded.

δ. Abdomen basally banded.
Thorax with front half white, rest bronzy-brown ... ... *pseudonivea*, Ludlow.
Thorax deep brown, with scattered golden scales, showing two dark eye-like spots ; head white, dark on each side and behind ... ... *albocephala*, Theobald.
Thorax brown with golden stripes ; abdomen with narrow basal bands on fifth and sixth segments only ... ... *auriostriata*, Banks.

δδ. Abdominal banding indistinct.
Thorax with broad silvery white patch on each side in front ... ... *albolateralis*, Theobald.

δδδ. Abdomen unbanded.
Thorax with six silvery spots ... ... *argenteopunctata*, Theobald.

δδδδ. Abdomen with apical white lateral spots.
Thorax unadorned, except for pale scaled lines laterally ... ... *punctolateralis*, Theobald.

δδδδδ. Abdomen with basal white lateral spots.
Thorax with two pale median parallel lines and two silvery lateral spots ... *minuta*, Theobald.
Thorax unadorned.
A white spot middle of head ... ... *tripunctata*, Theobald.
No white spot ... ... *amesii*, Ludlow.

AAA. Proboscis yellow basally, dark apically.
Abdomen with apical pale bands ... ... *crassipes*, Van der Wulp.

AAAA. Proboscis with median interrupted white line on basal half.
Head black, anterior margin grey ... *albomarginata*, Newstead.

Stegomyia fasciata, Fabricius (Yellow Fever Mosquito).

This insect, which is the proven carrier of yellow fever, is commonly called the tiger, brindled, spotted day or striped mosquito. It is also referred to by some writers as *S. calopus*, Meigen. It is subject to considerable variation in colour, but the thoracic markings are generally very constant. The general colour is almost black to deep brown, the head with a median white area, white at the sides and in front around the eyes; the thorax has two median parallel yellow lines, a broad curved silvery one on each side and white spots at the sides; the scales on the intervening spaces of the thorax are brown. The dark abdomen has basal white bands and basal white lateral spots. The dark legs have basal white bands, the last segment of the hind legs being all white except in a variety from South America and the West Indies (*luciensis*), which has the tip of the last hind tarsal dark. The abdomen may also vary in colour, some having pale scales over most of the surface (*queenslandensis*).

The food of the adult female consists mainly of man's blood, but she will also feed on dogs and other animals. The male has been said to bite, but such is very unusual. This mosquito bites mainly in the daytime up till about 5 p.m.

The adults breed the first day after emergence. They may live a considerable time, Bancroft having kept females for two months in confinement. The ova are laid separately, often in chains; they are black, oval, with a reticulated membrane outside, some of the reticulated cells containing air. They may hatch in from six to twenty hours, the larval stage nine days, the pupal stage three; thus the whole cycle may be completed in from twelve to thirteen days. The ova when dry can remain undeveloped for a considerable time. The larvæ are greyish-white, with short, thick siphon, and feed at the bottom of the water, only coming to the surface now and again to breathe. This is almost entirely a domesticated gnat, seldom being found far from man's habitations. Its larvæ occur in such small collections of water as old sardine tins, jam-pots, calabashes, puddles, barrels, wells—in fact, wherever water is held up, even to the gutters of houses. Not only are they found breeding on land, but also on board ship, although they prefer artificial collections of water. They may also breed in larger natural collections.

This insect is easily transported by steam and sailing ships and by train, and this doubtless explains its very wide distribution. The adults may live for fifty days, and it is on this account and their frequent occurrence on ships that danger lies in regard to the Panama Canal. An infected insect may leave that endemic centre of yellow fever and live until the vessel arrived at the Philippine Islands and fly ashore, and so introduce the disease for the native *fasciata* possibly to spread.

Roughly the distribution of this pest is as follows: Africa from South to North, but especially along the coast and up the Nile. In Asia, in India, Ceylon, Burma, Siam, along the ports of the Malay Peninsula, in French Cochin China, Philippine Islands, the Andaman and Nicobar Islands, Japan, Malay Archipelago, and East Indies, Turkey in Asia, Arabia and Palestine.

In Australia it occurs in Queensland, New South Wales, Victoria and South Australia.

In Europe in Italy, Spain, Portugal, Greece, in the Mediterranean Islands.

In South America, Central America, Mexico, North America, and the West Indies it is very abundant, and it also is found in the Bahama Islands, Fiji, Sandwich Islands, Samoa, the Azores, Teneriffe and Santa Cruz, Pitcairn Islands and Bermuda.

For a full account of its distribution the reader is referred to the following: "The Distribution of the Yellow Fever Mosquito (*Stegomyia fasciata*, Fabricius) and General Notes on its Bionomics;" "Mém. 1er Congrès international d'Entomologie, 1911, ii, pp. 145-170, F. V. Theobald. In addition to being the yellow fever carrier, it is supposed by Wenyon to be the intermediate host of the parasite of Bagdad sore.

Stegomyia scutellaris, Walker.

A vicious biter, found in India, China, Malay, East Indies, and Ceylon. The thorax has one median silvery stripe, and so can easily be told from *S. fasciata*.

A very similar species occurs in Fiji, but can be told by the pleuræ having white lines, not spots (*S. pseudoscutellaris*, Theobald). It is the intermediate host of filaria in Fiji (Bahr).

A number of nearly allied genera occur here (*vide* synoptic table).

Genus. **Theobaldia**, Neveu-Lemaire.

Theobaldinella, Blanchard.

Includes several large Culicines, of which *T. annulata*, Meigen, is the type. The wings are usually spotted (*annulata*, *incidens*, etc.), but may be nearly plain (*spathipalpis*). The males have the palpi swollen apically, and the females have long five-jointed palps.

Several of these are vicious biters.

Theobaldia annulata, Meigen.

This large gnat (6 mm. long) can be told by its wings having five large spots of dark scales and by its legs having broad basal white bands to the tarsi. The larvæ occur in rain barrels and small pools. It is essentially a domestic form, occurring in houses and privies. Its distribution is Europe generally and North America. The bite is very severe, and in some districts gives rise to painful œdema.[1]

Theobaldia spathipalpis, Rondani, occurs in Italy, Mediterranean Islands, Palestine, the Himalayas, Khartoum, and in South Africa. It is about the same size as *T. annulata*, but is yellowish-brown in colour, with striped thorax and mottled and banded legs. It occurs in privies and bites very severely.

Genus. **Culex**, Linnæus.

"Syst. Nat. Ed.," 1758, x, Linnæus; "Mono. Culicid.," 1901, i, p. 326; 1910, v, p. 322, Theobald.

This large genus still contains many forms which should be excluded. The species normally have narrow curved median head-scales, and similar ones on the

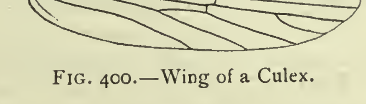


FIG. 400.—Wing of a Culex.

scutellum; the female palpi are shorter than in the former genus and the male palpi are pointed; the lateral vein-scales are narrow and linear.

The type is *Culex pipiens*, Linn., the common gnat of Europe. The thorax

[1] Theobald, "Second Report on Economic Zoology," 1903, p. 9.

is covered with narrow curved golden-brown scales, the abdomen has basal pale bands to the segments and the legs and proboscis are unbanded. The stem of the first submarginal cell is always less than one-fifth the length of the cell. It lays its eggs in rafts in water-butts, etc., and even in the foulest water. They are first deposited in England in June and July, and again soon after hatching in August. In some districts this gnat bites man viciously, in others not at all.

The common tropical gnat (*Culex fatigans*, Wied). This resembles the European *Culex pipiens*, but can always be told by the stem of the first submarginal cell always being much longer than it is in *C. pipiens*. This is one of the species that has been proved to transmit filariæ to man, etc. Varieties of it occur in almost every country between 40° N. and S., having a very similar range to *S. fasciata*. In all countries it appears to be connected with the transmission of *Filaria bancrofti*, and it is also said to carry the micrococcus of dengue fever.

Genus. **Melanoconion**, Theobald.

"Mono. Culicid.," 1903, iii, p. 238; 1907, iv, p. 507; 1910, v, p. 455.

This genus is composed of eight species, most of which are small black gnats which bite viciously and which occur in swamps and jungles. They can at once be told from Culex by the veins of the wings having dense broadened scales on their apical areas and along the upper costal border. The femora and apices of the tibiæ are swollen.

The black mosquito, *Melanoconion atratus*, Theob. This small gnat is a very troublesome pest in swamps in the West Indies. The female bites both by day and by night, and the bite causes severe irritation. The larvæ live in permanent ponds. It is almost black in colour, but sometimes presents a dull coppery sheen; each segment has small lateral basal white spots. Length 2·5 to 3 mm.

It occurs in Para and British Guiana as well as in the West Indies.

Ordinary mosquito netting is no use for keeping off this pest.

Genus. **Grabhamia**, Theobald.

"Mono. Culicid.," 1903, iii, p. 243; 1907, iv, p. 284; and 1910, v, p. 277.

Allied to Culex, but separated by the wings having short fork-cells, mottled scales, the median ones thick and also some of the lateral ones short and broad; the last two joints of the male palps are very slightly swollen. The eggs are laid singly, not in rafts, and the larvæ have short, thick siphons. Ten species occur and are found in Europe, North America, West Indies and Natal. *G. dorsalis*, Meigen, bites severely in Europe. *G. sollicitans*, Walker, is a great scourge along the New Jersey Coast and at Virginia summer resorts and in Florida. It breeds in brackish water and is the most common mosquito of the Atlantic seaboard.

Genus. **Pseudotæniorhynchus**, Theobald; **Tæniorhynchus**, Theobald, non-Arribalzaga.

Differs from the former in having the whole wing veins clothed with dense, broadish elongated scales. They occur in South America (*T. fasciolatus*, Arri.), in Africa (*T. tenax*, Theob.), in Europe (*T. richardii*, Ficalbi). The latter bites very severely.

Genus. **Tæniorhynchus**, Arribalzaga ; **Mansonia**, Blanchard ; **Panoplites**, Theobald.

Compt. rend. heb. Soc. Biol., 1901, iii, 37, p. 1046; "Mono. Culicid.," 1901, ii, p. 173; and 1910, v, p. 446, Theobald.

A very marked genus, easily told by the broad asymmetrical wing scales. It occurs in Africa (*T. africana* and *T. major*, Theob.) ; in Asia (*T. uniformis*, Theob. ; *T. annulipes*, Walker, etc.) and in Australia (*T. australiensis*) ; in the Americas and West Indies (*T. titillans*, Walker). The eggs (fig. 395, *d*) are peculiar in form and are laid separately; the larva has not been described ; the pupa has long curved siphons. They mostly occur along rivers, in swamps and forests, and bite very severely. They also enter houses (*T. titillans*). *T. uniformis* is most troublesome during the rains. The saliva is strongly acid. Both these species carry the larvæ of *Filaria bancrofti.*

Genus. **Chrysoconops**, Goeldi.

"Os Mosq. no Para," 1905, p. 114, Goeldi; "Mono. Culicid.," 1910, v, p. 433, Theobald.

Bright yellow or yellow and purple mosquitoes, with rather dense wing scales. Numerous species occur in Africa (*aurites*, *annettii*, *fuscopennatus*, etc.), others in India, Australia and South America.

Low found filariæ in the thoracic muscles of *fuscopennatus* in Uganda.

Several of the *Ædeomyina* bite, especially the small *Uranotænias.* They are all sylvan species, seldom entering houses. They need not, therefore, be referred to here.

For full details of the Culicid genera and species the reader is referred to my monograph[1] and other works mentioned below.

Other Nematocera.

Other nematocerous flies are midges, daddy-long-legs and sand-flies. The ones which cause annoyance to man besides *Culicidæ* are the following :—

Sand-flies (*Simulidæ*), certain midges (*Chironomidæ*), and a few owl midges (*Psychodidæ*).

The *Nematocera* have long thread-like jointed antennæ and their pupæ are, as a rule, naked ; the larvæ have a distinct head and can thus be told from the next section (*Brachycera*).

Family. **Simulidæ.**

This family consists of a single genus, Simulium, Latreille, which Roubaud has recently divided into two sub-genera called Pro-Simulium and Eu-Simulium. These insects, which are frequently spoken of as sand-flies, are found in all parts of the world ; they are all small insects varying from 1·5 to 3 mm. The females are very bloodthirsty, but the males appear to be incapable of sucking blood.

The head sunk under the humped thorax ; antennæ short, straight ; palpi short

---

[1] "A Monograph of the *Culicidæ* of the World," 5 vols. and atlas, 1901 to 1910, British Museum (Nat. Hist.) ; and the following : Howard, Dyar and Knab, "The Mosquitoes of North and Central America and the West Indies," 1912 ; James and Liston, "The Anophelinæ of India," Leicester, 1908 ; "The *Culicidæ* of Malay," Inst. Med. Res., Fed. Malay States, iii ; *Ann. Trop. Med. and Par.*, papers by Newstead and Carter ; *Mem. Inst. Oswaldo Cruz*, papers by Lutz, Neva, Chagas ; and the *Bulletin of Entomological Research*, etc.

and broad, of four segments, bent; wings broad and in some iridescent, legs stout. The male has holoptic eyes, whilst in the female they are small and widely separate. The sucking proboscis is short. The thorax and abdomen are clothed with short hairs which may form spots and markings; these are golden, silvery, grey, or brownish. In the sub-genus Pro-Simulium the second segment of the hind tarsi in both sexes is elongate, linear, and without a basal notch; in Eu-Simulium it is short, curved, and dorsally notched at the base.

Simulidæ often occur in swarms, and attack not only man but cattle, horses, and poultry. In some districts they are more annoying than mosquitoes.

Their life-cycle has been most completely worked out by King, in Africa.

The larvæ and pupæ occur in swiftly flowing water, by waterfalls, in rapids, etc. The ova are laid in gelatinous masses on plants or rocks close to or overhanging the water. The larva is cylindrical, enlarged posteriorly, where it is provided with a sucker, by means of which it attaches itself to a rock, water weeds, debris, etc.; anteriorly it has a proleg close behind the head on the lower surface. The head is dark and chitinous. The respiration takes place by means of branched tracheal gills which protrude from the dorsal surface of the last body segment; they are retractile. The colour varies from deep green to yellow or almost black. Their food consists of algæ and other organisms in the water brought to their mouth by two fan-like organs placed on the head. The larvæ can crawl from place to place by means of the thoracic proleg; they occur in masses, usually in a more or less erect attitude. A network of threads is spun on their support, by means of which King tell us "they are enabled to maintain their position against the strongest current; frequently they will leave their support and let themselves out into the stream anchored by threads of silk and enabled by them to return."

When full fed the larva spins a pocket-shaped cocoon on the support, within which it pupates. The pupa is motionless and has a pair of branched spiracles projecting from behind the head. When the adult emerges, a bubble of air collects around it, and in this it floats to the surface and at once takes wing. The European species take a month to complete larval life, a week being spent in the pupal stage. The flies are most restless, and even when stationary continually move their legs about like feelers. Sometimes the swarms consist entirely of females, sometimes early in the season mostly of males.

The females pierce the skin of humans on tender spots, such as ears, the forehead, around the eyes and nose, and crawl into the cavities. They are quite harmless at night, mainly attacking about sunrise and sunset. Some crawl up the arms and legs and down the neck, and leave behind little red weals which itch intensely (*S. damnosum*, Theob.), and blood may flow freely from the wounds.

The following are some of the worst species:—

Simulium columbaschensis, the "Kolumbatz fly," which abounds in the damp marshy lands along the Danube, and is a great plague to man and beasts in Hungary, and is also abundant in Austria and Moravia, and is most numerous after inundations from the Danube. They sometimes appear in such swarms that it is impossible to breathe without getting them into one's mouth. There are instances of children being killed by these flies when left on the ground by their mothers when working in the fields.

S. damnosum, Theob. This occurs throughout Equatorial Africa and is known as the "jinja fly" in Uganda, the "fouron" in the French Congo, the "kilteb" in the Sudan. It is a most vicious biter, and in some parts occurs in "belts"; Dr. Christy found one such extending from the shores of the Victoria Nyanza northwards along the right bank of the Nile for twelve or fifteen miles or more, and perhaps three or four miles wide. In this area the flies swarm in millions at certain seasons, so much so that the natives have to leave their plantations. The bite causes a weal, marked by a drop of blood.

S. griseicollis, Becker. The so-called "nimitti" occurs in Upper Egypt and the Anglo-Egyptian Sudan. It lives near the river and is not found more than half a mile from it. Human beings are bitten on the face and hands, animals in the region of the pudenda.

S. latipes, Meigen. This is a European species, also found in Natal.

S. wellmanni, Roubaud. The "ohomono" of Angola, where it bites viciously and is dreaded by the naked porters.

S. buissoni, Roubaud. Occurs in abundance in the Marquesas Islands. It has been *suggested* that this species may help to propagate leprosy.[1]

A large number of these insects have been described by Lutz in Brazil.[2]

A *Simulium* sp. (?) is very harmful to poultry in Cape Colony.[3]

In America, *Simulidæ* are most annoying. One, *S. meridionale*, Riley, also known as the turkey gnat in the Mississippi Valley, has been supposed to be the carrier of chicken cholera ; anyhow, it has caused the death of thousands of chickens and turkeys in Virginia annually.[4]

In Mexico Townsend found a Simulium which was named *S. occidentalis*, which caused great annoyance to man, many people being so susceptible to them as to

FIG. 401.—Wing of Simulium.

FIG. 402.—Wing of Chironomus.

preserve through the gnat season a chronic inflammation of the exposed parts of face and neck, resulting from the repeated bites giving rise to sores.[5]

Men and horses have been partially incapacitated by the bites of sand-flies or Simulium in a Hampshire wood (Cantlie, *Brit. Med. Journ.*, April 28, 1900, v, No. 2,052, p. 1023).

Family. Chironomidæ (Midges).

The *Chironomidæ* or midges are not only frequently mistaken for mosquitoes, but some are very annoying to man by biting him as mosquitoes do. They are easily distinguished from true mosquitoes (*Culicidæ*) by the following characters : (1) head small, often retracted under the cowl-like thorax ; (2) no scales to the wings or body ; and (3) the different arrangement of veins on the wings (fig. 402).

Two genera are important as annoying man, namely, Culicoides, Latreille, and Johannseniella, Williston. The larvæ of *Chironomidæ* are either aquatic, both fresh water and marine, and help to make the former foul,[6] according to Slater, or may, as in *Ceratopogoninæ*, live beneath the bark of trees, etc. The pupæ are very varied and also the life-histories of the different genera.[7] The blood-sucking habit is confined to the sub-family *Ceratopogoninæ*.

---

[1] *Bull. du Mus. d'Hist. nat.*, 1906, xii, p. 522.

[2] *Mem. Inst. Oswaldo Cruz*, 1910, ii, fasc. 2, pp. 211-267.

[3] C. Fuller, "A New Poultry Pest," 1899, Leaflet No. 1, Dept. Agric.

[4] *Insect Life*, 1888, i, p. 14. [5] *Ibid.*, 1893, v, p. 61.

[6] *Entomologist*, 1879, p. 89. [7] Theobald, "An Account of British Flies," i, p. 172.

Sub-family. Ceratopogoninæ.

This sub-family of midges consists of very small species varying from 1 to 2 mm. in length ; the wings have darkened areas, and the second longitudinal vein is wanting, and the first and third veins are stouter than the others and placed close to the anterior margin, the fourth and fifth are forked ; the antennæ in both male and female are composed of fourteen segments, six or eight in the males bearing long hairs.

The chief blood-sucking species belong to the genera Culicoides, Latreille, and Johannseniella, Williston. The latter genus differs from the former in the absence of an empodium or median appendage on the last segment of the tarsi. The genus Ceratopogon, as restricted by Kieffer, is not supposed to take vertebrate blood, but Austen has recently noticed that the type specimen of *C. castaneus*, Walker, and a new species described by him, apparently have their bodies distended with blood. The wings in the *Ceratopogoninæ* are carried flat when at rest.

FIG. 403.—A Ceratopogon, or midge. Greatly enlarged.

In spite of their small size the females are the most bloodthirsty and annoying of all insects. The Culicoides, which are often called " sand-flies," bite during the day and rarely at night. Usually they are most troublesome between 3 and 6 p.m. They frequently attack in swarms, especially in the open, and owing to their minute size can get through fine mosquito netting. Some of them produce a distinct "buzz" when on the wing. These insects are found in all parts of the world. No species has been definitely connected with any disease, but Culicoides has been suspected of carrying the germs of Delhi boil. The larvæ of Culicoides are elongate in form and have smooth bodies composed of thirteen segments including the head, which is horny ; there is no proleg on the first segment as seen in Chironomus, and on the anal segment are retractile gills. They are very active and live in the sap of various trees which saturates diseased bark.

The pupæ are smooth, but the abdominal segments bear a transverse row of small spines. Austen describes a number of Culicoides and one Johannseniella and three Ceratopogons from Africa,[1] and Lutz[2] a number of this sub-family from Brazil,

[1] *Bull. Ent. Res.*, 1912, iii, pp. 99-108.

[2] *Mém. Inst. Oswaldo Cruz*, 1913, v, fasc. 1, pp. 45-72, pls. 6-8 ; and 1914, vi, fasc. 2, pp. 81-99.

including a new genus, Centrorhyncus. Another genus, Tersesthes, Townsend (Centrotypus, Grassi ; Mycterotypus, Noe), also occurs in Brazil.

Culicoides ornatus, Taylor, is described from Townsville, Australia, found in mangrove swamps. It is a very vicious biter and causes considerable irritation, settling on hands and wrists (Taylor, *Rep. Ent. Aust. Inst. Trop. Med.* [1911], 1913, p. 24).

Family. Psychodidæ (Owl Midges).

This family of diptera is of considerable importance, not only on account of the blood-sucking habits of some species, but especially on account of one at least having been proved to be the carrying agent of "papataci" fever, a three-day fever very prevalent in Malta and several parts of Southern Europe in the autumn.

It is also possible that these small flies are connected with the formation of "Delhi boil," caused by a protozoan parasite.

Psychodidæ are all very small flies, many of which have a moth-like appearance, and owing to their fluffy nature are spoken of in Britain as "owl flies," sometimes also as "window flies." Their bodies and wings are covered with hairs, densely in some (sub-family *Psychodinæ*), and in a few with patches of flat squamæ. In the non-blood-sucking *Psychodinæ* the wings are carried in a peculiar manner downwards over the body, to a *slight extent* resembling the *Hepialidæ*, or swift moths. The

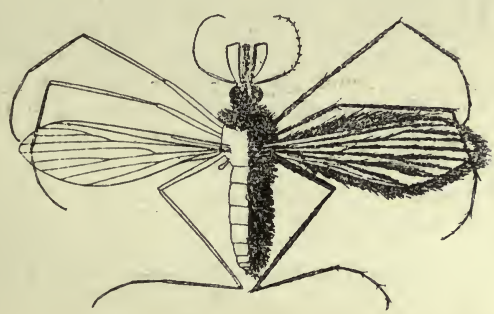


FIG. 404.—An owl midge, *Phlebotomus* sp. Greatly enlarged. (From Giles's "Gnats or Mosquitoes.")

wings may be ovoid or lanceolate, and have a marked venation as seen in the figure. The proboscis is short and non-suctorial in the majority of genera, but in the sub-family *Phlebotominæ* it is elongated and hard. The antennæ are long and of sixteen segments, and bear whorls of fine hair.

There are two sub-families, *Psychodinæ* and *Phlebotominæ;* in the former the mouth is not suctorial; the female has a horny ovipositor and the second longitudinal vein is branched at the root of the wing ; in the second sub-family the proboscis may be formed for sucking, the female has no horny ovipositor, and the second long vein has its first fork near the middle of the wing.

The sub-family *Phlebotominæ* contains the genus Phlebotomus, which occurs in South Europe, South Asia, Africa, North and South tropical America. They are all small grey, brown, or dull yellow-coloured flies, and carry their wings when at rest upwards like a butterfly. The proboscis is moderately long and the legs long and thin.

The females are most vicious blood-suckers, but in some species anyhow the males also bite (*P. duboscii*). They are mainly nocturnal feeders and hide away during the day in any dark corners or crevices.

The life-cycle has been worked out by Newstead[1] and Grassi[2] in Europe, and by Howlett[3] in India.

The larvæ have been found in crevices in rocks and caves, in dirty cellars, and dark damp places containing rubbish, and are also said to live in crevices in the walls of privies and cesspits.

The minute larva is very marked ; as figured by Newstead it has two long chætæ projecting upwards, in some stages branched, in others simple, and on the segments a few blunt spine-like processes. The pupæ are found in similar situations. The ova are very minute, elongate, translucent white, and covered with a thin coating of viscous matter when first laid ; soon after they become dark brown, shiny, with long black wavy lines. Newstead found the incubation period in Malta to last for about nine days in *P. papatacii*. Five species are known in Europe, five in Africa,[4] two in North America, and eight are described by Annandale[5] in the Oriental region. Lutz and Neiva have described three species from Brazil[6] (*P. longipalpis, intermedius* and *squamiventris*).

Brachycera (Flies).

The antennæ as a rule have three segments, and are usually shorter than the head. The first segment of the antennæ is frequently very small, and the third one is generally the largest, and sometimes possesses a terminal annulated bristle. The palpi have from one to three segments; the mandibles are covered by the labium. The three thoracic rings are coalesced ; wings are almost always present, the posterior ones being rudimentary and covered with a little scale. From the ova legless maggots are hatched, which as a rule have not a distinct head, but occasionally possess two claw-like hooklets. These maggots live in decomposing organic matter; they rarely live in water and some of them are parasitic. They either become barrel-shaped pupæ within the last larval integument or, after casting it, are transformed into naked pupæ. The larvæ of numerous *Brachycera* have been observed in man, some in ulcers or on mucous membranes, others in the skin or in the intestine, etc. In many cases the report only mentions the presence of the larvæ of flies ; in other cases the species has been determined ; whilst in still other cases the corresponding adult creature is unknown. We must therefore confine ourselves to describing the most common varieties.

Family. **Phoridæ.**

These flies belong to the same division of *Diptera*, the Aschiza, as the family *Syrphidæ* or "hover flies." They are all small insects with marked antennæ and wings ; the former have the third segment globular and enlarged, and thus hiding the first two ; the wings are short and broad, the venation shows two short, thick, long veins with four thin ones running out from them. The larvæ normally live in decaying animal and vegetable matter, but one species, *Aphiochæta ferruginea*, Brun., has been found as an intestinal parasite of man.

[1] *Bull. Ent. Res.*, 1911, ii, pt. 2, pp. 47-78.

[2] "Ricerche sui Flebotomi," *Mem. della Soc. ital. della Scienze*, 1907, ser. 3, xiv, pp. 353-394.

[3] "Indian Sand-flies," *Ind. Med. Cong.*, 1909, sec. III, pp. 239-242.

[4] Newstead : *Bull. Ent. Res.*, 1912, iii, pp. 361-367.

[5] *Rec. Ind. Mus.*, v, pt. 3, Nos. 13 and 14.

[6] *Mem. Inst. Oswaldo Cruz*, 1912, iv, fasc. 1, pp. 84-95.

Aphiochæta ferruginea, Brun.

This small fly belonging to this family is of an orange-ochreous colour, the upper part of the thorax tawny, and with dark bands on the abdomen, legs pale yellow, the hind femora tipped with dark brown. It measures only 2 to 3 mm. in length. This insect is shown by Austen to be widely distributed in the tropics, being found in India, Burma, West Africa, and Central America. The larvæ breed in decaying animal matter, such as putrid meat, decomposing shell-fish, etc.

Heusner bred out sixty-three flies from larvæ taken from an Indian's foot.

Baker (*Proc. Burma Branch Brit. Med. Assoc.*, 1891, p. 11-16) found that the maggots of this fly were passed *per anum* by a European at intervals during a period of ten months. Baker found that the larvæ fed on human fæces; from the egg stage to the deposition of eggs from the resultant brood of flies occupied twenty-two days. He concludes that they are capable of propagating, and do so while living within the human intestines. He also records the larvæ in two girls.

The larva does not seem to have been described, but Austen describes the pupa (*Trans. Soc. Trop. Med. and Hyg.*, iii, No. 5, p. 229).

Phora rufipes, Meig.

The larvæ of the "hump-backed fly" live in rotting potatoes, mushrooms, radishes, etc., and when accidentally introduced into the intestine of man can, like other larvæ, live there twenty-four hours and even more, and may set up serious gastric disturbances.

P. rufipes is the same as *P. pallipes*, Latr.

Family. Sepsidæ.

Small blackish flies, elongate, with abdomen narrowed at the base, thickened and curved downwards towards the extremity. Larvæ often found in decaying vegetables, ham, cheese, etc. The larvæ have the power of skipping; conical in form, pointed in front, truncated behind, about 5 mm. long, shiny and smooth, the anal segment with fleshy protuberances. The genus Piophila has a short proboscis and the cross-veins of the wings approximate.

Piophila casei, L.

Cheese flies. The larvæ live in ripe cheese, with which they are sometimes introduced into human beings (Meschede).

The larvæ of the cheese flies (*Piophila casei*) may pass through the alimentary canal of human beings alive, and have been occasionally referred to in cases of internal myiasis. It also breeds in dead bodies in adipose tissue. Howard records it on human excrement. It is thus possible that some of the recorded cases of this pest being passed alive may be due to eggs deposited on human fæces.

Family. Syrphidæ (Hover and Drone Flies).

Amongst the large family of *Syrphidæ* is found a section known as the *Eristalinæ* or drone flies, whose curious long-tailed larvæ are popularly called "rat-tail larvæ," on account of the end of the body being drawn out into a long telescopic tail of two segments, at the end of which are placed the breathing pores. These larvæ live in water, no matter how foul, and in liquid manure. They have occasionally been obtained in foul drinking water by human beings and from eating watercress improperly washed or from badly kept beds. Austen (*Trans. Soc. Trop. Med. and Hyg.*, iii, No. 6, p. 221) records that in the autumn of 1907 a number of the larvæ of the common drone fly (*Eristalis tenax*) were passed *per rectum* by a woman in Hampshire who had recently arrived from France. The patient had eaten a considerable quantity of watercress before leaving France. I have twice found small Eristalis larvæ clinging by their long tails on watercress served at table.

Family. **Drosophilidæ.**

Small, rather plump flies, with short, broad abdomen, with bristles on the head and legs. Often abundant in decomposing fruit, and may occur in dense masses.

Drosophila melanogaster, Br.

The larvæ of this fly occur in over-ripe fruit and in fungi, often also in human habitations, and live in substances undergoing acid fermentation (vinegar, decaying fungi, rotting fruit, in damaged spots in diseased trees), much more rarely in animal substances, and they occasionally gain access to the human intestine (for example, by the medium of sour milk). When introduced in any quantity, they cause vomiting or attacks resembling colic ; when taken in the pupal stage no unpleasant results are produced.

Family. **Muscidæ.**

Teichomyza fusca, Macq.

Syn. : *Scatella urinaria*, Rob. Desv. ; *Ephydra longipennis*, Meigen.

The larvæ live in the urine in privies. Several authors state they have found them in fresh fæces or in vomited matter. Pruvot states that they continue for three days in the stomach of rats into which they have been intentionally introduced. (Pruvot, G., "Contrib. à l'étude des larves de dipt. trouv. dans le corps humain," *Thèse de Par.*, 1882; Chatin, J., in *Comp. rend. Soc. de Biol.*, Paris, 1888 [8], v, p. 396 ; Roger, H., *ibid.*, 1851 [1], iii, pp. 88, etc.)

Homalomyia canicularis, L., etc.

Homalomyia manicata, Meig., live as larvæ in decomposing vegetable matter or in cultivated vegetables (cabbage) ; they are easily recognizable by their plumed bristles, which are situated laterally on the body segments. They obtain access fairly often to the human intestine and give rise to very uncomfortable symptoms. Cases have been recorded from Germany, Austria, France, England, North America (Wacker, in *Artzl. Intelligenzbl.*, 1883, xxx, p. 109; Florentin, in *Compt. rend. Soc. de Biol.*, Paris, 1904, lvi, p. 525 ; and other authors).

The larvæ of an allied genus (Anthomyia), which, however, does not possess plumed bristles, has been found in the external auditory meatus of a man (*A. pluvialis*, according to Danthon).

[*H. canicularis* is common to Europe and North America, and is an abundant house-fly. It is the small house-fly so often seen on windows. Besides living on vegetable matter, they have also been found in the nests of the humble bee. Larvæ of this species (fig. 405) were sent to the British Museum, taken from the fæces o a woman suffering from cancer.[1] They were found at Shrewsbury. Hagen[2] reports the larvæ of this fly as occurring alive in the urethra of a patient.—F. V. T.]

Homalomyia scalaris, Fabr.

[This is not a synonym of the above, but a distinct species.

[*H. manicata*, Meigen, is also distinct.—F. V. T.]

Anthomyia desjardensii, Macq.

This fly, allied to Homalomyia, is the cause of both intestinal and cutaneous myiasis at Bihé, Angola (Wellman, *Journ. Trop. Med. and Hyg.*, June, 1907, x, p. 186).

Hydrotæa meteorica, L.

The larvæ live in decaying vegetable substances, also in dung, and have been evacuated in some cases by man (Zetterstedt, Joseph).

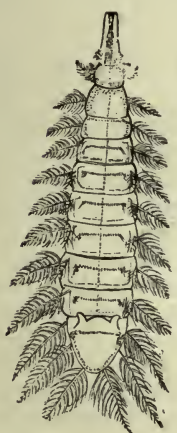


FIG. 405.—Larva of *Homalomyia canicularis*. Enlarged.

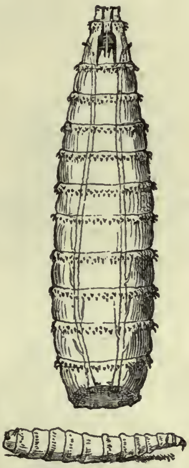


FIG. 406.—Larvæ of *Calliphora vomitoria*. Enlarged.

FIG. 407.—Larva of *Chrysomyia macellaria*. 4/1. (After Conil.)

Cyrtoneura stabulans.

Larvæ in fungi, but occasionally also on larvæ of butterflies and *Hymenoptera*; occasionally introduced into the human intestine (Joseph).

Musca domestica, L.,

and *M.* (*Calliphora*) *vomitoria*, L., and allied species; larvæ of these have been repeatedly found in the intestine and nose of man (Mankiewicz, etc.).[3]

[1] Theobald, "First Report Economic Zoology," *Brit. Mus.* (*Nat. Hist.*), p. 55.

[2] Hagen, *Proc. Bost. Soc.*, *N.H.*, xx, p. 107.

[3] "Larvæ of a Musca, probably *M. corvina*, were passed in numbers *per rectum* by a child in Liverpool with Homalomyia larvæ,"—"Second Report Economic Zoology," Theobald, 1903, p. 16.

Musca domestica, Linn. (Common House-fly).

It is not only on account of a few larvæ of the common house-fly (*Musca domestica*) being found in the intestines of man that it is of importance medically. It is far more important on account of the part it plays in the spread of diseases of the intestines, such as typhoid fever and cholera, infantile diarrhœa and dysentery.

Howard and Clark (*Journ. Exp. Med.*, 1912, xvi, No. 6, pp. 850-859) have shown that the house-fly is capable of carrying the virus of poliomyelitis for several days on the surface of the body and for several hours in the gastro-intestinal tract. The house-fly may also distribute the ova of *Tænia solium* and the white worms (Oxyuris and Ascaris). It has also been proved that they may carry the germs of tuberculosis, and it is said that they play an important part in the spread of infectious ophthalmia in Egypt.

This insect is found in all parts of the world. In warm countries it breeds all the year round, and it may do so even in temperate climates in warm places, such as stove houses. Most, however, die off in the autumn; but some survive the winter as adults, in such places as kitchens, restaurants, and warm houses. I have never failed to find a few *Musca domestica* in houses during the winter. The majority, however, hibernate as puparia.

The females deposit from 120 to 150 eggs in a batch in stable manure, rotting vegetation, house refuse, spent hops, old soiled bedding, etc. A single female may lay as many as six batches of ova during her life. The eggs are shiny white, and hatch in from eight to twenty-four hours in warm weather to three or four days in cool weather. The white footless maggots are cylindrical, tapering to a point at the head end, truncated posteriorly. The head consists of two dark mandibular hooks and two short antennæ. On the tail end are two plates, the stigmata, in which the main tracheal trunks open; in the second segment are a small pair of projecting stigmata. The larval stage lasts from seven to five days in hot weather; but in cold weather in temperate climes it may last six or eight weeks.

The larva on reaching maturity becomes a barrel-shaped puparium of a dark brown to black colour, and in this case changes to the pupa. This stage lasts from three days in the tropics to four or five weeks in cold weather, the life-cycle thus varying from ten days in the tropics to fourteen in warm weather in Europe up to three or four months under unfavourable conditions.

All breeding grounds should be burnt or otherwise done away with, such as stable manure, house and kitchen refuse, human excrement and soiled substances, also decaying vegetation as soon as possible, certainly by every sixth day. Stable manure should be kept in closed receptacles and should be removed by every sixth day to at least one mile from habitations and sprinkled with chloride of lime. All kitchen and household refuse should be burnt at once or buried in pits and covered with soil. Latrines should be as far as possible from hospitals, mess rooms and tents. Food—especially milk, sugar and fruit—should be kept screened with muslin when house-flies are about. Mess rooms and tents and hospitals should have doors and windows screened with fine wire gauze during the fly season. All possible steps should be taken to prevent them contaminating man's food and from breeding in human excrement and from entering hospitals. When present in dwelling-houses in numbers they may be killed by fumigation with pyrethrum or sulphur.

Genus. Chrysomyia, Rob. Desv.

Chrysomyia (Compsomyia) macellaria, Fabr.; Lucilia macellaria, Fabr.

Syn.: *Lucilia hominivorax*, Coq.; *Calliphora infesta*, Phil.; *Calliphora anthropophaga*, Conil.

A species distributed from the Argentine to the south of the United States which deposits its ova on ulcers, in the aural meatus or in the nasal cavities of persons who sleep in the open air. The larvæ are yellowish white, 16 mm. long, are armed with two strong mouth hooks, and provided with spinous rings (screw-worm); they lie hid in the nasal and frontal sinuses, in the pharynx, larynx, etc.; they perforate the mucous membranes, even cartilage, migrate into the eyes, the cranial cavity, middle ear, and cause severe disturbances; after the mature stage, in which the larvæ leave the host to enter the pupal state, these symptoms often spontaneously

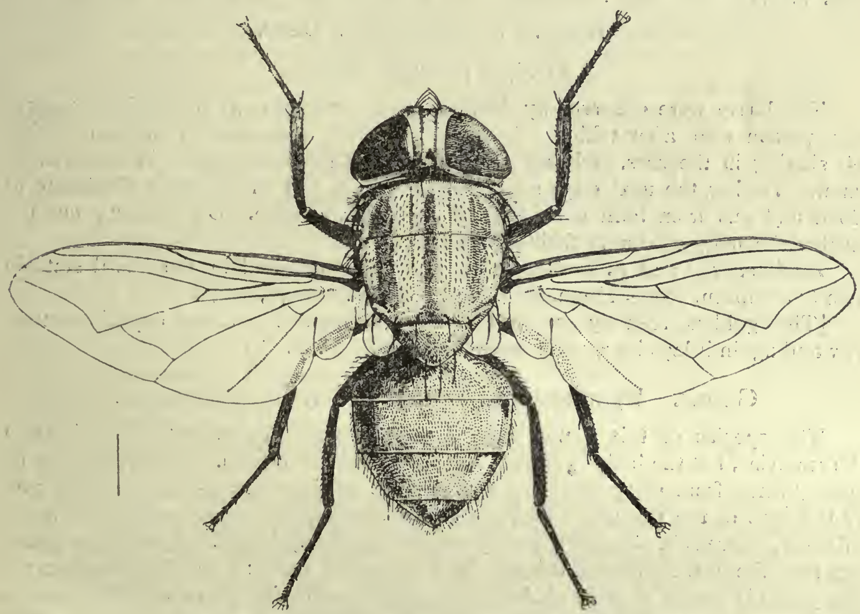


FIG. 408.—The screw-worm fly (*Chrysomyia macellaria*).

abate after a lapse of eight days, leaving behind greater or less cicatrices, and consequently also defects in function of the organs attacked. Very often, however, sepsis sets in, usually with a fatal termination.

(Coquerel in: *Arch. gén. de méd.*, 1858 (5), p. 513; 1859, xiii, p. 685; *Ann. Soc. ent. France*, 1858 (3), vi, p. 171; 1859, vii, p. 234. Weber in: *Rec. de mém. de méd. milit.*, 1867 (3), xviii, p. 159. Francius, A., in: *Arch. f. path. Anat.*, 1868, xliii, p. 98. Conil in: *Bol. Acad. nac. cienc. Cordoba*, 1881, iii, p. 296. Humbert, Fr., in: *Proc. U.S. Nat. Mus.*, 1883, vi, p. 103; *Amer. Nat.*, 1884, xviii, p. 540. Lindsay in: *Journ. Trop. Med.*, 1902, v, p. 220, and other authors.)

[This species is known as the screw-worm fly. It attacks animals as well as man, especially laying its eggs on wounds formed by barbed wire. It may also be found on dead flesh. Dr. St. George Gray sent me specimens from St. Lucia, from the nose and mouth of a patient in Victoria Hospital. Others were found in the vagina of another patient. Out of the four patients attacked, two occupied the same bed, one after the other, and a third the next bed to it. The other case was in a more remote part of the hospital. There are numerous records of this fly attacking man. It occurs from the Argentine to Texas.—F. V. T.]

Chrysomyia viridula, Rob. Desv.

[This species is somewhat larger than the former; the body is metallic bluish-green, the dorsum of the thorax with three blackish, longitudinal stripes, and the face ochraceous; about 10 mm. long. Austen records this species from man, Dr. Daniels having bred it from larvæ from a sore on a human being in New Amsterdam, British Guiana. Dr. Laurence also bred it in Trinidad. In the latter case between 100 and 150 maggots were discharged from the nose of a woman suffering from facial myiasis (*Brit. Med. Journ.*, January 9, 1909, p. 88 + fig.). —F. V. T.]

Genus. Lucilia, Rob. Desv.

Lucilia nobilis, Meig.

The larvæ were observed by Meinert in Copenhagen in the auditory meatus of a person who, after taking a bath, fell asleep in the open air, and on waking felt singing in the ears, and had a sensation as if there were water in the auditory canal. During the next days severe pains set in, and there was a discharge of blood and pus from both ears, as well as from the nose. On washing out the meatus the maggots made their appearance.

Lucilia cæsar and *L. sericata* have also been observed in the larval state in man (Thompson, Hope, Henneberg and Calendoli, Napoli, 1907).

[This golden-green fly usually lays its eggs on decomposing organic matter; now and again it lays its eggs in wounds on man.—F. V. T.]

Genus. Pycnosoma, Brauer and v. Bergenstamm.

The species of this genus have a general resemblance to the Lucilias and Chrysomyias, but the body is stouter and the abdomen banded. The genus can be distinguished from Chrysomyia by the absence of the three thoracic stripes and by the eyes of the male, in which the facets forming the upper portion are much enlarged, whereas in Chrysomyia they are not noticeably larger. Austen also points out that the sterno-pleural bristles in Pycnosoma are 1 : 1, in Chrysomyia 2 : 1. The genus is found in tropical Asia and Africa only. All records of Chrysomyia (Compsomyia) in India must be referred to this genus. Bezzi and Stein (" Katalog der Paläarktischen Dipteren," 1907, iii, p. 543), however, regard the two as synonymous.

The larvæ are frequently found in the nostrils of man and burrow into the sinus, but normally they live on decaying animal matter.

Pycnosoma forms the so-called Indian screw-worm. Patterson (*Ind. Med. Gaz.*, October, 1909, xliv, No. 10) records the case of a woman at Tezpin, Assam, from whom as many as 100 larvæ were removed at one time, and later the left orbital cavity was found packed with hundreds of maggots; eventually the patient died. It is possible that this, however, was due to a species of Sarcophaga. Austen undoubtedly records this genus causing nasal myiasis in India (*Trans. Soc. Trop. Med. and Hyg.*, iii, p. 235). At Dehra Doon, U.P., a woman discharged 100 larvæ from her nose, with great pain in the nasal region and frontal sinuses.

The so-called " peenash," a common malady in Rajputana, is a true nasal myiasis.

Genus. Sarcophaga, Mg.

Sarcophaga carnosa, L., 1758.

Larvæ of flesh-flies provided with two claws at the anterior end, which settle on raw or cooked meat, and in the open on carcases of animals; they are often observed in man, both in the intestine (introduced with food) and in the nasal cavities, frontal sinus, conjunctiva, aural meatus, anus, vulva, vagina, prepuce, and open ulcers, often migrating further from the regions first attacked. (Gayot in *Compt. rend. Acad. Sci.*, Paris, 1838, vii, p. 125. Grube in *Arch. f. Naturg.*, 1853, xix, 1, p. 282. Legrand du Saulle in *Compt. rend. Acad. Sci.*, Paris, 1857, xlv, p. 600, and other authors.)

[This fly is viviparous. The fly varies from 10 to 30 mm. in length, and is of a general ash-grey colour; the thorax with three dark stripes, the abdomen light grey with three black spots on each segment; legs black; base of wings yellow. It also attacks animals and birds, especially geese. The genus Sarcophaga is universally distributed. The maggots are whitish or yellowish footless larvæ of twelve segments, tapering to a point in front, broadened posteriorly. There are two mouth hooks, by means of which they rasp their food. The breathing pores are at the end and consist of two groups of three slits, each surrounded by a hardened area. They pupate in their old skin, which turns brown.—F. V. T.]

Sarcophaga magnifica, Schiner, 1862.[1]

Syn.: *Sarcophaga wohlfahrti*, Portschinsky, 1875.

A species widely distributed over the whole of Europe, occurring especially in Russia (Mohilew); the presence of the larvæ in man was first observed by Wohlfahrt (1768). The larvæ settle in the pharynx, in the nose, the aural meatus, the conjunctiva, and in other regions of the human body; they also attack domestic animals and birds. As Portschinsky has shown, they cause severe inflammations, hæmorrhages and suppurations in the organs in which they occur; children are especially attacked. A number of cases have been observed also in Central and Western Europe. [The fly has a light grey abdomen with shiny black spots which do not change their shape and appearance according to the angle in which the fly is viewed.—F. V. T.]

(Wohlfahrt: "Observ. de vermibus per nares excretis," Halæ, 1768; *Nov. Act. Acad. Caes. Nat. curios.*, 1770, iv, p. 277. Gerstäcker in: *Sitzungsb. Ges. nat. Frde. Berl.*, 1875, p. 108. Portschinsky in: *Horæ soc. entom. ross.*, 1875, 1884, p. 123. Laboulbène in: *Ann. Soc. ent. France*, 1883 (6), iii; *Bull.*, p. xcii. Leon in: *Bull. Soc. des Méd. et Nat. de Jassy*, 1905, xix, p. i. Freund, L., in: *Verh. Ges. deutsch. Naturf. u. Ärzte*, Homburg [1901], 1902, ii, 2, p. 450, and other authors.) [Probably most cases of attack in Europe are due to this species.—F. V. T.]

The above cited do not exhaust the number of observations of diptera larvæ parasitic in man; there are yet to be mentioned the larvæ of *S. hæmorrhoidalis*, *S. hæmatodes* (of G. Joseph), those of *S. ruficornis* (excitants of a cutaneous myiasis in the East Indies), those of species of Eristalis (of Hanby and others), and those of *Phora rufipes* (of Kahl, of Warsaw, and others). In many cases the determination of the diptera larvæ has been omitted (or must be omitted); such is the case with diptera larvæ in the eye (Schultz-Zehden in: *Berl. klin. Wochenschr.*, 1906, p. 286. Ollendorf in: *Med. Korrespondenzbl. d. würt. ärtzl. Landesver.*, 1904, p. 1017. Kayser in: *Klin. Monatsbl. f. Augenheilkunde*, 1905, xliii, i, p. 205. Ewetzky and v. Kennel in: *Zeitschr. f. Augenheilkunde*, 1904, xii, p. 337, and other cases). Austen

[1] [The correct name for this fly is *Wohlfahrtia magnifica*, Schiner.—F. V. T.]

records several cases of myiasis due to Sarcophaga (*vide Trans. Soc. Trop. Med. and Hyg.*, 1910, iii, No. 6).

The larvæ of African *Muscidæ* have now become of greater interest; like several Oestrid larvæ they live normally in the skin of mammals, but also attack man. The knowledge of these species is certainly very insufficient, but this is not likely to be the case much longer, as medical men practising in the Colonies are giving their attention to these parasites. At the present time four distinct forms are recognized according to Gedoelst.[1]

Sarcophaga chrysotoma, Wied.

[This species is recorded as attacking human beings at New Amsterdam, British Guiana. The fly is 15 mm. long, has a golden-coloured face, three broad black thoracic stripes and ochraceous buff anal segments. It was bred from larvæ obtained by Dr. Roland from a sore on a girl's foot. It is known to occur in the Brazils and the West Indies. Another species was also bred which Austen was unable to identify.—F. V. T.]

Sarcophaga plinthopyga, Wied.

[This and other species of Sarcophaga are called "yaw flies" in Dominica, as they are believed to be concerned in the dissemination of frambœsia or yaws (Nicholls) (*vide* Austen, *Trans. Soc. Trop. Med. and Hyg.*, 1910, iii, p. 239).—F. V. T.]

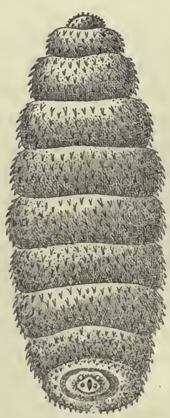


FIG. 409.—Ochromyia larva on the skin of man, South Africa. 3/1. (After Blanchard.)

Ochromyia anthropophaga, E. Blanch.; Cordylobia arthrophaga, Grünberg.

Indigenous to the Senegal and neighbouring districts; in the district of Cayor (between the mouth of the Senegal and Cape Verde) the larva is known as the "ver de Cayor." It lives under the skin, especially at the lower extremities and the lower region of the trunk, producing small boils, which cause pain, but after about eight days, when the larva leaves the body to enter the pupal stage, the pain discontinues. Besides man the larva occurs in dogs, goats, cats, and in the jackal. It is still questionable whether the fly deposits its eggs direct or on the ground, from whence the larvæ as they emerge gain access to animals and man. Larvæ yellowish-white, 14 mm. long, 4 mm. wide, eleven segments[2]; head with two globular antennæ-like appendages, two black curved mouth hooks, and two wart-shaped, finely spinous structures at their base. Body evenly covered to the seventh segment with small black prickles, which are stronger at the sides and the anterior borders of the segments; from the seventh they increase in size, on the two hindermost they are wanting; on the last segment two deep yellow spiracles, each with three markedly curved fissures; in

[1] [The following are known to cause myiasis in man in Africa: *Cordylobia anthropophaga*, Grünb.; *Auchmeromyia luteola*, Fabr.; *A. rodhani*, Gedoelst; *Oestrus ovis*, Linn.; and *Anthomyia desjardensii*, Macq. The *anthropophaga*, Blanchard, and the *depressa*, Walker, referred to here are Grünberg's *anthropophaga*.—F. V. T.]

[2] [Austen gives the length as 12 to 12·5 mm. and the breadth as 5 mm.; he describes the larva as follows: Bluntly pointed at the anterior extremity, and truncate behind; from third

addition two stigmata on the posterior border of the first segment. Duration of the larval stage about eight days. Upon the construction of roads in Guinea the larva is spread by dogs far into the interior.

Auchmeromyia (Bengalia) depressa (Walker).[1]

Distributed in the region of Natal and apparently over the whole of South Africa. The "larva of Natal," as one may still term the species provisionally, as its identity is not certain, possesses on its head (besides the mouth hooks) lateral protuberances beset with a row of chitinous spines. The cuticle of the body is spinose. The spines are difficult to recognize on account of their transparency and want of colour; they are longest over the anterior segments, from the fifth they become smaller, and over the hindermost they are very small. Apart from the foremost segment, the position they take is that of rows running transversely or obliquely, two to four generally in juxtaposition; the number of spines in the groups gradually increases posteriorly, attaining the number of eight to twelve on the sixth segment, and this number is maintained to the end of the body. Isolated spines are found over the head; over the second, third and fourth segments single ones are still found adjoining the groups of spines, from the fifth onward they are wanting. From here the spines cover the whole free surface of the segments; over the fourth the anterior three-quarters, over the third two-thirds and over the first and second only the anterior half. The stigmata found at the anterior end also serve as distinguishing characters. The parasitic stage appears to last about fourteen days. [Fuller (*Agric. Journ.*, Dept. Agric. and Mines, Natal, 1901, iv, p. 606) refers to this as *Bengalia depressa* also.—F. V. T.]

FIG. 410.—Head end of "larva of Natal." Magnified. (After Gedoelst.)

Genus. Cordylobia, Grünberg, 1903.

Cordylobia grünbergi, Dönitz.

Syn.: *Ochromyia anthropophaga*, Grünberg, *nec* Blanch.; *Cordylobia anthropophaga*, Grünberg.

Endemic in German East Africa and neighbouring regions. Larva up to 14 mm. long, 4 to 5·5 mm. wide, of cylindrical shape, slightly narrowed behind, truncated, gradually tapering in front; antennæ-like processes, cone-shaped, blunt.

---

to eleventh segments thickly covered with minute recurved spines of brownish chitin, usually arranged in transverse series of groups of two or more, which can be seen to form more or less distinct undulating and irregular transverse rows. In each of the two posterior stigmatic plates, the respiratory slit on either side of the median one is characteristically curved, resembling an inverted note of interrogation. The barrel-shaped puparium is on an average 10·3 by 4·6 mm.; its colour varies from ferruginous to nearly black.—F. V. T.]

[1] [According to Austen this is *Cordylobia anthropophaga*, Grünb. *Bengalia depressa*, Walker, is a very different insect, whose life-history is unknown.—F. V. T.]

Smaller cylindrical formations at the base of the mouth hooks surrounded by a circle of chitinous hooks. Body from the first segment covered with small brown squamous spines which are disposed in numerous irregular transverse rows. The spines are small over the two first segments, the two posterior thirds of all the segments, as well as from the eighth; over the third to the seventh they are larger, but between these there are very small spines. The breathing pores of the stigmata at the anterior end are kidney-shaped; the orifices are elongated and very tortuous, each divided into three. The larval period appears to last several weeks.

Cordylobia anthropophaga, Grünberg.

This well-known cutaneous African parasite seems to have been the cause of much confusion in regard to names. It belongs to the genus Cordylobia of Grünberg, and is one of the family *Muscidæ*, and differs from Auchmeromyia in that the second abdominal segment of the female is of normal size, whilst in Auchmeromyia it is more than half the length of the whole abdomen, and in the male the eyes are holoptic or close together, whilst in Auchmeromyia they are wide apart. The flies of this genus (three so far described) attack man in their larval stage (anyway two of the three), and also dogs and other animals, by burrowing into the skin and producing painful boils.

[*C. anthropophaga*, Grünberg, is widely distributed in Africa, extending from Senegal, where its maggot is known as the "ver de Cayor," and is referred to on p. 590 as *Ochromyia anthropophaga*, E. Blanchard, to Natal, where it is known as the "Natal worm," and referred to erroneously on p. 591 as *Bengalia depressa*, Walker.

[It is a thick-set Muscid of a general straw-yellow colour, with blackish markings on the dorsum of both thorax and abdomen, about 9·5 mm. long. The larva is fat and when mature about 12 mm. long, bluntly pointed in front, truncate behind; from the third to eleventh segments it is thickly covered with minute recurved spines of a brownish colour, arranged in transverse series of groups of two or more, which form more or less distinct irregular transverse rows. On each of the two posterior stigmatic plates, the respiratory slit on either side of the median one is characteristically curved, resembling an inverted note of interrogation. The puparium is brown to ferruginous or black and about 10 mm. long. The maggots are found in both natives and white men, and occur as a severe pest in dogs, also in monkeys, rats, and other mammals. In Sierra Leone it is called the "tumba fly." The larvæ have been frequently found as true subcutaneous parasites, each larva living singly and forming a boil or warble in the skin, with an opening just as in an ox-warble, through which the maggot breathes and eventually escapes. Although they more usually occur as isolated specimens, Marshall found in Salisbury, South Rhodesia, that sixty were extracted from one lady, and Bérenger-Féraud, in Senegal, that more than 300 occurred in a single spaniel puppy.

[Neave (*Bull. Ent. Res.*, 1912, iii, p. 217) records it from ulcers in a native at Lourenço Marques in 1908, and at the same time from ulcers in a dog, and that it is a severe pest to man in Mozambique and parts of the Transvaal. It seems to be more abundant in North Rhodesia and Nyasaland than to the north (Neave, *Bull. Ent. Res.*, 1912, iii, p. 310). It is also recorded in Zanzibar, German East Africa, Uganda, East Tropical Africa (Neave).

[Simpson (*Bull. Ent. Res.*, iii, p. 170) records a Muscid larva taken from the breast of a European in South Nigeria that was probably Cordylobia.

[It is not known how infection takes place. Neave (*Bull. Ent. Res.*, iii, p. 310) says: "Many instances in human beings would preclude the possibility of eggs having been laid direct on the skin: in these cases they have probably been laid on the clothing put out to dry.

[Gedoelst has described another species, *C. rodhani*, and Austen a third species, *C. prægrandis*, from Nyasaland, Cape Colony, Transvaal, Natal, North-west Rhodesia, and German East Africa.

[The following are some papers dealing with this subject: *Proc. Ent. Soc.*, London, for year 1907, p. xlvii; *Journ. R.A.M.C.*, 1908, pp. 5-11, figs. 1 and 2, by Austen; *Journ. R.A.M.C.*, 1908, pp. 1 and 2, by Major F. Smith; *Trans. Soc. Trop. Med. and Hyg.*, 1910, iii, pp. 223-225, by Austen.—F. V. T.]

Lund's Larva.

Endemic in the region of the Congo State; called after Commander Lund, from the skin of whose arm it was extracted; 12·5 mm. long, 4·5 mm. broad; colour yellowish, with brown rings, on account of the division of the brown spines; head cone-shaped, with two hemispherical smooth antennæ, two thick black mouth hooks and wart-shaped bodies, between which are situate two to three longitudinal rows of dark brown chitinous laminæ. The body segments are covered over their whole

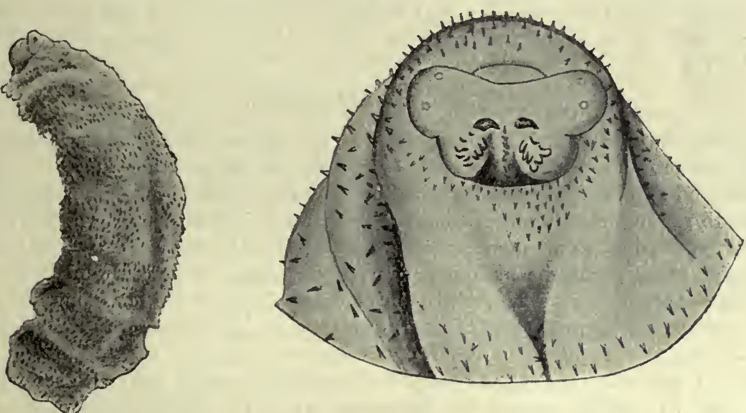


FIG. 411.—Lund's larva: on the left, the whole larva, magnified six times. On the right, the head end, much enlarged. (After Gedoelst.)

surface with irregularly distributed triangular yellow spines, the points of which are coloured dark brown. Its size increases from the second to the sixth segment, diminishes from the seventh to the ninth, at the tenth it is reduced, and at the eleventh quite small. The posterior stigmata are bean-shaped, each with three markedly tortuous openings. Duration of the larval stage unknown; the same applies to the pupal and imago stages.

Auchmeromyia luteola, Fabricius.

[This fly, the parent of the so-called Congo floor maggot,[1] belongs to a nearly allied Muscid genus to Cordylobia, but which can at once be told by the great length of the second abdominal segment. The maggot occurs in numbers in the

[1] Dutton, Todd and Christy, "The Congo Floor Maggot," *Mem. xiii Liv. Sch. Trop. Med.*, p. 40.

native huts in the Congo region and is fairly common in central and northern parts of Mozambique; it is also recorded from the Zambesi River and the vicinity of Barberton in the Eastern Transvaal (*Bull. Ent. Res.*, 1912, iii, p. 216), in German East Africa, in Nyasaland, and British East Africa. It is also recorded from Bara, Kordofan,[1] where they occurred on the floor of the men's prison and bit the prisoners. They were destroyed by sprinkling Jeyes' fluid on the floor. Neave states (*ibid.*, p. 310) that it occurs in the more neglected huts in native villages throughout tropical Africa, and frequently enters a tent when pitched near a village. It is also found in West Africa. The fly is thick-set and about the size and build of a bluebottle fly; length 10 to 12 mm.; tawny in colour to dirty yellowish-brown, with dusky hairs, giving it a smoky appearance; the flattened thorax has long dark stripes and the abdomen a dusky line in the centre of the second segment, which meets a dark line on its posterior border; the dusky third segment has a narrow yellowish anterior line; the fourth segment is also dusky; legs buff with black hairs; the fifth tarsal segment black. The larvæ are whitish, becoming reddish after a feast of blood, with much wrinkled skin and rather flat and broad. They live in crevices of the mud floor, under sleeping mats during the daytime, and come out at night and suck the blood of sleepers and then retire to shelter again. Dutton, Todd, and Christy noticed that where people slept on beds or platforms raised above the floor the maggots were not so numerous as under the sleeping mats laid on the ground. They turned up many of the maggots from a depth of three inches or more.[2] —F. V. T.]

Family. **Oestridæ.**

[The family of *Oestridæ* or warble flies are all parasitic in their larval stage, usually termed the "bot" stage. They are found as parasites in warm-blooded animals, and man is frequently attacked by them. The members of this family have the mouth rudimentary, many of them are hairy and bee-like, with large eyes and the head large, the lower part more or less swollen. The thorax is large with a distinct transverse suture, and the abdomen short and stumpy or very slightly elongated. The male genitalia are hidden, whilst the female ovipositor is often elongated. The wings may be transparent (Hypoderma) or mottled (Gastrophilus), and have muscid-like venation; the tegulæ usually large, the legs moderately long.

[As a rule each species is confined to a particular host, but as we see recorded here those that attack animals may also attack man. The flies occur in warm weather and usually during the warmest part of the day, and have a strong dislike to shade and water. The genus Hypoderma attack oxen, sheep, goats, antelope and musk deer; Oestrus, sheep, antelope and horses; Gastrophilus, the horse and ass; Cephenomyia, the deer; Cepholomyia, the camel and buffalo; Dermatobia, dogs, cats, oxen, deer, apes and man; Cuterebra and Rogenhofera, rodents and opossums.

[Some live as parasites in the stomach and intestines (Gastrophilus); others infest the skin (Hypoderma, Dermatobia and Oestromyia, the latter on *Lagomys* and *Hypodæus*); *Œdemagena tarandi* also infests the skin of the reindeer in Siberia and boreal America. Oestrus lives in the nasal sinus, and Cephalomyia in the throat as well, Cuterebra and Rogenhofera, the skin or scrotum, so that we have really three groups of parasitic oestride larvæ: (i) cutaneous, (ii) intestinal, and (iii) facial.

[No species seems confined to man, but the so-called "creeping disease," caused by Hypodermæ, and the attack of sheep nasal fly are comparatively common, as also is the Dermatobia attack.—F. V. T.].

---

[1] Balfour, *Journ. Trop. Med.*, 1909, xii, No. 4, p. 47.

[2] *Journ. Trop. Med.*, 1905, viii, No. 6, p. 90.

Cutaneous Oestridæ.

The eggs are deposited on the surface of the body; the larvæ burrow in the skin, which they reach after somewhat long peregrination.

Genus. Hypoderma, Latreille.

Hypoderma bovis, de Geer.

The cattle fly or warble fly, which swarms during the hot season, settles on the head or on the hair of grazing cattle: through the young being licked off they gain access to the mouth and are swallowed.[1] The larvæ appear first in the commencing portion of the stomach, to escape, as some state, into the preceding sections of the alimentary canal; at any rate, they are found from July onward regularly in the submucous tissue of the pharynx, in which they travel about for several months (up to November, and in isolated cases up to February); they then penetrate the muscularis and migrate by way of the subserosa along the mediastinum, the crura of the diaphragm, the renal capsules, and the intermuscular connective tissue of the psoas muscle in the direction of the spinal canal, into which they penetrate by way of the muscles and nerves, through the intervertebral foramina. Here they stay for about two to three months, then they leave the spinal canal again through the vertebral foramina and make their way (from January to March) through the intermuscular connective tissue of the muscles of the back to the skin of the back, where sooner or later (from January to June) they arrive and enter a resting stage, which commences with penetration of the skin and terminates with outward migration from the boils due to the wound set up by the maggot. At the commencement of this period the larvæ cast their skin, and their form, hitherto cylindrical, becomes oval. After about a month, a second moulting of the skin takes place—the third larval stage, which lasts about two and a half months (up to June). The approaching end of the same is indicated by a change of colour on the part of the larva from the hitherto yellowish-white to brown and finally to blackish-brown. When they have become mature the larvæ leave the warbles, drop on to the ground and pass into the pupal stage in the superficial layers of the soil within twelve to thirty-six hours. After about a month the flies emerge. Irregularities with regard to the time and direction of the migrations of the larvæ take place (Jost, H., in *Zeitschr. f. wiss. Zool.*, 1907, xxxvi, p. 644).

In a number of cases the larva of the cattle fly has been observed in the human integument, usually in the winter months, that is, during the migration period; consequently, it is not surprising that the larvæ before they enter on the resting stage and produce a warble undergo migrations. But that this takes place subcutaneously—which does not appear to be so in the case of cattle—is perhaps explained by the fact that in man, on account of the short space that has to be traversed, the larvæ are not sufficiently developed to enter on the resting stage simultaneously upon having obtained access to the integument. Whether the Oestrid larvæ in Bulgaria that similarly migrate beneath the skin in man belong to the cattle fly or to another species, or even another genus, has not yet been

[1] [This is not the case, for Carpenter has shown that muzzled calves become infected ("Mém. First Int. Cong. Ent.," pp. 289-293). Jost (*Zeitschr. f. wiss. Zool.*, 1907, xxxvi, pp. 644-715) thinks that the ova, not young larvæ, are ingested (vide note in Supplement. —F. V. T.]

ascertained. (Doctorow, in *Arch. de Par.*, 1906, x, p. 309; Spring, A., in *Bull. Acad. sci. Belg.*, 1861 (2), iv, p. 172; Walker, R., in *Brit. Med. Journ.*, 1870, i, p. 151; Kjelgaard, in *Ugeskr. f. Laeger*, 1904, p. 535; Condorelli, M., in *Bull. Soc. Zool. Ital.*, 1904, xiii, p. 171.)

Hypoderma lineata, de Villers.

The larvæ of this species, that occurs not only in Europe but in North America, live under similar conditions in the skin, very rarely in man; also migrating subcutaneously (Topsent in *Arch. de Par.*, 1901, iv, p. 609).

[In Sweden, the ox warble fly (*H. bovis*) is well known to attack man. Schoyen states "that over 100 years ago up to the present time cases of travelling grubs under the human skin in some districts of Sweden were well known." The species appeared to be *H. bovis*, many of which he had examined. They accomplished long ramblings under the skin, always in an upward direction, previous to their appearance through an opening in a tumour on the upper part of the body, on the head, neck, or shoulders. An interesting case is recorded in *Insect Life*, ii, pp. 238-239. A bot similar to *H. diana* was taken from the eye and cheek of a child at Kane, McKean County, Pa., U.S.A. It was said to have travelled in five months from the elbow to the eye. Riley later (*Insect Life*, iv, p. 310) was inclined to think the maggot was that of *H. lineata*, the common American ox warble, which is also found in Europe in great numbers. I have recorded another case in England (*Rept. Econ. Zool.* for year ending September 30, 1910, p. 128), where Dr. Menzies removed the larva of *H. bovis* from the upper eyelid of a patient. It caused considerable swelling of the face, much pain and distress; but the case did well, and the wound healed at once. The larva was nearly mature. Numerous other references to this so-called creeping disease will be found in the Supplement.

[It is quite probable that *bovis* and *lineata* are confused in the latter accounts. The larvæ are, however, easily distinguished if carefully examined.—F. V. T.]

Hypoderma diana, Brauer.

In its larval stage it lives like other species of Hypoderma, attacking the red deer (*Cervas elaphas*) and roe deer (*Cervas capreolus*); it is occasionally also found in man (Joseph, in "Myiasis externa dermatosa," Hamburg, 1800; Völkel, in *Berl. klin. Wochenschr.*, 1883, xx, p. 209).

Genus. Dermatobia, Brauer.

Dermatobia cyaniventris, Macq.

Syn.: *Dermatobia noxialis*, J. Goudot.

The genus Dermatobia represents the subcutaneous *Oestridæ* of Europe in warmer parts of America. Both domesticated and wild mammals are attacked, according to one statement birds also (*Ramphastus*), and man with fair frequency.[1] It is assumed that in all cases one and the same species is concerned, for which recently a name originating from C. Linné, jun. (*Oestrus hominis*), has been employed. Three larval stages are recognized in the skin; the two first appear to

[1] Duprey advances the opinion that Dermatobia deposits its eggs not only on the skin of man and animals, but also on the leaves and twigs in the bush, where, too, young larvæ have been met with which gain access from hence to men and animals (*Journ. Trop. Med. and Hyg.*, 1906).

resemble one another in the club-shaped or tadpole-like appearance (called macaque in Cayenne, mayacuil [mayoquil] in Mexico), the third is swollen spindle-shaped (Berne, called torcel). Segments 2 to 4 in the club-shaped larvæ are closely beset with small black spines, segments 5 to 7 bear at the anterior border a complete ring of strong black hooks, segments 4 to 6 a similar ring, which, however, is interrupted at the ventral surface. The four last segments forming the tail are smooth, only at the posterior end are there small spines. The arrangement of spines of the third stage

FIG. 412.—*Dermatobia noxialis*, Goudot.

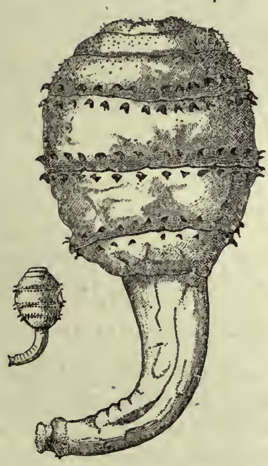


FIG. 413.—Larva of *Dermatobia cyaniventris* in its natural size and magnified. (After Blanchard.)

FIG. 414. — Larva of *Dermatobia cyaniventris*. Enlarged. (After Blanchard.)

differs from this. Italian workmen that have been employed in Brazil show the presence of Dermatobia larvæ on their return (Blanchard, in *Bull. Soc. Ent. France*, 1893, p. 24; *Bull. Soc. centr. de Méd. vet.*, 1896; *Ann. Soc. Ent. France*, 1894, lxiii, p. 142; Ward, H. B., in Mark Annivers. Vol., Article 25, p. 483, New York, 1903).

[*Dermatobia cyaniventris*, Macquart, 1843, is said not to be the same as *noxialis* (*vide* Brauer, "Mono. Oestriden," 1863, p. 266). It is known by various other names, as nuche or gusano in New Granada, the ura in Brazil, and the macaw fly in Cayenne. It occurs in Central and South America and the West Indies. According to Goudot the fly is found in great numbers on the borders of large woods and lands covered with underwood.

[It is seldom that more than one larva is found in each individual. It is generally found in the arm and leg, but now and then the face. The perfect insect has never been bred from a larva removed from a human being, so that there is still uncertainty as to the actual species. *D. cyaniventris* is 11 to 12 mm. long, has an ochraceous buff-coloured face, dark grey thorax, metallic dark blue to purple abdomen, and brownish wings. *D. noxialis* is somewhat larger.

[In the *Journal of Tropical Medicine and Hygiene*, January 15, 1905, viii, p. 23, reference is made to this Oestrid in Trinidad, where it is called the "mosquito worm." One case here recorded showed no fewer than four worms on the chin and one on the hand. It is here stated that the fly never attacks man or animals directly, as it is said to do by Scheube, but that the eggs are deposited on leaves and branches in wooded lands and forests, and thus man, hunting dogs and wild animals in passing through get the larvæ deposited on them accidentally. The affection is common in Trinidad. Mention is made that a little 1 in 40 carbolic lotion syringed into the aperture in the skin over the worm quickly killed it.

[The cattle worm, or founzaia ngómbe, is the name given to a larva which develops beneath the skin of oxen and men in Central Africa, especially amongst the natives and stock of Unyamonezi. According to P. Dutrieux, the egg is laid by a large fly that accompanies cattle. It is unknown between the central plateau or the Ugogo and the East Coast.—F. V. T.]

Cavicolous Oestridæ.

The forms belonging to this group inhabit as larvæ the nasal and frontal sinuses of ruminants, *Equidæ* and *Proboscidæ*, which they leave for the pupal stage. The larva of—

Genus. **Oestrus**, Linnæus,

Oestrus (Cephalomyia) ovis, L.,

occurring in sheep, has also been observed in man in six cases in the nose and larynx (Saitta in *Gaz. d. Osp. d. Clinic*, 1903, No. 128). So far as is known, the eggs are deposited in the nasal cavity.

[*Oestrus ovis* frequently occurs in man. MM. Sergent (*Ann. de l'Inst. Pasteur*, 1907, pp. 392-399) mention that they lay their ova on the noses, eyes and mouth of humans in Algeria whilst flying, but that they disappear after three to ten days or the inflammation produced by them. Portschinsky (*Mem. Bur. Ent. Sci. Com. Cent. Bd. Land Adm. and Agric.*, 1913, x, No. 3, p. 63) also gives cases. He doubts that ova are laid on the nose; evidently the Russian habit is anomalous, for the Sergents, Collings and myself find ova laid as a common occurrence. I have often seen them on the nose of sheep. This fly also occurs in the Argentine (Serres, in *Gaceta Rural*, April, 1913, vi, pp. 759-761).

[The tamné or thimni of the Kabyles, a human myiasis of the Tuareg mountains in the Sahara, is caused by *Oestrus ovis*. Here the larvæ are said to be ejected on to the conjunctival and nasal mucous membrane of humans.

[Ed. and Lt. Sergent (*Bull. Soc. Path. exot.*, 1913, vi, No. 7, pp. 487-488) report their attack from the Ahaggar mountains, in Central Sahara. The Tuareg name for the fly, tamné, is the Targui form of the word thimni used by the Kabyles.—F. V. T.]

Gastricolous Oestridæ.

The eggs are deposited on the hairs of *Equidæ*, and the larvæ escaping from them are licked up and swallowed. They pass their larval stage, according to the species, in various parts of the intestine and stomach, and when mature, pass out *per anum* in order to undergo the pupal stage.

Genus. **Gastrophilus**, Leach.

One of the most frequent species is *Gastrophilus equi*, Fabr.; the eggs are laid on the hairs; the larvæ live some ten months in the stomach, living attached to the inner surface. The eggs of *G. hæmorrhoidalis*, L., are deposited on the lips or the long hairs on them. The larvæ adhere to the cardiac end of the stomach, to the stomach itself, and finally to the terminal portion of the intestine. Here, however, and elsewhere in the intestine, the larvæ of *G. pecorum*, Fabr., are also met with, whilst the larvæ of *G. nasalis* (so called because the eggs are deposited in the nasal orifices) almost exclusively inhabit the anterior section of the duodenum.

Cholodkowsky attributes the "wormlet" observed by Samson and Sokolew (*Wratsch*, 1895, Nos. 48 and 57) and others (*ibid.*, 1896-98) to *Gastrophilus* larvæ. It burrows into the epidermis of man by minute passages. This observation should, however, be verified. The phenomenon is designated as skin-mole, larva migrans, and creeping eruption.

Other Papers on Dipterous Larvæ, etc., in Man.

(1) "Ein Fall von lebenden Fliegenlarven im menschlichen Magen," *Deutsch med. Wochenschr.*, Leipz. and Berl., xxiv (12), pp. 193-194. Bachmann, and review of same, "Living Fly Larvæ in the Human Stomach," *Philadelphia Med. Journ.*, 1898, i, 18, p. 773.

(2) "Sudi una larva di dittero parassita della congiuntiva umana," *Ann. di ottal.*, Paira, 1895, xxiv (4), pp. 329-336, 1 fig., E. Baquis.

(3) "Sur quelques diptères suceurs de sang, observé à Terre-Neuve," *Arch. de Par.*, Paris, 1900, iii (1), pp. 202-204, E. Barret.

(4) "An Account of the Larvæ of two Species of Insects discharged from the Human Body," *Edin. Med. and Surg. Journ.*, January 1, 1811, vii (25), pp. 41-48, 1 pl., figs. 1 to 8, T. Bateman.

(5) "Un cas de myiase par la *Sarcophaga magnifica* en Roumanie," *Bull. Soc. Zool. de France*, Par., 1891, xvi (2), pp. 25-26, R. Blanchard.

(6) "Sur les oestrides américains dont la larve vit dans la peau de l'homme," *Ann. Soc. ent. de France*, 1892, v, pp. 109-154, figs. 1-12, R. Blanchard.

(7) "Note additionnelle sur les oestrides américans dont la larve vit dans la peau de l'homme," *Bull. Soc. ent. de France*, Paris, 1894, xiv, pp. 209-211, R. Blanchard.

(8) "Note sur des larves de Dermatobia provenant de Brésil," *Bull. Soc. ent. de France*, Paris, 1893 (2), pp. 24-27, R. Blanchard.

(9) "Larven der Wohlfahrtfliege (*Sarcophila wolfahrtii*) im Zahnfleische eines Menchen," *Wratsch.*, St. Petersburg, 1888, 5-6, E. K. Brandt.

(10) "Ueber den sogenannten *Oestrus hominis* und die oftmals besichteten Verirrungen von Oestriden der Säugetheiere zum Menchen," *Verhandl. d. k. zool.-bot. Gesellsch.*, 1860, x Abhandl., pp. 57-72, Brauer.

(11) "Ueber die Larven der Gattung Cuterebra, Clk.," *Verhandl. d. k. zool.-bot. Gesellsch.*, 1860, x Abhand., pp. 777-786, Brauer.

(12) "Des désordres produits chez l'homme par les larves de la *Lucilia hominivorax*," *Thèse*, Paris, 1864, 43 pp., V. Audouit.

(13) "Note on the 'Flesh Worm,'" *Med. Press and Circ.*, London, April 12, 1882, lxxxii (N.S. xxxiii), p. 314, P. S. Abraham.

(14) "Larvas de la *Calliphora limensis* en fosas nasalis," 1855, 18 pp., F. Aguirre.

(15) "Raro caso di parasitismo nell 'uomo dovuto alla larva di una mosca (*Sarcophaga affinis*, Meigen)," *Boll. d. Soc. Rom. per gli Stud. Zool.*, Roma, 1893, iv (5-6), pp. 278-289, 1 pl., 3 figs., Giulo Alessandrini.

(16) "Observations sur l'espèce de ver nommé Macaque (Oestrus)," *Mém. Acad. Sci. par Hist.*, 1753, p. 72, F. Artur.

(17) "Contribuição ao estudo da biologia da *Dermatobia cyaniventris*," *Trav. do Inst. de Manguinhos*, 1908.

Biting-mouthed and other Noxious Diptera which may be Disease Carriers.

[Amongst the division *Brachycera* (as meant in this work) we get several groups of flies which, like the fleas and mosquitoes, are partially parasitic on man, the adults, mainly in the female sex, being provided with a piercing mouth with which they extract the blood of man and animals. The importance of these parasites is nct the mere fact that they feed upon our blood, but that they often carry germs from man to man (tsetse-flies and trypanosomiasis, *Tabanidæ* and anthrax). Amongst the most important biting-mouthed *Diptera* in this section are the following: *Tabanidæ*, or gad-flies; *Glossinæ*, or tsetse-flies; and certain other *Muscidæ*. Some of the exotic *Asilidæ* and a few *Leptidæ* also bite man.

Family. **Tabanidæ** (Gad-flies).

[The *Tabanidæ* have a broad, rather flattened body and a large head; eyes united in the male (except in some Chrysops). The antennæ are composed of three segments, have the third joint composed of five to eight annuli—in Chrysops they are fairly long. The proboscis is projecting, and sometimes much elongated. The legs are moderately stout. The venation of the wings is shown in fig. 415.

[This family of gad or horse flies contains a great number of genera, all of which may bite animals and man more or less severely. The female alone is blood-sucking, the males feed upon the juices of flowers. The females deposit their spindle-shaped white, black, or brown eggs on leaves, stems of plants that either overhang or stand in water, and amongst rushes; they are at first white, but become brown or black. The eggs are laid in rounded, flattened or conical masses composed of layers one upon the other. The larvæ are carnivorous, feeding upon snails, worms, other larvæ, etc., and have a distinct head; they are cylindrical, composed of eleven segments, the last with a vertical breathing pore, or the last two segments may form a breathing tube. The majority taper to a point at each end, in colour shining white or dull grey to yellowish, many of the larger specimens mottled or banded with dark brown or black. The first seven abdominal segments are encircled near the anterior margin with a ring of fleshy protuberances consisting of a transverse dorsal ridge which may be divided by a depression into two. The young larvæ burrow into any soft vegetable substance; they live both in the water and under damp soil surrounding water, also in damp earth generally. The larvæ are not only carnivorous, but they are cannibals, frequently devouring their own species. They may take more than a year to mature.

[The pupæ are found close to the surface of mud and earth, and are mostly dull yellowish to brown in colour, with rows of spines on the distal third of each abdominal segment; the thorax bears a pair of ear-shaped spiracular structures, and there are also six denticles at the apex of the abdomen.

[A habit common to the adults of most of the *Tabanidæ* of considerable economic importance is that of the adults coming to water to drink. Portschinsky[1] has found that by applying kerosene to the pool they frequent the adults are killed, and Hine[2] that the same oil kills the larvæ that fall into the water from eggs laid on plants above.

[*Tabanidæ* are not only of importance as purely biting insects, for they may often convey pathogenic organisms from one animal to another, such as the bacillus of anthrax, which they are known to carry, and possibly also trypanosomes in regard to man. Chrysops also acts as a host of *Filaria loa* in South Nigeria (Leiper, *Brit. Med. Journ.*, January, 1912, pp. 39-40). Two species are incriminated, *viz.*, *C. silacea* and *C. dimidiata.* With animals these flies play a more important part, for MM. Sergent, in Algeria, have proved that species of Tabanus are able to transmit three forms of animal trypanosomes by biting a healthy animal as long as twenty-two hours after having bitten an unhealthy

FIG. 415.—The ox gad fly (*Tabanus bovinus*, Linn.).

one. In India they have also been shown to transmit the parasite of "surra" in dogs and rabbits by Rogers. Other observers have since corroborated these results, and Mitzmain, who has recently performed valuable work in this connection, states that *T. striatus* is undoubtedly the carrier of this disease in the Philippine Islands. Certain members of the genus Hæmatopota have also been shown to be capable of the direct transmission of *Trypanosoma evansi.* Martoglio (*Ann. d'Ig. sper.*, 1913, xxiii, N.S., No. 3, pp. 363-366) states that the trypanosome disease of dromedaries known as salaf is transmitted by *Tabanidæ*, especially Pangonia (*P. magretti* and *P. beckeri*) in Italian Somaliland. It is quite likely that these flies play a much greater part in the spread of such diseases than is imagined at the present time.

[The *Tabanidæ* are divided into two groups or subfamilies: (1) The *Pangoninæ*,

[1] *Vide Bull.* 20, *N. Sc.*, *U.S. Div. Ent.*

[2] "*Tabanidæ* of Ohio," *Ohio State University Bull.* 19, 1903, sec. 7, p. 14.

and (2) the *Tabaninæ;* the former have spurs on the hind tibiæ and usually ocelli; the latter have neither tibial spurs nor ocelli.

[The *Pangoninæ* contain two main genera, Pangonia and Chrysops. In the former the proboscis is much elongated, and the third antennal segment is composed of eight rings, and is never angulated or ungulated at the base. The proboscis is often very long.

[In Chrysops, the so-called blinding storm flies, all the three segments of the antennæ are long, the third having only five annulations, and the proboscis short but very strong.

[There are many genera in the *Tabaninæ*, which are found in all parts of the world, of which two only are shown here—*viz.*, Tabanus and Hæmatopota. The former has the first two segments of the antennæ short, the third angulated at the base, sometimes spurred and composed of five annulations; the second has the second segment short, and the third composed of four annulations—never angulated nor spurred at the base—and the wings are adorned with grey or brown markings. These latter are usually called "brimps" and "clegs" in Britain, the former gad or horse flies, the seruts and mangrove flies of tropical countries.

FIG. 416.—The brimp (*Hæmatopota pluvialis*, Linn.).

Family. Asilidæ (Wolf Flies).

[These flies are of little importance in regard to the subject dealt with in this book; but I have notes sent concerning the biting habits of one or more species belonging to this family from the Malay States and Africa.

[*Asilidæ*, or wolf flies, are easily told by the following characters: Large or moderate-sized flies, thickly hairy; head separated from thorax by a narrow neck; eyes separated in both sexes; proboscis firm and horny, adapted for piercing; abdomen long, pointed, and composed of eight segments. Legs strong and bristly, of moderate length. Wings sometimes mottled, lying parallel over the abdomen when at rest. There are nearly 3,000 species. They live mostly upon insects, but some are said to bite animals and man. They are, however, of little importance in this respect.

Family. Leptidæ.

[This widely distributed family of flies has a few species which suck the blood of man, and the writer has been personally badly bitten in Norway by a Leptis which was apparently *Leptis scolopacea.*

[The *Leptidæ* have usually blotched wings and similar venation to Tabanus ; they are elongated flies of moderate or large size, and of dull colours. The antennæ are varied and consist of three segments, either with or without a terminal bristle or with the third segment compound, and in a few they may be almost nematocerous. The wing veins are distinct, very crowded anteriorly, the third long vein is furcate, basal cells large, and there are usually five posterior cells, the anal cell being open in some ; the squamæ are always small, sometimes only rudimentary.

[Four are known to be blood-suckers, namely the American Symphoromyia, *Trichopalpus obscurus* in Chili, and *Leptis strigosa* and *L. scolopacea* in Europe. The genus Symphoromyia has a single spur on the hind tibiæ, none on the fore or mid tibiæ, the third segment of the three-ringed antennæ kidney-shaped, and a short proboscis. In the genus Leptis the hind tibiæ have two spurs, and the third antennal segment is not reniform.

[The other biting genus Trichopalpus can be told at once by the elongated proboscis. Most of this family live upon other insects. The larvæ live in earth, decaying wood, sand, stagnant waters, and the nests of wood-boring beetles ; they are usually cylindrical and may have fleshy abdominal legs ; the anal segment has a transverse cleft, and often two posteriorly directed processes and two stigmata between them. They are all predaceous, and in one genus (Vermileo) make pitfalls in sand like the ant lions (*Myrmeleon*).

Blood-sucking Muscidæ.

[The blood-sucking *Muscidæ* are mainly contained in the following genera: Glossina, Stomoxys, Hæmatobia, Lyperosia, Stygeromyia, Philæmatomyia and Bdellolarynx.

[The first is the most important genus on account of the part it plays in the spread of trypanosome diseases. Stomoxys may also serve as a disease carrier. The remainder and a few more genera cause considerable annoyance by their bites, and may also act as occasional carriers of pathogenic organisms. All these flies have their mouth parts elongated to some extent, forming a distinct proboscis, which becomes more or less strongly chitinized ; the labella are usually serrated or spiny, and thus form a structure easily capable of piercing the skin. Unlike the *Culicidæ*, the blood-sucking *Muscidæ* have the sanguinary habit common to both sexes.

Genus. Glossina, Westwood.

[This genus contains sixteen species,[1] all of which are confined to the Ethiopian region. Glossina may be distinguished from other allied genera by the proboscis, the antennæ, wings, and male genitalia. The proboscis projects forwards and has a swollen bulb-like base to the slender labium which holds the two structures, the needle-like epipharynx and the thread-like hypopharynx ; the whole proboscis is

---

[1] This does not include *G. maculata*, Newstead, which is regarded by Austen as a synonym of *G. palpalis*, Rob. Des. ; according to this authority the curiously spotted appearance of the type and only example of *G. maculata* is due to foreign matter.

ensheathed in the maxillary palpi. The antennæ have the first two segments small, the third large with a marked pore, the orifice of the sense organ near the base; from the base of the third segment also arises the three-jointed arista, the first two segments being, however, minute; the third bears a series of from seventeen to twenty-one fine branched hairs on one side. The male genitalia or hypopygium is more or less oval and tumid, its long axis lying in the antero-posterior direction, with a vulviform median groove (the anus) running from the anterior margin to beyond the middle.

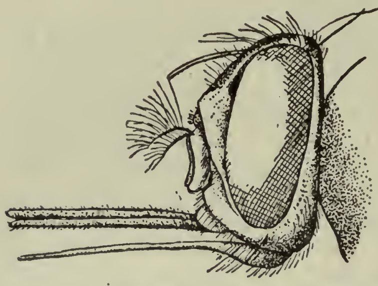


FIG. 417.—Head of *Glossina longipalpis*, Wied. (After Grünberg.)

[Newstead has shown the importance of the study of the genitalia in separating species (*vide Bull. Ent. Res.*, ii, pp. 9-36 and 107-110, and iii, pp. 355-360; and *Ann. Trop. Med. and Par.*, vii, No. 2, pp. 331-334).

[The tsetse-flies reproduce differently from all other *Muscidæ*. The female produces at each birth a single full-grown larva, which is retained within the oviduct and there nourished by the secretion of special glands, and on being born crawls to some hiding place and at once becomes a puparium.

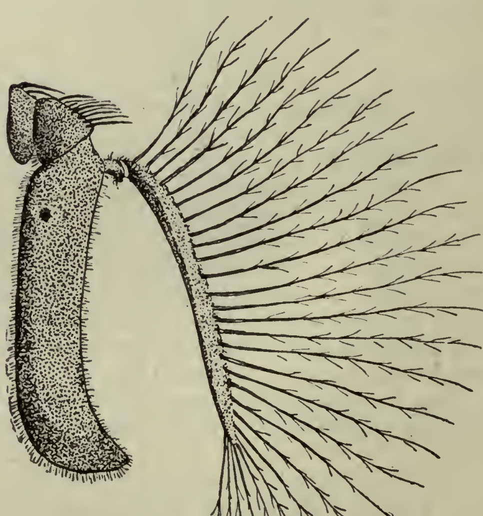


FIG. 418.—Antenna of *Glossina pallidipes*, male. (After Austen.)

[The larva is a yellowish footless maggot nearly as large as the mother's body, the skin shagreened and the anal extremity having a pair of large, black, granular prominences separated by a depression containing the breathing pores.

[The puparium is brown of various shades, the tumid lips of the larva being conspicuous, the size and shape of the lips enabling the puparia to be identified.

[These puparia are often found in masses at the base of trees, in hollows in trees and rocks just buried under vegetal debris. These insects are generally confined to definite tracts known as "fly-belts." They usually occur in damp, hot places on the borders of rivers and lakes, and never far from water in the case of the *palpalis* group, although others of the *morsitans* group may be found a considerable distance from water. They are usually absent on grass plains, but may now and then occur there (Kinghorn, *vide* Hindles' "Flies and Disease, Blood-sucking Flies," 1914, p. 274); cover of trees, shrubs, or thick reeds is essential to them.

[Their range in Africa extends roughly from 18° N. to 31° S.

[*Glossina palpalis* is the chief carrier of the more prevalent type of sleeping sickness. Two distinct types of parasites can produce this disease, *viz.*, *Trypanosoma gambiense*, which produces the ordinary sleeping sickness, transmitted by *G. palpalis*, and *Trypanosoma rhodesiense* the Rhodesian or Nyasaland sleeping sickness, transmitted by *G. morsitans*, and possibly identical with *T. brucei*, the parasite of N'agana. Koch has also shown that *G. pallidipes*, Austen, and *G. fusca*, Walker, can be artificially infected with the human trypanosome. It appears probable that Koch used *G. brevipalpis*, not *G. fusca*, in his transmission experiments, as at that time *fusca* included nearly all the large tsetses, but *brevipalpis* is its Eastern representative.

[A TABLE OF SPECIES (modified after Austen) is appended here:—

I.

Glossina palpalis GROUP.

1.	Dorsum of abdomen ochraceous buff or buff; third and following segments exhibiting sharply defined, dark brown or clove brown, interrupted transverse bands	*tachinoides*, Westwood.
	Dorsum of abdomen not so marked	2.
2.	Third joint of antennæ pale (cream buff to ochraceous buff), clothed with long and fine hair, forming a conspicuous fringe on front and hind margins	*pallicera*, Bigot.
	Third joint of antennæ entirely dark (mouse-grey) except at extreme base on outer side, and without a conspicuous fringe of long and fine hair ...	3.
3.	Dorsal surface of abdomen dark sepia brown; median paler area on second segment broad, and more or less quadrate or irregular in outline; hypopygium of ♂ buff or ochraceous buff ...	*caliginea*, Austen.
	Dorsal surface of abdomen blackish-brown; median paler area cuneate (*i.e.*, triangular in outline); hypopygium of ♂ grey	*palpalis*, Rob. Desv.

II.

Glossina morsitans GROUP.

1.	Hind tarsi entirely dark; small slender species; abdomen bright ochreous or reddish ochreous with dark lateral markings	*austenii*, Newstead.
	Hind tarsi not entirely dark; abdomen drab-grey, buff or ochreous buff with conspicuous dark interrupted transverse bands	2.

2. Last two joints of front and middle tarsi with sharply defined clove brown or black tips ... 3.
   Last two joints of front and middle tarsi without sharply defined clove brown or black tips (front and middle tarsi either entirely pale or, at most, last two joints of front tarsi faintly brownish at the tips), and last joint and distal half of penultimate joint of middle tarsi light brown, never so dark as to form a sharp contrast with the remaining joints ... ... *pallidipes*, Austen.
3. Third joint of antennæ with a distinct fringe of fine hair on front margin; dark brown or clove-brown bands on abdominal segments extending close to hind margins (*i.e.*, pale ground colour, apart from the median interspace, confined to a very narrow hind border) ... ... *longipalpis*, Wiedeman.
   Third joint of antennæ without a distinct fringe of fine hair on front margin; dark brown or clove-brown bands on abdominal segments not extending close to hind margins ... ... *morsitans*, Westwood

III.

Glossina fusca GROUP.

1. Third joint of antennæ fringed with fine hair on anterior and posterior margins; fringe on anterior margin conspicuous under a hand lens magnifying 15 diameters (nominal) when head is viewed in profile ... ... 2.
   Third joint of antennæ with fringe of fine hair on anterior margin so short as to be scarcely noticeable under a hand lens magnifying 15 diameters (nominal) when head is viewed in profile (longest hairs in fringe in length not exceeding one-sixth of width of third joint); palpi long and slender ... 3.
2. Longest hairs in fringe on front margin of third joint of antennæ, in length equal to from one-fourth to one-third (not exceeding one-third) of width of third joint; palpi of moderate length ... *tabaniformis*, Westwood.
   Longest hairs in fringe on front margin of third joint of antennæ in length equal to from one-half to three-fourths of width of third joint; palpi noticeably long and slender ... ... *nigrofusca*, Newstead.
3. Pleuræ drab-grey or isabella-coloured, hind coxæ buff or greyish-buff ... ... *fusca*, Walker.
   Pleuræ dark grey; hind coxæ mouse-grey ... ... *fuscipleuris*, Austen.

IV.

Glossina brevipalpis GROUP.

1. Dorsum of thorax with four sharply defined brown, more or less oval or elongate spots, arranged in a parallelogram, two in front and two behind the

transverse suture ; proboscis bulb with a sharply defined brown or dark brown tip ... ... *longipennis*, Corti.

Dorsum of thorax without such spots ; proboscis bulb not brown or dark brown at tip ... ... 2.

Wings with upper thickened portion of anterior transverse vein much darker in colour than adjacent veins and thus standing out conspicuously against the rest of the wing ... ... *brevipalpis*, Newstead.

Wings with upper, thickened portion of anterior transverse vein not much darker in colour than adjacent veins, and thus not standing out conspicuously against the rest of the wings (wings practically unicolorous) ... ... *medicorum*, Austen.[1]

Glossina palpalis, Rob. Desv.

[This is the chief carrier of sleeping sickness in Nature. It is found in places over the whole of West Africa from the mouth of the Senegal River to Angola, and extends eastwards into the Bahr-el-Ghazal. The eastern boundary follows the valley of the Nile and includes the eastern shores of Lakes Victoria and Tanganyika; from the southern end of the lake the boundary tends south-west, approximately following the frontier between North-eastern Rhodesia and the Congo Free State, and passing through the Katanga district of the latter country into Angola (Austen). It may occur up to 3,000 ft.; but, according to Bagshawe, it has not been recorded above 4,000 ft. It feeds on the blood of many animals, including reptiles, amphibia, birds, and even amphibious fishes, as well as all the wild mammals. It seems, however, to possess a decided predilection for man, and undoubtedly thrives better upon mammals and birds than upon cold-blooded animals.

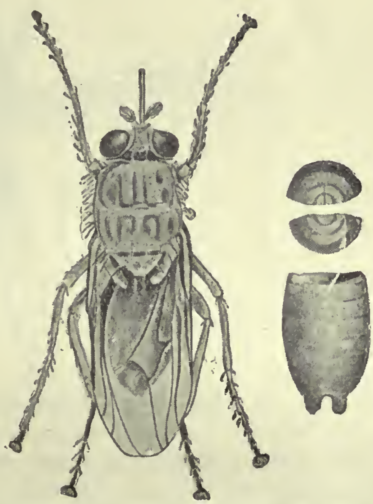


FIG. 419.—*Glossina palpalis* and puparium. (After Brumpt.)

[It is not usually found far from water, requiring a humid atmosphere and temperature of about 85° F. (shade). But a marked seasonal distribution is shown, the flies considerably extending their range during the rainy season, and thus visiting districts which are dry for the greater part of the year; as the rains diminish the fly gradually leaves the temporary haunts and returns to the more permanent ones. It bites only by day, and then only in sunny weather, and usually lives in shade.

[Roubaud has shown that the first larva produced is about three weeks after copulation, and that others are produced at an interval of nine or ten days. The puparium stage is rapidly produced after the expulsion of the larva, often in

[1] Newstead has recently described another species as *G. severini* (*Ann. Trop. Med. and Par.*, 1913, vii, No. 2, pp. 331-334). It is allied to *G. fuscipleuris*, Austen.

three-quarters of an hour. The puparium stage lasts from thirty-two to thirty-five days. The puparia occur in well-drained humus close to water, sheltered by trees or bushes, in crevices in rocks, and between the exposed roots of trees, sometimes in sand.

[Bruce has shown that only a very small percentage of flies fed experimentally on infected animals ultimately become infective, and that the infectivity of this small percentage depends upon a delayed infection of the salivary glands.

[A variety, *wellmani* of Austen, is found in Angola, Gambia, the Katanga district of the Congo Free State, the Matondwi Islands of Tanganyika, etc.

Glossina morsitans, Westwood.

[This species has been shown by Kinghorn and Yorke, and also by Bruce, to be responsible for the transmission of *Trypanosoma rhodesiense*, the micro-organism producing sleeping sickness in man in Rhodesia and Nyasaland and also in parts of German and Portuguese East Africa. Fisher and Taute have demonstrated

FIG. 420.—The tsetse-fly (*Glossina morsitans*, Westwood).

experimentally that *Trypanosoma gambiense*—the sleeping sickness parasite of other parts of Africa—may also be transmitted by this fly, and in addition it is known to be capable of disseminating several species of trypanosomes pathogenic to animals. Of these, *T. brucei* (= ? *T. rhodesiense*), the parasite of tsetse disease, first incriminated by Bruce, is perhaps the most important.

[It is the most widely spread of all tsetse-flies; its range extends from Senegambia in the north-west to Southern Kordofan and Southern Abyssinia in the north-east, and then southwards to the Bechuanaland Protectorate, North-eastern Transvaal and Zululand. The actual localities given by Austen are Gambia, French Guinea, Gold Coast, Togoland, Dahomey, Northern Nigeria, Congo Free State, the Bahr-el-Ghazal, the Uganda Protectorate, German East Africa, and Portuguese East Africa.

[This species is confined to "belts," often of very limited extent, and appears to prefer regions where there is sufficient vegetation for moderate but not excessive cover and a hot, moderately dry climate. It is not nearly so dependent upon water as is *G. palpalis*, and generally is most active in a dry atmosphere ; some observers, however, state that in certain districts it is more common along the banks and edges of rivers. This tsetse-fly has been taken as high as 5,500 ft. altitude. It infests native villages as well as the bush. Like other tsetse-flies it bites not only during the hottest part of the day, but also on bright warm moonlight nights, and it feeds on the blood of all mammals.

[The structure of the male genitalia of those representatives of *G. morsitans* occurring on the West Coast of Africa and in parts of the Soudan presents certain constant differences from that of the typical form of this species ; this form is known as *G. morsitans*, race *submorsitans*, Newst.

Genus. **Stomoxys**, Geoffroy.

[The members of this genus which occur in temperate and tropical countries are provided with a hard, slender, shiny black proboscis which projects horizontally from beneath the head; by means of this structure they can bite severely. In general appearance they resemble house flies, but the proboscis at once

FIG. 421.—The stinging fly (*Stomoxys calcitrans*, Linn.).

distinguishes them. In many parts of Britain they are known as storm flies on account of their frequent appearance indoors previous to a storm of rain or wind, which I have invariably found to be correct; they are also called stinging flies. In colour they are greyish, dusky or brownish-grey or black, varying from 5 to 7 mm. in length; the thorax has dark longitudinal stripes and the abdomen dark spots or bands. In the male the eyes are closer together than in the female. These flies usually occur in stables and farmyards, along woods and in lanes, and mainly attack mammals.

[One species (*Stomoxys calcitrans*, Linnæus) occurs practically all over the world. The female lays her eggs in moist, warm, decaying vegetation ; as many as eighty may be laid by a single female. The ova are white, banana-shaped, with a broad groove on the shorter curvature; they may hatch in two or three days. The creamy-white larva tapers to a point at the head end, and is truncated at the tail end. Two black mouth hooks are plainly visible at the cephalic extremity. There are two plates on the posterior surface of the last segment which bear the respiratory pores, nearly circular in outline. It reaches maturity in fourteen to twenty-one days; when mature it is 11 mm. long. The pupal stage is passed in the old larva skin and lasts from nine to thirteen days; it is barrel-shaped, 5 to 8 mm. long, and of a bright reddish-brown to dark chestnut-brown colour.

[This insect may act as a carrier of anthrax, and has been proved to be the agent of an extensive epidemic of malignant pustule in the Isle of Pines, New Caledonia.[1]

[Noè's[2] experiments tend to show that it is an intermediate host and transmitter of *Filaria labiato-papillosa* of the ox.

[Surra is generally stated to be transmitted by Stomoxys as well as Tabanus, and yet Nitzman in the Philippines obtained uniformly negative results in exhaustive experiments. Others have also been unsuccessful. Certainly Stomoxys can transmit the disease in French West Africa (Bonet and Roubaud), and mechanically has been proved to be capable of disseminating other trypanosomes (experimentally): sleeping sickness (*T. gambiense*); nagana (*T. brucei*); souma (*T. cazalboui*); and el debat (*T. soudanense*).

[*S. calcitrans* may also be a carrier of poliomyelitis (Rosenau and Brues, *Harvard Alumni Bulletin*, 1912, xv, No. 9, pp. 140-142). Several species are ow known (*S. brunnipes*, Grünb.; *S. inornata*, Grünb.; *S. nigra*, Macq.; *S. omega*, Newst.; *S. ochrosoma*, Speiser, etc.).

Genus. **Lyperosia**, Rondani.

[A genus of small flies which bite man and animals, but are not so far connected with the transmission of any disease in man, but in Java it appears to carry surra (P. Schat, *Meeledeel Praefstation Oost-Java*, 1903, 3e ser., No. 44), the species being *Lyperosia exigua*, Meijere. These flies can be told from Stomoxys by the palpi being broader, flattened laterally, and as long, or nearly so, as the proboscis. When not feeding the palpi enclose the proboscis, as in Glossina. They are usually about half the size of Stomoxys, and are the smallest blood-sucking *Muscidæ*. They frequently swarm around and upon domesticated animals.

[The life-history of the horn fly in America (*L. irritans*, Linn.) is well known. It lays its ova singly in freshly dropped cow-dung, and there the maggots feed, pupating in the soil beneath.

[Patton and Cragg also give some details as to the life-history of *Liperosia exigua* ("Medical Entomology," p. 375) as follows: "*L. exigua*, whose habits have been observed in Madras, usually lays twelve eggs at a time. The flies immediately return to the cow and the process is repeated when the dung is again dropped. The larvæ migrate from the dung when about to pupate, and the puparia are always found in the earth at some distance away or under the sides of the patch of dung. The fly usually hatches out in five days, though sometimes as late as the eighth. Weiss has studied the life-history of *irritans* var. *weisii* from Algeria; its larval stage lasts five days, and the flies hatch out of the puparia in another five days."

[The other biting genera of *Muscidæ*, Hæmatobia, Hæmatobosca, Bdellolarynx, Stygeromyia, and Philæmatomyia, although sometimes annoying to man, have not in any way been connected with any disease.

[The horse fly (*Hæmatobia irritans*, L.[3]) attacks cattle chiefly, but now and then man is bitten. The different species can be told from Stomoxys by the palpi being nearly as long as the proboscis.

---

[1] *Bull. des Séances de la Soc. ent. de France*, 1878, pp. cxliv, cxlv.

[2] *Atti della Reale Accad. dei Lincei, Anno CCC. Se Quinta*, 1903, xii, 2 sem. fasc., pp. 387-393.

[3] This is apparently the *stimulans* of Meigen.

[The genus **Philæmatomyia**, Austen, is intermediate between Stomoxys and Musca in structure, and between the non-blood-sucking Musca, as *M. domestica*, and the blood-sucking *Musca pattoni*, Austen, which feeds on the blood exuding from the bites of true blood-suckers. They occur in Central Africa and India, Ceylon and Cyprus (*vide* "The Life-history of *Philæmatomyia insignis*, Austen," *Ann. Trop. Med. and Par.*, 1912, v, p. 515).

[Two flies belonging to the family **Anthomyidæ** also attack man, namely :—

[*Hydrotæa meteorica*, L. (the meteoric fly). This fly attacks man as well as animals. They especially bite around the eyes and nostrils of animals, but are not so particular with man ; the head, however, is usually chosen. Linnæus called it the meteoric fly because it often forms clouds around horses' heads at the approach of rain. The Hydrotæas are usually black or blue-black in colour with bare eyes and simple abdomen, the front femora peculiarly constructed. *H. meteorica*, L., occurs in Britain.

[The members of the genus Hydrophoria, Desvoidy, also bite man.

Pupipara or **Eproboscidæ.**

[The *Pupipara* are all blood-suckers, the majority occurring as parasites on mammals and birds, where they are more or less permanent parasites. Occasionally some may attack man. They all produce their young fully formed, and they assume the pupal stage immediately after extrusion. The puparia are large. They are mostly flat, louse-like flies which may or may not be winged. In the case of Melophagus I have found the puparia are often passed by the female. The winged forms have a short quick flight, and when disturbed will seek shelter in man's hair or beard. Two main families occur : (1) the *Hippoboscidæ*, and (2) the *Nycteribiidæ*. The former occur on animals and birds, the latter on bats only, but may invade man. Two other families are known—the *Braulidæ* (bee parasites) and the *Streblidæ* (bat parasites).

[The mouth of the *Hippoboscidæ* is long and sharp, forming a proboscis. The thorax and abdomen are flat and leathery. The legs are stout and strong, and terminate in large dentate claws and other structures of use in holding on to the hair or feathers of their host when blood-sucking.

[Austen says it is probable that the *Hippoboscidæ* are descended from ancestors belonging to the *Muscidæ*, which underwent modification in bodily structure as the consequence of the adoption of a parasitic mode of life.

[Two wings are present in the true Hippoboscæ, *Hippobosca equina* (of the horse), *H. camelina* (of the camel), *H. maculata* (of oxen), and *H. capensis* (of dogs), but are absent in Melophagus, the sheep tick or ked fly (*M. ovinus*).

[In two genera, Lipoptena and Echestypus, wings are at first present, but are lost as soon as the fly finds its permanent host.

[With regard to their biting man, such is only occasional. I have known sheep shearers to be badly bitten by *Melophagus ovinus*, and have more than once been attacked myself when standing where shearing is taking place. Sharp records the grouse parasite, *Ornithomyia lagopodis*, as once biting severely a gamekeeper in Scotland. There are also records of *H. maculata* biting man in Africa and India.

[Although so far not connected with any human disease, it is interesting to note Theiler has shown that *Hippobosca rufipes*, v. Olfers, and *H. maculata*, Leach, are capable of transmitting *Trypanosoma theileri*, Laveran, the cause of gall sickness amongst cattle in the Transvaal. It is now considered, however, that *Trypanosoma theileri* is non-pathogenic, and that the cause of gall sickness is a piroplasma-like organism known as *Anaplasma marginale*. Theiler, Laveran and

Mesnil all hold this view (*vide* Laveran and Mesnil, "Trypanosomes and Trypanosomiases," second edition, 1912, p. 330).

[*Lynchia.*—Three members of this genus have been shown to transmit the non-pathogenic (?) organism, *Hæmoproteus columbæ* amongst pigeons in Algeria and S. America.

Insects and Epidemic Poliomyelitis.

[In a recent number of the *Journal of Economic Entomology*,[1] Brues and Sheppard point out the possibility of acute epidemic poliomyelitis (infantile paralysis) being an insect-borne disease. They summarize as follows :—

[Many facts connected with the distribution of cases and the spread of epidemics of this disease with histories of insects bites, suggest at least that the disease may be insect-borne. Field work during the past summer, together with a consideration of the epidemiology of the disease so far known, points strongly towards biting flies as possible carriers of the virus. It seems probable that the common stable fly (*Stomoxys calcitrans*, L.) may be responsible to a certain extent for the spread of acute epidemic poliomyelitis, possibly aided by other biting flies such as *Tabanus lineola.* No facts which disprove such a hypothesis have as yet been adduced, and experiments based upon it are now in progress.

[If the disease should prove to be common to any species of domestic animals, as is now strongly suspected, a secondary connection of ticks in spreading the disease among such animals seems probable, as has been mentioned.

[The following is some of the more important literature on *Diptera* in general : Meigen, J. W., "Syst. Besch. d. bek. europ. zweiflügligen insecten," 1818-1838, 7 vols. ; Brauer, F., "Monographie der Oestriden," Wien, 1863 ; *Idem*, "Nachtr. hiersu," *Wien. ent. Zeit.*, 1887, vi, pp. 4, 71 ; Schiner, J. R., "Fauna austriaca : die Fliegen," Wien, 1860-64 ; Löw, Fr., "Ueber Myiasis und ihre Erzeuger," *Wien. med. Wochenschr.*, 1882, xxii, p. 247 ; 1883, xxxiii, p. 972 ; Joseph, G., "Ueb. Fliegen als Schädlinge und Parasiten des Menschen," *Deutsch. med. Zeit.*, 1885, i, p. 37 ; 1887, iii, pp. 713 and 725 ; Peiper, E., "Fliegenlarven als gelegentl. Paras. d. Mensch.," Berlin, 1900 ; Theobald, F. V., "Monograph of the Culicidæ of the World," 1901-1911, 5 vols. and 1 atlas, plates ; Austen, E., "A Monograph of Glossina Tsetse-flies," 1903, 1 vol. ; Van der Wulp, "Diptera neerlandica," 1877 ; Walker, "Insecta Britannica : Diptera," 1851-53 and 1856 ; Lundbeck, "Diptera danica," 1907-12 ; Zetterstedt, "Diptera scandinaviæ," 1850 ; Theobald, "British Flies," 1892 ; Aldrich, "N. American Diptera," 1905 ; Loew and Osten Sacken, "Monographs of the N. American Diptera," 1862-63 and 1869 ; Macquart, "Diptera exotique," 1830-47 ; Rondani, "Diptera exotica et Italica," 1863-68 ; Williston, "Manual of Families and Genera of N. American Diptera," second edition ; Verrall, "British Flies." A fuller literature will be found in Peiper, as well as in Huber's "Bibliographie d. klin. Ent.," 1899, iii, Jena, in the Bibliography at the end of this work and in the *Rev. of App. Ent.* (Dulau and Co., London), where all references to modern research can be found.—F. V. T.]

---

[1] Charles T. Brues and Philip A. E. Sheppard, "The Possible Etiological Relation of certain Biting Insects to the Spread of Infantile Paralysis," *Journ. Econ. Ent.*, 1912, cciv, pp. 305-324.

ADDENDA.

Akamushi or Kedani Sickness (*vide* also p. 487).—Schuffner (Far East. Assoc. Trop. Med., *Compt. rend. Trois. Cong. Biennial*, 1913, Saigon, 1914, pp. 309-315) states he observed a peculiar fever in Deli, Sumatra, somewhat resembling typhoid. This he traced either to a mite or tick. He figures the possible carriers, namely, a Trombidium and *Cheyletidæ*. He calls this disease pseudo-typhus—a variant of Japanese kedani sickness, which, he says, also occurs in the Philippines.

Ticks.—AFRICAN TICK FEVER: Marzinovsky (*Proc. of Conference of Bacteriologists and Representatives of Medical Sanitary Authorities on the Campaign against Infectious Diseases in connection with the War, Soc. Russ. Physicians in mem. Pirosov*, Moscow, 1915, pp. 56-68), states that African tick fever has been imported into Persia, and that it is there carried by *Ornithodorus tholosani*.

TICK PARALYSIS: Todd ("Paralysis and Tick-bite," *Can. Med. Assoc. Journ.*, 1914, iv, No. 9, pp. 825-826) refers to paralysis ascribed to the bites of ticks in children, and possibly adults, in America, British Columbia and Australia. He states that a young child, perfectly well one day, has more or less complete paresis or paralysis on the next, fever, a rapid pulse, and other constitutional symptoms. The child may be dull and stupid, and may have convulsions. If the tick is not found and removed the child may die, but if it is removed, the symptoms disappear and recovery is complete in a few hours. The tick must be entirely removed.

Diptera.—PSYCHODIDÆ: Bolt (*China Med. Journ.*, Shanghai, xxix, No. 2, pp. 78-86) states that sand-flies (Plebotomus) and the fever due to them are common in North China, May and June being the worst months. The natives of the region appear to be immune, but all others suffer. Old ruined buildings are the favourite haunts of the Phlebotomus. The species of Phlebotomus has not been determined.

Pulicidæ.—DERMATOPHILUS (SARCOPSYLLA) PENETRANS, OR THE "JIGGER."—This flea (*vide* p. 544) is believed by Lama (*Giorn. Ital. Mal. Ven.*, Milan, 1914, xlix, pp. 465-472) frequently to carry leprosy and he points out that the early lesions of leprosy usually appear on the uncovered parts of the body. This flea also attacks rats.

Brachycera.—LEPTIDÆ (*vide* p. 603): White, A. ("The *Diptera-*

Brachycera of Tasmania," part I, *Papers and Proc. Roy. Soc. of Tasmania for* 1914, 1915, pp. 35-74), describes a new blood-sucking Leptid, *Spaniopsis tabaniformis*, which resembles a small gad fly (Tabanus) in appearance.

Pycnosoma putorium: This is believed by Roubaud ("Les Producteurs de Myiases et Agents similaires chez l'homme et les animaux," Paris, 1914, part I) to be largely concerned in the spread of amœbic dysentery in French West Africa.

Lucilia argyrocephala, Macquart: This green-bottle fly is described by Roubaud as producing myiasis in Africa ("Les Producteurs de Myiases et Agents similaires chez l'homme et les animaux," 1914, Paris, part I). It attacks ulcers and sores in man and animals.

Auchmeromyia luteola, Fabr.: Schwetz (*Ann. Trop. Med. and Par.*, 1914, viii, No. 3, pp. 497-507), collected a large quantity of this insect at Kabinda. He placed them in flasks with sand and a few days later they pupated, and in fifteen days several flies hatched out. The larval period varies from an unknown minimum up to several months. The larva may live for at least two months without food. A female oviposited on the 17th, and on the 18th one larva hatched. The pupal stage seems to last eight to fifteen days. The larvæ appear to bite by day as well as night according to native information.

Cordylobia anthropophaga, Grünb.: Roubaud ("Etudes sur la Faune parasitaire de l'Afrique occidentale française," part I, "Les Producteurs des Myiases et Agents similaires chez l'homme et les animaux," Paris, 1914) gives the life-history of this species. One fly laid 150 ova in a glass vessel, on the sides, and on some rotten fruit, and died the following day. He found that fifteen larvæ just hatched placed on sand in a glass vessel with a guinea-pig gave rise to characteristic tumours on the ventral surface of the body and the anus. Other experiments failed. It thus seems that infection takes place from larvæ which have hatched apart from the host. Infection of man is regarded as accidental; no positive infection of horses, oxen, sheep or pigs is known—it is rare in goats, and poultry never seem to be attacked. The result of experiments tends to show that the apparent choice of a host is mainly a question of body temperature. The larva, whether freshly emerged or eight to ten days old, penetrates the skin immediately, boring obliquely between the epidermis and dermis. Once removed from the tumour the maggot cannot bore again. The first moult takes place about three days after penetration, and the total period of residence in the host is seven to eight days. Upon emerging the larva falls to the ground and buries itself. In two or three days it pupates and this stage lasts no longer than twenty days. High temperatures, such as 95° F., appear to be fatal.

Myiasis.—Coates, G. M., "A Case of Myiasis Aurium accompanying the Radical Mastoid Operation," *Journ. Amer. Med. Assoc.*, Chicago, Ill., 1914, lxiii, pp. 479-480: Apparently *C. macellaria*, forty to fifty coming away with the gauze after the operation.

Huber, G. U., and Flack, F. L., "An Unusual Case of Screw-worms in the Nose and Nasal Accessory Sinuses," *Journ. Amer. Med. Assoc.*, Chicago, 1914, lxiii, pp. 2288-2289.

Auricular Myiasis.—Francaviglia, M. C., "An cora sulla myiasi auricolare," *Boll. Sedute Accad. Gioenia*, Catania, 1914, No. 31, pp. 15-23. This writer mentions the following parasites in the human ear: *Sarcophaga carnaria*, L.; *Wohlfartia magnifica*, Schiner; *Chrysomyia macellaria*, F.; *Calliphora vomitoria*, L.; and *Anthomyia pluvialis*, L. He refers to a severe myiasis in Russia, due to a fly variously recorded as *Sarcophaga wohlfarti*, Rond.; *S. ruralis*, Meig.; or *Sarcophila meigeni*, Portsch. These are all probably synonyms of *W. magnifica*. *Chrysomyia macellaria*, in Central America and South America, is quite as harmful as *S. carnaria*, causing perforation of the tympanum and meningitis. *Lucilia nobilis* and *L. cæsar* have also been incriminated. Of the sub-family *Anthomyinæ*, the larvæ of *Fannia scalaris*, Meig., *F. canicularis*, Meig., *F. incisurata*, Zett, and *Hydrotæa meteorica*, L., are chiefly associated with myiasis. He recommends, if the larvæ are outside the tympanum, an injection of chloroform vapour by a few drops of water saturated with chloroform, by an emulsion of 5 per cent. carbon bisulphide or with benzine. When detached they may be removed with forceps or a solution of boric acid. If the tympanum has been perforated, the larvæ must be removed at once.

Francaviglia also records the larva of *Oestrus ovis* in the human ear (*Boll. Sedute Accad. Gioenia*, Catania, 1914, No. 31, pp. 23-27).

Body, Head, and Clothes Lice. — Lobaczewski (*Wien. klin. Wochenschr.*, Vienna, 1915, xxviii, pp. 373-374) recommends the impregnation of body linen with a 30 per cent. solution of oleum betæ in 96 per cent. alcohol as an efficient method of keeping the body free of lice. But the process must be renewed each time the linen is washed and it takes fifteen minutes to carry out. On adding the oil to the alcohol, a portion of the former is precipitated, the supernatant fluid is decanted and poured over the linen, which is wrung out in it and dried. The garments retain their lice-proof properties until washed. Three days after wearing the clothes thus treated no lice remain on the body.

Portnikov, *Proc. of Conference of Bacteriologists and Representatives of Medical Sanitary Authorities on the Campaign against Infectious Diseases in connection with the War, Soc. Russ. Physicians in mem. Pirosov*, Moscow, 1915, p. 131).

Pediculus capitis and *Phthirus pubis* are shown to be successfully controlled by applying spirit extract of sabadilla and both white and grey mercury ointment, solution of corrosive sublimate of a strength of 1 in 250 to 1 in 100, amyl and ethyl alcohol, benzine, chloroform, carbon tetrachloride, methane, birch tar, liquid of malinin, etc. The control of *Pediculus vestimenti* by the mixture of tartaric acid and sodium sulphite slightly moistened with water is advised. It is placed in small linen bags underneath the shirt; the heat of the body produces a reaction which continues for two days, giving off a large amount of SO_2, which spreads beneath the shirt and kills all the parasites but does not affect the skin. Marzinovsky, in the same *Proceedings* (pp. 56-68), gives a number of remedies for *Pediculus vestimenti* (called *humanus*), and mentions quinine or mercury, which latter the natives in Turkestan carry on their hands and legs in bracelets soaked in mercury compounds. He also mentions ethereal oils, the most effective being clove oil, eucalyptus, oil of anise and camphor. He recommends for disinfecting clothing for army purposes the chamber used by the Japanese on a large scale. Kummerfelds' wash is advised, and is prepared as follows: 20 parts of precipitated sulphur are incorporated in a mortar with 50 parts of glycerine; 2 parts of camphor are separately ground with 50 of eau-de-Cologne and 20 of borax, and 870 parts of distilled water are added; the whole is mixed together and 3 drops of an extract of musk are added; shake in order to prevent the sulphur settling down; 50 parts of ether are added to the mixture. This sounds an expensive and troublesome preparation to make.

Shipley A. E., "Flowers of Sulphur and Lice," *Brit. Med. Journ.*, 1915, p. 295. It is here stated by Dr. Lounsbury that the South African troops were supplied by the Government with bags of flowers of sulphur sewn in small calico bags and secured to the underclothing next the skin as a preventive of lice. The bags were 2 in. square, one on the trunk and one against each leg. This is a generally accepted preventive, but is best mixed with equal parts of creosote and naphthalene.

Shipley, A. E., "Insects and War," *Brit. Med. Journ.*, September 19 to November 14, 1914. General advice given *re* lice.

SUPPLEMENT:

CLINICAL AND THERAPEUTICAL NOTES.

PROTOZOA.

INTRODUCTION.

THE aim of the present volume is to give an account of the animal parasites of man, the number of which is very large. The Protozoa that infest man are very important, and the literature relating to them and to the treatment of the diseases that they produce is very extensive. All that can be done in this Appendix is to give a very brief outline of some of the more recent and approved methods of treatment, for further details of which the reader should refer to standard medical works, among which the following are noteworthy :—

Allbutt and Rolleston (1907): "System of Medicine," vol. ii, part 2, "Tropical Diseases and Animal Parasites," London.

Castellani and Chalmers (1913): "Manual of Tropical Medicine" (second edition), London.

Laveran and Mesnil (1912): "Trypanosomes et Trypanosomiases" (second edition), Paris.

Manson (1914): "Tropical Diseases" (fifth edition), London.

Mense (1905): "Handbuch der Tropenkrankheiten," Leipzig.

Ross (1911): "The Prevention of Malaria," London.

Scheube (1910): "Die Krankheiten der Warmen Länder," Jena.

References to the treatments tried in many parasitic diseases can be found in the *Sleeping Sickness Bulletin* and *Kala-azar Bulletin*, both now superseded and greatly extended in scope in the *Tropical Diseases Bulletin*, published by the Tropical Diseases Bureau, Imperial Institute, London, S.W.

The following diseases, due to protozoa and allied forms, are discussed :—

I. Amœbic Dysentery.
II. Trypanosomiases.
III. Flagellate Diarrhœa and Dysentery.
IV. Leishmaniases—Kala-azar and Oriental Sore.
V. Spirochætoses — Relapsing Fevers, Yaws, Syphilis and Bronchial.
VI. Malaria.
VII. Balantidian or Ciliate Dysentery.

I.—AMŒBIC DYSENTERY.

Amœbic dysentery, due to *Entamœba histolytica* (see pp. 34-41), is present throughout the tropical world and also occurs in temperate zones.

Walker and Sellards[1] (1913) conducted important experiments with amœbæ on prisoners in the Philippine Islands. They showed experimentally that cultural amœbæ are non-pathogenic. As regards experiments with *Entamœba coli*, after feeding to twenty individuals they concluded that *E. coli* is a parasite of the human intestine but non-pathogenic and non-culturable. In a third series of experiments, after feeding with motile *Entamœba histolytica*, tetragena cysts were found in the stools later; when tetragena cysts were administered, motile *E. histolytica* were present in the subsequent stools. Some of the histolytica cases developed dysentery after a time. They lay stress on the necessity for the frequent examination of stools in order to detect carriers. The incubation period of entamœbic dysentery is usually long.

With regard to the symptomatology of amœbic dysentery, Castellani and Chalmers distinguish four types—the acute, chronic, latent, and mixed types.

The acute type has an abrupt onset; pain is felt in the lower part of the abdomen, and the motions, rarely exceeding thirty daily, are accompanied by much griping and straining. Blood and mucus are present in the motions, and occasionally greyish material, consisting of leucocytes, mucus, Charcot-Leyden crystals, amœbæ, and bacteria, sometimes with particles of tissue. Nausea and vomiting may occur, Digestion is usually deranged. The abdomen is sunken, the liver and spleen are normal, but tenderness is felt along the course of the large intestine. The urine may be diminished in quantity.

The chronic type may succeed the acute, or appear like diarrhœa, the motions being fæculent and containing mucus. Between exacerbations, constipation may occur. The number of motions may only be twelve to fourteen per diem. Gangrenous complications may occur at any time, and chronic dysentery may persist for many years.

The latent type is important, as the patients, though free from dysenteric symptoms, harbour amœbæ and act as parasite carriers. The latent condition may lead to acute attacks or to liver abscess.

The mixed type occurs where amœbic and bacillary dysentery are combined. There is much fever, nausea, and vomiting. The motions are numerous and often very offensive.

Treatment.—The most modern method of treatment, due to Leonard Rogers, is by emetine. According to Castellani and Chalmers, it is well to relieve griping and straining by either a hypodermic injection of morphia or by small enemata of 40 minims of

[1] *Philippine Journ. Sc.*, B, viii, p. 253.

laudanum in 1 oz. of mucilage of starch or by using $\frac{1}{4}$ gr. morphia or $\frac{1}{4}$ gr. codeine suppository. A dose of castor oil (ʒiv to ʒvi) with or without a few minims of liquor opii sedativus or a few doses of saline may be given during the first twenty-four hours. After the castor oil has acted or simultaneously, emetine treatment should be commenced; $\frac{1}{3}$ to $\frac{1}{2}$ gr. of emetine hydrochloride, dissolved in sterile normal salt solution, is injected hypodermically three times a day for two or three days.

If emetine cannot be obtained, 5 gr. doses of ipecacuanha every three to six hours in the form of membroids, or as pills coated with salol or keratin, can be substituted.

After acute symptoms have disappeared, intestinal irrigations once or twice daily, on alternate days, are useful. A solution of tannic acid (3 to 5 per 1,000) or of quinine bihydrochloride varying in strength from 1 in 5,000 to 1 in 750 is very slowly injected in quantities of $\frac{1}{2}$ to 3 pints by means of a long, soft, rectal tube.

For gangrenous dysentery Castellani and Chalmers state that appendicostomy, with irrigation of the whole lower bowel with quinine lotion (1 in 1,000) or collargol (1 in 500), is the only chance.

The use of emetine should be continued in smaller doses after the dysenteric symptoms have ceased, in order to prevent relapses and as a possible safeguard against the development of a liver abscess.

Recently (July, 1914), Dr. W. E. Deeks[1] has given an account of his successful procedure in dealing with the dysenteries in the Ancon Hospital, Panama Canal Zone, of which medical clinic he is the chief. With regard to amœbic dysentery he advocates: (1) Rest, to increase the patient's resistance; (2) a generous milk diet, which is practically all absorbed before it reaches the large bowel; (3) saline or plain water irrigations, one to three daily; (4) the administration of bismuth sub-nitrate in heroic doses; 180 gr. is given mechanically suspended in about a tumbler of plain or effervescent water every three hours, day and night in severe cases, only lessening the amount when improvement takes place. Mechanical suspension in a large quantity of water is essential. When the stools begin to decrease in number and the tongue becomes clean, the number of doses is reduced to three or four daily. In very chronic cases one or two doses daily for a month after convalescence are recommended.

In exceptional cases of extreme emaciation and exhaustion, showing marked toxic symptoms, surgical treatment is necessary, and at Ancon a wide, open cæcostomy is performed.

The treatment of dysentery with bismuth sub-nitrate has been in use for some years at Ancon. Latterly, a combined treatment by hypodermic injections of emetine and bismuth sub-nitrate by the

---

[1] *Annals Trop. Med. and Parasitol.*, viii, pp. 321, 353.

mouth has been used, and the authorities there consider that it is better to combine the two drugs rather than use each singly. Emetine probably acts as a direct poison to the amœbæ, while the bismuth probably acts by destroying the symbiotic organisms necessary for their growth.

With regard to preventive measures, all drinking water should be filtered and boiled, and uncooked vegetables and salads avoided. Scrupulous care with regard to personal cleanliness, and avoidance of touching the mouth or lips after contact with dysenteric patients, are essential. Isolation of parasite carriers is of great use in combating and controlling outbreaks of amœbic dysentery. The pollution of soil and water must be rigorously prevented.

Liver abscess due to amœbæ must be localized by exploratory punctures, and then opened and drained. Intramuscular injections fo emetine hydrochloride, $\frac{1}{6}$ gr. to $\frac{1}{2}$ gr. every day, will reduce the temperature and afford relief.

Oral endamœbiasis has been recently investigated by Bass and Johns, Smith and Barrett and colleagues (see pp. 43, 733). It responds to treatment with emetine, and $\frac{1}{2}$ gr. of emetine hydrochloride administered hypodermically each day is of service. Rinsing the mouth with a solution of fluid extract of ipecacuanha is also useful.

Rogers[1] (1915) recommends a combined treatment of emetine and streptococcal vaccines for pyorrhœa alveolaris.

II.—TRYPANOSOMIASES.

The human trypanosomiases are those occurring in Africa, due to *Trypanosoma gambiense* and *T. rhodesiense* and spread by Glossinæ, and that due to *T. cruzi*, occurring in South America and spread by the Reduviid bugs, *Triatoma* spp. These trypanosomiases present different clinical features and are best dealt with separately.

African Sleeping Sickness.

Sleeping sickness, due to *Trypanosoma gambiense* or varieties thereof, was first reported from West Africa and is now present, not only along the West Coast and in Nigeria, but throughout the Congo basin into Uganda, north of which it exists in the Bahr-el-Ghazal province of the Sudan. In Nyasaland and Rhodesia a more virulent but less widely distributed disease is produced by *Trypanosoma rhodesiense*.

There is a general similarity between the two diseases, and the symptoms as described by the leading authorities agree in the main. The malady due to *T. rhodesiense* has been known only since 1910 and the differences between the malady due to it and to *T. gambiense* will be indicated.

[1] *Ind. Med. Gazette*, April, 1915, l, p. 121.

The course of the disease may be roughly divided into three stages, the incubation, the febrile or glandular, and the cerebral stage.

The exact incubation period is not known with certainty in man. Probably, in most cases, it does not exceed two to three weeks, but disease signs may not appear for months. The bite of the Glossina gives rise to local irritation, which may be overlooked. The irritation usually subsides in the course of a few days.

The febrile, or glandular stage, is marked by attacks of fever of an intermittent type. An erythematous eruption is often found on Europeans. This rash begins as irregularly shaped pinkish patches which clear in the centre until a ring is produced. It may occur on any part of the body but is more frequent on the trunk. A typical symptom is the enlargement of one or more of the lymphatic glands, especially those of the neck. A general, deep hyperæsthesia, known as Kerandel's sign, may be present, and if the patient strikes a limb against any hard object, a feeling of acute pain is felt, the sensation being slightly delayed. As repeated attacks of fever increase, the patient may become anæmic. The febrile stage may last for years, and cure may be brought about at this phase, but frequently, after the febrile stage has lasted some time, the cerebral stage is reached. Tachycardia is also a symptom. Auto-agglutination of the red blood corpuscles is another useful characteristic, as it is said to occur rarely in other tropical diseases, but some workers doubt its value.

The cerebral, or true sleeping sickness stage is marked by a great change in the habits of the victim, who becomes apathetic and dull, careless and dirty in habits, and begins to experience difficulty in walking. Tremors of varying degrees of severity are common and the gait is peculiar. There is usually fever with rise of temperature from 100° F. to 104° F. in the evening, becoming subnormal in the morning. For some days before death, it often becomes permanently subnormal. Congestion and œdema of the lungs, with patches of pneumonia, are not infrequently observed before death. The torpor gradually deepens, and the patient loses flesh. Frequently the lips swell and saliva dribbles. The patient usually becomes comatose and death ensues. Mania and delusions, and psychical and physical symptoms resembling those found in general paralysis of the insane, sometimes occur, and death may arise from secondary complications such as pneumonia or dysentery.

Pathologically, the disease seems to consist of a chronic inflammation of the lymphatic system. The trypanosomes reach the lymphatic glands which become inflamed, and gradually invade the blood and the cerebrospinal fluid. Sooner or later, as a result of the lymphatic disease, changes occur in the membranes and substances of the brain and spinal cord. There is round-celled perivascular infiltration of the pia-arachnoid of the brain and spinal cord. These changes cause compression of the blood-vessels, and so lessen the supply of blood to the brain and spinal cord. Further changes in the latter organs result in the production of the symptoms that have given the disease the name of "sleeping sickness."

The disease due to *Trypanosoma rhodesiense* generally runs a more rapid course than that due to *T. gambiense*. The torpor and sleepiness may not be obvious or be very slight, and the enlargement of the lymphatic glands of the neck also may not be marked or may appear to be absent. The duration of the disease often appears to be from three to six months.

Treatment is only of use if commenced in the earlier stages of the disease. The substances of most value so far are arsenic in the form of atoxyl (introduced by Wolferstan Thomas in 1905) and antimony in the form of tartar emetic. Castellani and Chalmers and Manson recommend treatment by combining the use of both substances. The combined treatment is recommended not only because both substances have been proved of service independently, but also because certain strains of trypanosomes resistant to arsenic are known, and trypanosomes can develop a resistance to arsenic. Such forms, that would not be affected by the atoxyl, are left open to attack by the antimony salt. Daniels also recommends combined arsenic and antimony treatment, and (1915) uses atoxyl and antiluetin.

Atoxyl is best given intramuscularly in 10 per cent. solution in sterile normal saline solution. Galyl is also said to have given good results.

Castellani and Chalmers recommend: (1) Manson's method of administration of atoxyl, viz., 2 to 3 gr. of atoxyl are given by intramuscular injection every third day for at least two years; or (2) Broden and Rodhain's method, 7½ gr. of atoxyl by intramuscular injection every fifth day. For the combined therapy by atoxyl and antimony they recommend the following:—"An atoxyl injection (3 gr.) is given every third day or 7½ gr. every fifth day, and sodiotartrate of antimony (Plimmer's salt) is administered daily, 2 gr. dissolved in a large quantity, of water (2 pints) by the mouth or by the rectum. Tartar emetic, however, is best given by intravenous injections, using solutions of 1 in 100 or 1 in 1,000. The dose of the drug to be given is 5 to 10 cg. per injection. It is important that none of the fluid of the injection should escape into the surrounding tissues, as a violent inflammation may result. These injections should be administered monthly on ten consecutive days for a long period."

Macfie and Gallagher (1914) injected 6 gr. of atoxyl intramuscularly every week in cases infected with *T. nigeriense* in the Eket district of Southern Nigeria.

Large doses of atoxyl were often said to cause distressing results such as optic atrophy, and when the onset of such occurred the drug was usually discontinued. However, Daniels[1] (July, 1915) points out that eye troubles, such as iridocyclitis, are symptoms of trypanosomiasis.

Other arsenical preparations such as soamin and arsenophenylglycin have been used, but less successfully than atoxyl. Fowler's solution, well diluted, has been given by the mouth when treatment by injection was not possible, the doses commencing with 5 minims and increasing to 15 minims.

Salvarsan and neo-salvarsan have also been tried for sleeping sickness. Plimmer recommended powdered antimony suspended in sterile olive oil. Ranken used precipitated metallic antimony in normal saline solution injected intravenously.

Laveran and Thiroux have recommended a combined treatment of atoxyl and an inorganic salt of arsenic such as orpiment. The orpiment is given as pills, in doses of 2 gr. of orpiment two or three times daily. Opium is added to the orpiment to prevent diarrhœa. This treatment is said to have been used in man with good results.

Trypanosoma rhodesiense seems less amenable to treatment than *T. gambiense*.

The main preventive measures seem to lie in segregation of the sick in areas not infested with Glossinæ, and in measures against these flies, such as bush clearing and destruction, to some extent, of *proved* reservoirs in big game.

South American Trypanosomiasis.

The chief clinical features of the trypanosomiasis occurring in Brazil have already been indicated (see p. 87). With regard to treatment, according to Castellani and Chalmers the indications are the same as those for African trypanosomiasis, together with treatment for hypothyroidism. Preventive measures are directed against the Reduviid bug, *Triatoma megista*, that transmits the disease. The bugs occur in numbers in the cracks of the houses of the poor of Minas Geraes, and may be destroyed by sulphur fumigation, lime-washing or whitewashing.

III.—FLAGELLATE DIARRHŒA AND DYSENTERY.

The chief causal agents are *Trichomonas hominis* (*T. intestinalis*), *Chilomastix* (*Tetramitus*) *mesnili* and allied organisms (see pp. 54 to 57), and *Lamblia intestinalis* (see pp. 57 to 60 and Appendix pp. 734 to 736).

These parasites and the associated diarrhœas occur in temperate as well as in warm climates. Probably some of the diarrhœas in India are thus caused. The same, or similar parasites occur in various Muridæ, especially rats and mice, which may act as reservoirs.

---

[1] *Journ. Trop. Med. and Hyg.*, xviii, p. 157.

(i) Mello-Leitao[1] (1913), writing from Rio de Janeiro, states that there is a primary flagellate dysentery, due to *Trichomonas intestinalis* (Leuckart) and to *Lamblia intestinalis* (Lambl), either separately or in combination. He considers it a benign disease, and the most frequent form of dysentery in young children. Trichomonas and Lamblia were found to be pathogenic to children under 3 years of age.

Escomel[2] (1913) collected 152 cases of dysentery in Peru due solely to Trichomonas. Examination of the reservoirs containing the water used for drinking purposes showed the presence of Trichomonas. After the reservoirs were cleaned no more Trichomonas was found and the cases of dysentery ceased.

Brumpt[3] (1912) described a colitis due to *Trichomonas intestinalis* in a patient returned from Tonkin.

Cases of infection by *Chilomastix* (*Tetramitus*) *mesnili*, with colitis or dysenteric symptoms, are recorded by Brumpt (1912) from France, and by Nattan-Larrier[4] (1912) from the Ivory Coast respectively.

Marques da Cunha and Torres[5] (1914) describe five cases of chronic diarrhœa in Brazilian children due to the *Chilomastix* (*Tetramitus*).

Gäbel[6] (1914) described a case of seasonal diarrhœa contracted in Tunis and caused by a Tetramitid parasite which he named *Difämus tunensis*, as the discoverer considered that it lacked an undulating membrane in its large cytostome.

Derrieu and Raynaud[7] (1914) record a case of chronic dysentery in Algeria due to a Trichomonad possessing an undulating membrane and five free flagella. The parasite was named *Hexamastix ardindelteili*, but the generic name *Hexamastix* is pre-occupied. Chatterjee's *Pentatrichomonas bengalensis* (1915) is possibly the same organism.

Treatment.—Escomel (1913), finding ipecacuanha and calomel useless, recommends turpentine for Trichomonad dysentery. Two to 4 grm. of essence of turpentine in an emulsion are given by the mouth, and enemata containing 15 to 20 drops of turpentine emulsified in the yolk of an egg to which is added a little water and tincture of opium. Derrieu and Raynaud found this treatment effective in Algeria. Smithies[8] (1912) reports two cures of cases of severe dyspepsia, in which Trichomonads were found in the stomach contents, after administration of a single dose of 50 to 60 gr. of thymol, given at bed-time, together with 2 gr. of calomel, and followed by an ounce of Carlsbad salts in the morning. The patients came from the

---

[1] *Brit. Journ. Children's Diseases*, x, p. 60.
[2] *Bull. Soc. Path. Exot.*, vi, p. 120.
[3] *Ibid.*, v, p. 725.
[4] *Ibid.*, v, p. 495.
[5] *Brazil Medico*, xxviii, p. 269.
[6] *Arch. f. Protistenkunde*, xxxiv, p. 1.
[7] *Bull. Soc. Path. Exot.*, vii, p. 571.
[8] *Amer. Journ. Med. Sci.*, cxliv, p. 82.

Southern United States, and had been in the habit of drinking unfiltered surface water in the localities in which they lived. Mello-Leitao[1] used magnesium sulphate and water or milk diet. Sometimes enemata of collargol (1 per cent.) or electrargol were required. Rosenfeld recommended calomel. Methylene blue has also been tried. Recently, Escomel[2] (1914) recommends enemata of an aqueous solution of iodine (1 per 1,000) and farinaceous diet. Lynch[3] (1915), working in South Carolina, recommends a mouth wash of saturated solution of bicarbonate of soda three times daily in oral infections. A similar solution was used as a douche in vaginal trichomoniasis.

Stiles (1913) points out that when amœbæ or flagellates are found in a large percentage (10 to 40, or even 60) of the members of a community, means should be taken to improve the methods for the disposal of the dejecta, so that the food-supply may be carefully protected against fæcal contamination. Cysts of the parasites may be air-borne or conveyed to food on the bodies of house-flies.

(ii) *Lamblia intestinalis* in man may cause diarrhœa with dysenteriform stools. The diarrhœa may be of a chronic recurrent character. The flagellate, or a variety of it, is fairly common in the digestive tract of rats and mice.

Mathis[4] (1914) gives an interesting account of cases in Tonkin. In a child, aged 3, the stools were at first glairy and blood-stained, containing many encysted Lamblia. The child's home was infested with mice. In another case, the house of the patient harboured numerous rats.

According to Mathis, prognosis is favourable, but emetine hydrochloride is without action on Lamblia. Prowazek and Werner[5] (1914), however, state that emetine will act upon the flagellates, but not upon the cysts. They recommend uzara (two tablets, three times daily) and extract of male fern as useful in certain cases. Martin Mayer (1914) found emetine hydrochloride successful in a case in the Hamburg Seamen's Hospital, but Assmy (1914) points out that a suitable diet and daily doses of magnesium sulphate are sufficient, in his experience, to effect an improvement, and he doubts the specific action of emetine. Escomel (1914) recommends milk diet, then calomel succeeded by castor oil.

According to Noc, Lamblia may also be water-borne. Healthy carriers of Lamblia cysts are known. Food should be protected from being soiled by rats and mice.

---

[1] *Brit. Journ. Children's Diseases*, x, p. 60.
[2] *Bull. Soc. Path. Exot.*, vii, p. 657.
[3] *Amer. Journ. Trop. Dis. and Prevent. Med.*, ii, p. 627.
[4] *Bull. Soc. Med. Chirurg. Indo-Chine*, v, p. 55.
[5] Beihefte z. *Arch. f. Schiffs- u. Tropen-Hyg.*, xviii, 5, p. 155.

IV.—LEISHMANIASES.

A. Kala-azar.

(i) *"Indian" Kala-azar due to* Leishmania donovani.

Indian kala-azar due to *Leishmania donovani* is a very fatal disease with a rate of mortality varying from 70 to 98 per cent. of the cases.

The incubation period is very variable and the early symptoms not well defined. The incubation period seems to range from three weeks to several months after exposure to infection. The onset seems to commence with a rigor and attack of irregular, remittent fever, which may show two remissions per day in a four-hourly temperature chart. Rogers considers the daily double remission almost diagnostic. The duration of this first attack is from two to six weeks. The spleen and liver enlarge, especially the former, and are painful and tender. Towards the end of the time the temperature declines and the first period of the disease ends. After this period an apyrexial interval occurs, which, after some weeks, ends in an attack of fever resembling the first. Periods of pyrexia and apyrexia alternate. Anæmia commences and asthenia appears and deepens steadily. The patient is now thin and wasted, the abdomen much swollen and protuberant, the ribs show clearly, the limbs are wasted and skin and tongue darker than normal. In Europeans the skin is of a remarkable earthy hue, and in natives of India darker than normal, approaching black. Intestinal disturbances, often in the form of very obstinate and intractable diarrhœa or dysenteric attacks, are common. Papular eruptions often appear, particularly on the thighs ; hæmorrhages also may occur. The disease lasts for periods varying from seven months to two years, and usually ends fatally.

Treatment, unfortunately, has not been very successful up to 1915. Manson has reported two cases of cure by intramuscular injections of atoxyl daily or every other day in doses of 3 gr. Rogers has advocated large doses of quinine, 60 to 90 gr. daily until the temperature falls and then 20 gr. daily. Castellani and Chalmers consider the best results are obtained by large doses of quinine given intramuscularly, supplemented by a course of quinine cacodylate injections or atoxyl injections. Tartar emetic should be tried (see pp. 627, 629), especially as L. Rogers (July, 1915) has had promising results in ten cases. Castellani (1914) and Mackie (1915), have also had successful results. Leishman states that the administration of red bone-marrow, either raw or in the form of tablets, may be beneficial. Good nursing and careful diet are essential, and diarrhœa or dysentery must receive the appropriate treatment.

With regard to preventive measures, the extermination of bugs and other biting insects seems to be of most service. Domestic and personal cleanliness is of great importance. Patients should be segregated. It would probably be as well if houses in which many cases of kala-azar occurred were destroyed. Dodds Price, in Assam tea gardens, moves the coolie lines 300 to 800 yards from old infected ones, with satisfactory results.

(ii) *Infantile Kala-azar due to* Leishmania infantum.

This malady is found among children, rarely in adults, along the Mediterranean littoral.

The disease commences insidiously and is often unrecognized until some intestinal disturbance occurs. The spleen is then found to be somewhat enlarged, and the case has often been regarded as one of malaria. The child becomes anæmic, suffers from diarrhœa, alternating with constipation, and has attacks of irregular fever. The spleen continues to enlarge and protrudes from under the cover of the ribs. Hæmorrhages from the nose and gums and into the skin occur. Anæmia and wasting set in. The abdomen then becomes very enlarged. The child becomes much less active both physically and mentally, and looks prematurely old. Death often occurs from exhaustion, though some cases of spontaneous recovery are known.

Treatment up till recently has been unsatisfactory. Some of the remedies tried, as quoted by Castellani and Chalmers, are 15 cg. doses of atoxyl, benzoate of mercury (2 to 4 mg. as a daily injection), thiarsol (5 to 15 mg. by subcutaneous injection), salvarsan, etc. Recently Cristina and Caronia (1915)[1] have given repeated intravenous injections of 1 per cent. aqueous solution of tartar emetic, the dose varying from 2 to 10 cg. The treatment in various cases has lasted from 15 to 40 days.

Prophylactic measures seem to lie in the destruction of infected dogs and diminishing the breeding of fleas (see p. 111).

B. Oriental Sore, due to Leishmania tropica.

Oriental sore, known under many other names (see p. 107), is a local infection of the skin due to *Leishmania tropica*. The incubation period varies from a few days to some weeks, or even months, and then one or several small itching papules appear. Each spot becomes red and shotty, the papules increase slowly in size and the surface becomes covered with papery scales. After a variable time, usually not exceeding three to four months, ulceration occurs and a yellowish secretion is exuded that soon dries into a scab. Under the scab ulceration continues by erosion of the edges, and subsidiary sores arise around the parent ulcer and usually fuse with it. Healing commences after six to twelve months. Granulation begins at the centre

[1] *Bull. Soc. Path. Exot.*, viii, p. 63.

and spreads outwards, and when healing is complete, a depressed, whitish or pinkish scar remains.

Many treatments for Oriental sore have been devised but do not seem particularly satisfactory. Castellani and Chalmers state that the scabs should be removed by boracic acid fomentations, and the ulcers thoroughly disinfected once or twice daily with a 1 per 1,000 solution of perchloride of mercury, after which an ordinary antiseptic ointment is applied.

The use of permanganate of potash has been advocated both by French and English doctors. Both large and small sores can be treated. The patient's skin around the sore is protected by a thick layer of vaseline, and the surface of the ulcer powdered with potassium permanganate, which is kept in position by a pad of gauze and a bandage. The treatment is said to cause great pain for six to eight hours, but at the most, three treatments are necessary before the sore becomes a simple ulcer, well on the way to healing. The permanganate may also be used in ointment. Excision of the ulcer when small is advisable when the site of the ulcer permits of this. According to Manson, reports on treatment by radium, salvarsan and carbon dioxide snow are decidedly promising. Mitchell (1914)[1] reports favourably on the use of carbon dioxide snow in the form of a pencil, in India. In Brazil several workers (1914) record successful results from the intravenous injection of a 1 per cent. solution of tartar emetic in distilled water. Low (1915) has successfully treated a case by direct local application of tartar emetic. Row (1912) has treated cases of Oriental sore by inoculation of killed cultures of the causal organism.

As the disease is very contagious, the slightest wound, and any insect bite, should be thoroughly disinfected with 5 per cent. carbolic acid or iodine. Destruction of bugs, lice, and other biting insects should be enforced. As dogs may contract the disease (see p. 108), it is well not to allow them in the house and not to encourage undue contact with them.

Naso-oral Leishmaniasis (*Espundia*) *due to* Leishmania tropica.

This form of Leishmaniasis has been reported from South America and recently by Christopherson[2] (1914) from the Sudan. In South America it is often called Espundia, also Buba and Forestal Leishmaniasis. The primary lesion is found usually on the forearms, legs, chest or trunk. This ulcer is of the Oriental sore type, and after some months, or even as long as two years, heals up, leaving a thick scar. While the ulcer is open, or more often after it has healed, lesions appear on the mucosa of the mouth and nose. The hard and

---

[1] *Journ. Roy. Army Med. Corps*, xxiii, pp. 440-446 (see *Trop. Dis. Bull.*, v, No. 5, p. 276).
[2] *Annals Trop. Med. and Parasitol.*, viii, p. 485.

soft palate, gums and lips all may be attacked. The mucosa of the nose is usually attacked and the cartilages become destroyed, producing great deformity. In bad cases the pharynx and larynx may become infected.

Till recently it was believed that treatment was of little use unless the case could be investigated early. Escomel considered that if the primary cutaneous lesion was excised or destroyed, further progress of the disease was prevented. When lesions have appeared on the mucosa of the mouth or nose, little could be done. The ulcers might be cauterized and mild antiseptic mouth washes used.

In 1913 Vianna, working in Brazil, introduced treatment by tartar emetic, which is now becoming more widely known and proving efficacious. Carini[1] (1914) applies it thus. Tartar emetic (that is, potassium antimonyl tartrate) in 1 per cent. aqueous solution is introduced slowly into a vein, such as the vein at the bend of the elbow, in doses of 5 to 10 c.c. daily or on alternate days according to the tolerance of the patient to the drug. Eighteen to forty injections have been used. In some of the memoirs on the subject, the drug is referred to as antimony tartrate.

The course of the disease is chronic and may last for twenty to thirty years, death usually resulting from some intercurrent disease.

At present the actual transmitter of Espundia is not known with certainty. Various sand-flies (Simulidæ) have been suspected of transmitting the disease, though so far proof is wanting. It has also been suggested that the natural food sources of some Simulidæ known to bite man, namely, certain snakes[2] and lizards,[3] are possible reservoirs of the disease.

Prophylactic measures would seem to consist in the immediate disinfection of insect bites by tincture of iodine, and by avoidance of areas known to be infested with snakes and lizards, and insects that prey on them and man indifferently. The destruction of the primary lesion as soon as detected is essential, and the isolation of advanced cases of the disease seems advisable.

V.—SPIROCHÆTOSES.

A. Relapsing Fevers.

The relapsing fevers of Europe and of America, due to *Spirochæta recurrentis* and *S. novyi* (probably a race of *S. recurrentis*), present much the same symptoms, which differ in some respects from those

---

[1] *Bull. Soc. Path. Exot.*, vii, p. 277.

[2] Lindsay (1914), *Trans. Soc. Trop. Med. and Hyg.*, vii, p. 259.

[3] Sergent (Ed. and Et.), Lemaire and Senevet (1914), *Bull. Soc. Path. Exot.*, vii, p. 577.

due to *S. duttoni*, the excitant of "tick" or "relapsing" fever in Africa (see pp. 116-122).

The incubation period of *S. recurrentis* varies from two to twelve days, during which time a very slight indisposition may be noticed. The onset is usually sudden, with severe headache, pains in the back, limbs and stomach and a feeling of weakness. There is a rise of temperature to 103° F. or 104° F., and the temperature continues high till about the sixth or seventh day. The skin is yellowish, hot and damp; a rash, disappearing on pressure, may occur on the trunk and legs, nausea is always present and thirst is usual. The liver and spleen both enlarge. The number of respirations and pulse-rate become increased. On the sixth or seventh day a crisis occurs. There is violent perspiration, with a rapid fall of temperature, pulse and respiration become normal and the patient sleeps and awakes better. Improvement continues for some days, and recovery may ensue, but usually about the fourteenth day relapse occurs, lasting usually three or four days. A second relapse is unusual. Numerous complications are known, *e.g.*, bronchitis, pneumonia, diarrhœa and dysentery.

With regard to treatment, the specific appears to be salvarsan. Castellani and Chalmers recommend salvarsan administered intravenously. Intramuscular inoculations (for example, into the buttock) of a suspension of "606" in oil can also be given. The drug is very efficacious, but large doses should not be given. An intravenous injection of 4 or 5 gr. does not give rise to unpleasant symptoms but is sufficient to effect a cure.

The incubation period for the American form of the disease is at least five to seven days, and the first attack lasts about five to six days. The treatment is by salvarsan as detailed previously.

As relapsing fever is spread by body lice and possibly by bugs, preventive measures are directed against these insects. Strict cleanliness of person, clothing, bedding and dwellings is essential. Furniture, *e.g.*, wooden bedsteads, liable to harbour such insects should not be used.

The principal and best-known relapsing fever of Africa is that excited by *Spirochæta duttoni*, and transmitted to man by ticks, chiefly *Ornithodorus moubata*. The incubation period is usually about seven days but may be longer. The patient is dull and lethargic, perspires freely and is often constipated. The temperature rises to 103° F. or 105° F., there is headache, pains in the back and limbs, general chilliness and great pain in the region of the spleen, which often enlarges. The symptoms become worse, there is a fall of temperature with improvement in the morning, and a rise, with increase of pain, in the evening. Spirochætes are now found in the blood in greater numbers. The symptoms last three to four days and end in a crisis with profuse sweating and fall of temperature below normal. The day before the crisis there is a pseudo-crisis, when the temperature falls but there is no improvement. The patient is left weak and tired. Recovery may follow, but more usually a relapse occurs. The intermission period varies; five to eight days is common. The symptoms of the relapses are like those of the first attack. The number of relapses varies, five to eleven may occur.

The treatment recommended is by salvarsan, as for the European relapsing fever.

With regard to prophylaxis, localities where ticks abound must be avoided and the parasites themselves destroyed. Native huts should be avoided. Mosquito nets, a bed well off the ground and the use of night lights are advised by Manson to avoid attacks by ticks, which are often nocturnal in their habits.

In North Africa (Algeria, Tunis, Tripoli, Egypt), and sometimes in the Anglo-Egyptian Sudan, a spirochætosis due to *S. berbera* occurs. According to Castellani and Chalmers, the incubation period varies somewhat. The fever reaches its height during the first twenty-four hours, and afterwards shows a morning remission. Jaundice is often absent, but there may be hepatic tenderness and splenic enlargement. One or two relapses usually occur. The treatment is on the same lines as for the other spirochætal fevers. Sergent and Gillot[1] (1911), working at the Institut Pasteur of Algeria, have had good results by using injections of salvarsan in doses of 0·75 to 1·0 cg. per kilogramme weight of the patient. The prophylactic measures are directed against lice and other biting insects. Personal cleanliness is most necessary.

In Asia, a relapsing fever, due to the spirochæte named *S. carteri* by Manson in 1907, producing a mortality of about 18 per cent., occurs. The symptoms have a general resemblance to those produced by *S. recurrentis*, but on the fall of temperature to subnormal on the sixth or seventh day, when profuse perspiration and polyuria occur, instead of improvement following, the patient often becomes collapsed, with a clammy skin and feeble pulse. Improvement is slow. The first relapse occurs about the fourteenth day of the attack, when the temperature may be higher than for the first attack. There are seldom more than four relapses. The treatment is by salvarsan, of which doses of not more than 5 gr. intravenously should be given. Sudden heart failure being common, Castellani and Chalmers state that cardiac stimulants should be given. Prophylaxis is the same as for European relapsing fever.

---

[1] *Bull. Soc. Path. Exot.*, iv, p. 440.

B. Yaws or Frambœsia tropica.

Yaws is essentially a tropical disease, though it is found in the tropical and subtropical zones in all parts of the world, except in the mountains and cold districts. In 1905, Castellani found the causal organism, *Treponema pertenue* (sometimes called *Spirochæta pertenuis*) (see p. 127). The disease shows three periods: (1) The primary stage, consisting of the development of the primary lesion or papule, which is usually extragenital. The papule dries into a crust beneath which an ulcer lies. (2) The secondary or granulomatous stage, which commences from one to three months after the primary lesion is first seen. It consists of a general eruption of small papules, some of which enlarge and become granulomatous nodules covered with a yellowish crust. They are common on the limbs and face. (3) The tertiary stage, in which deep ulcerations and gummatous nodules appear. Any of the tissues may be involved. Osseous lesions may occur. The disease does not appear to be hereditary; it is usually spread by contact.

The best treatment appears to be by salvarsan or neo-salvarsan. Castellani and Chalmers recommend intramuscular and intravenous injections. For intramuscular injection an alkaline or neutral solution of the drug is preferable, or a suspension of the drug in oil may be used. The dose varies from 0·3 to 0·5 grm., according to the age and sex of the patient. For use intravenously, a slightly smaller dose is required. Galyl is also being used.

In countries where frambœsia is endemic, slight skin abrasions should be carefully treated with antiseptics. Yaws patients should be isolated till cured, and their dwellings and personal possessions disinfected.

C. Syphilis.

Syphilis, due to *Treponema pallidum* (sometimes called *Spirochæta pallida*), is prevalent throughout the tropics as well as in temperate zones. The disease is amenable to treatment by salvarsan and neo-salvarsan, for administration of which see relapsing fever and yaws. Galyl is also being used with favourable results. Lambkin's mercury cream has been found useful in treating numerous cases in Uganda. The life-history of the parasite is given on p. 124, and further medical details hardly come within the purview of this book.

D. Bronchial Spirochætosis.

Bronchial spirochætosis, due to *Spirochæta bronchialis* (see pp. 122, 739) is probably of wide distribution in the tropics. The spirochætes have been found in cases of chest complaints, especially those with bronchitic symptoms. The disease may be suspected in atypical cases of pneumonia and bronchitis, and may be mistaken for incipient phthisis.

Chalmers and O'Farrell[1] (1913), writing from Khartoum, recommended rest in bed, good food and ventilation, coupled with treatment by arsenic in some form, preferably associated with glycerophosphates. These may be given by the mouth, or intramuscularly as an injection of:—

Sodium cinnamate	0·05 grm.
Sodium cacodylate	0·10 ,,
Sodium glycerophosphate	0·10 ,,

Taylor[2] (1913-14), writing from Entebbe, Uganda, prescribes arsenious acid by the mouth in increasing doses. Creosote has been used in West Africa.

VI.—MALARIA.

Malaria, known also under the names of ague, paludism, marsh fever, remittent fever, intermittent fever and climatic fever, among others, is a very widely spread disease. It is most prevalent in the equatorial regions and gradually diminishes north and south of the equator. The various malarial parasites (see pp. 155 to 172) are spread by species of Anophelines, and hence malaria is present in districts favourable to these intermediate hosts, that is, in places where there is a considerable amount of atmospheric moisture and rain, as well as heat.

The principal malarial parasites are: *Plasmodium vivax*, the agent of simple tertian fever; *Plasmodium malariæ*, the parasite of quartan malaria, and *Laverania malariæ* or *Plasmodium falciparum*, producing malignant tertian or sub-tertian malaria (and quotidian, see p. 167). These various malarial fevers present certain clinical features in common, which will be stated here (see also pp. 155 to 157). For further particulars regarding malaria in all its aspects the reader is referred to the book by Sir Ronald Ross on "The Prevention of Malaria," to the "Manual of Tropical Medicine," by Drs. Castellani and Chalmers, and to the "Tropical Diseases" of Sir Patrick Manson.

Typical malarial fevers consist of a series of pyrexial attacks which recur at definite intervals of twenty-four (quotidian), forty-eight or seventy-two hours, according to the parasite present in the patient's blood. Each attack shows three stages, a stage of rigor, a heat stage and a stage of profuse perspiration. Following on these three stages, there is an interval relatively or actually without pyrexia. Then the fever returns again. A rise of temperature, often accompanied by a general feeling of malaise, may precede the initial stage of rigor. When the latter sets in, the patient feels intensely cold, shivers violently, the skin becomes cold and the features pinched. There may be violent

[1] *Journ. Trop. Med. and Hyg.*, xvi, p. 329.

[2] *Annual Med. and Sanit. Rept.*, *Uganda*, for 1913, p. 80.

vomiting and convulsive attacks in young children. The temperature, however, is really above the normal, and continues to rise. After about an hour, the shivering abates and the heat stage succeeds it. The temperature rises rapidly, even to 106° F. The patient becomes very flushed, the pulse is rapid, headache may be intense and the skin dry and burning. This stage, that causes acute distress to the patient, may last for one or often three to four hours, and then the patient commences to perspire profusely, the clothing and bedding often being saturated with sweat. After this, the fever rapidly declines, and when the sweating ceases, the patient may feel almost well although somewhat languid. The sweating stage persists from two to four hours, so that the attack lasts as a rule from six to ten hours. After an interval of one, two or three days, a recurrence takes place. During the early part of the attack, especially at the stage of rigor, there is great splenic enlargement. At first the enlargement disappears in the interval, but in the case of repeated attacks the spleen tends to become permanently enlarged. During malarial attacks and during the intermission period, there is a great increase in the amount of nitrogen excreted by the kidneys, while the excretion of iron and bile in the fæces is increased.

Stitt[1] (1914) points out that it is characteristic of malignant tertian paroxysms that they set in with chilly sensations rather than a frank, definite chill, and that the fever is of the remittent type.

Plasmodium malariæ and *P. vivax* rarely produce marked lesions in the bodies of their hosts, as they sporulate in the circulating blood and so do not accumulate in any one organ. On the other hand, *Laverania malariæ* (*Plasmodium falciparum*) multiplies within the internal organs of its host, and consequently aggregates or clusters of the parasites occur therein. The organ in which most sporulation occurs suffers most. The liver is generally enlarged, soft and congested. The capsule of the spleen is tense, but the splenic consistency is less than normal. The bone-marrow is often dark and congested in the spongy bones and brownish-red in long bones. The blood-capillaries of the brain and spinal cord are often filled or blocked with sporulating parasites and large quantities of pigment are found in these organs. Even if the parasites are absent, the pigment is present in the endothelial cells. Pigment is found in most organs of the body.

Atypical forms of malaria may occur in which some or all of the symptoms are much modified. Irregular fevers also may be produced by successive infections by the same parasite, or by the presence of two different malarial parasites.

---

[1] "The Diagnostics and Treatment of Tropical Diseases." London : H. K. Lewis.

As regards the diagnosis of malaria, according to Manson the three pathognomonic signs are—periodicity, the effect of quinine, and the presence of the malarial parasite.

Treatment.—The great specific for malaria is quinine. It attacks the merozoites or asexual generation. The drug can be administered by the mouth, by the rectum, by intramuscular injections or by intravenous injections, the two latter methods being adopted in serious infections or where gastric complications are present. When quinine is taken by the mouth, the more soluble acid salts, *e.g.*, quinine bihydrochloride and bisulphate, are better than the sulphate, the form in which quinine is usually sold. Tablets, pills and capsules are convenient means of taking quinine but must not be old or hard, or they may pass unchanged through the body. In the case of mild tertian or quartan malaria, Castellani and Chalmers recommend the administration of a dose of quinine four hours before the sporulation of the parasite is due. Another modification is to give 10 gr. of quinine by the mouth in the morning and a second dose of 10 gr. as above. In many cases they give 5 to 10 gr. of the drug three times a day. Administration of quinine *per rectum* may be useful but they recommend intramuscular inoculation. The solutions used must be sterile, and the "sterilettes," small, hermetically sealed vials, containing 1 grm. (15 gr.) or $\frac{1}{2}$ grm. ($7\frac{1}{2}$ gr.) of quinine in solution, are recommended. A deep injection into the deltoid or gluteus muscle is usual.

For pernicious infections, intravenous inoculation with not less than 1 grm. at a time is recommended.

After the fever has subsided, the administration of quinine in smaller doses must be continued for some time, in order to avoid relapses.

Stitt (1914) writes that "there now seems to be a tendency to use the alkaloid itself instead of its salts, it having been found that the alkaloid and its very insoluble tannate are absorbed from the digestive tract equally as well as the soluble salts." Euquinine or ethylcarbonate of quinine contains 81 per cent. of quinine, but is expensive.

During malarial attacks, constipation must not be allowed. Headache can be relieved by cold applications, and perspiration must be encouraged in the early stage by hot tea, warm lime drinks, etc. After bad attacks, a change to a cooler climate is desirable, but the quinine treatment must not be discontinued.

Preventive measures take two main forms, directed respectively against the malarial parasites in man, and against the mosquitoes that convey the parasite from man to man.

With regard to man, houses should be built away from low-lying marshy ground, and kept free from vegetation such as grass or brush which furnishes shelter to the mosquitoes. In the tropics, the chief reservoirs of the malarial parasites are the native children, hence European quarters should be away from native dwellings as far as possible. Mosquito nets, having twenty to twenty-four meshes per square inch, should be used invariably, and houses should be screened. Malaria-conveying mosquitoes bite chiefly towards evening. Quinine treatment for preventive purposes is important. A dose of 5 gr. of quinine daily, with a dose of 10 gr. on the seventh day (Castellani), is efficacious. Some workers, however, recommend a large dose (15 gr.) on two consecutive days every eight or ten days for three months, while others recommend 10 gr. twice a week. Celli administered 3 gr. of quinine morning and evening.

The second line of attack is directed against mosquitoes, especially Anophelines, on the lines so well set forth by Sir Ronald Ross.[1] The accumulation of small quantities of water in various vessels, many of them unnecessary, should be prevented, as *Stegomyia* (Culicines) breed in such receptacles. Anophelines breed in small pools. All drinking water and household vessels, water-butts and cisterns must be effectively screened with wire gauze. Cesspools, etc., must also be screened, and they, and all collections of water, should be oiled with crude petroleum sprays every week or ten days, or fortnight according to some workers. The petroleum is a good larvicide and suffocates the Anopheline larvæ, while its presence renders the site obnoxious to the adult mosquitoes. The amount of crude petroleum or kerosene will vary according to the locality concerned, due regard being paid to its powers of spreading on the surface treated. Different authorities have used different quantities, such as 1 oz. of oil to 1 square yard or to 15 square feet. Others have used 1 pint of the petroleum to a circle of 20 feet in diameter, while ½ pint for every 100 square feet of surface has also been recommended. The larvicide used so successfully in Panama consisted of :—

	Average mixture
Crude carbolic acid (containing 15 per cent. phenol) ...	300 gallons
Caustic soda	30 lb.
Resin	200 lb.

One part of this mixture in 5,000 parts of water containing mosquito larvæ destroys them within five minutes; 1 part in 8,000 of water kills larvæ in thirty minutes. Small fish, such as the "millions" fish, that feed on the larvæ, can be introduced into collections of water and are of local service. Ducks may also act as destroyers of larvæ. The growth of water-weeds and rank vegetation, that affords shelter to the larvæ, must be prevented as far as possible.

Wherever possible hollows should be filled up, swamps and roads

[1] "The Prevention of Malaria." Second Edition (1911). London: John Murray.

should be well drained. Much good has followed the use of such measures in Panama, Egypt, British Guiana and other places. The ideal conditions for malaria reduction appear to consist in a combination of general quinine prophylaxis with anti-mosquito measures.

VII.—BALANTIDIAN DYSENTERY.

This disease is also known as ciliate or ciliary dysentery. The chief causal agent is *Balantidium coli.* Others are *Balantidium minutum, Nyctotherus faba,* etc. (see pp. 200-206).

Balantidiasis is insidious and is marked by alternate attacks of diarrhœa and constipation with vomiting, while mucus is passed in the motions, which are foul smelling. There may be chronic ulceration of the colon. Œdema of the face and limbs and anæmia may occur.

Treatment is at present rather unsatisfactory. Castellani and Chalmers state that "the symptomatic treatment for entamœbic dysentery may be tried." Various treatments, more or less empirical, by calomel, quinine, carbolic acid in pill form, salicylic acid, extract of male fern, methylene blue, iodine solution, rice water and tannin enemata are mentioned by Prowazek[1] (1913) and by Seifert. E. L. Walker[2] (1913) found, from experimental work, that organic compounds of silver, *e.g.*, protargol, were most effective. Local treatment by large enemata of collargol or protargol seems to be indicated. Behrenroth[3] (1913) successfully treated a Prussian case with thymol, given in 4 grm. doses every two days, followed at the end of a fortnight by de-emetinized ipecacuanha, given in pills containing 6 cg. each, to the number of thirty a day. In about another fortnight the symptoms had subsided. The thymol checked the diarrhœa, but it was necessary to give the de-emetinized ipecacuanha to kill off the balantidia still present. Phillips (1915) also recommends thymol. Ardin-Delteil, Raynaud, Coudray and Derrieu (1914) found neither emetine hydrochloride nor protargol of use.

As regards prophylaxis Walker states that pigs "should be confined and not allowed to run in yards and dwellings." Behrenroth considers that dirty hands, for example, those of farm workers brought into contact with pigs, are probably the medium of infection. The personal cleanliness of such persons is, then, of the greatest importance.

---

[1] Beihefte z. *Arch. f. Schiffs- u. Tropen-Hyg.*, xvii, 6, p. 371.
[2] *Philippine Jl. Sc.*, Sect. B, viii, pp. 1-15, 333-349.
[3] *Arch. f. Verdauungs Krankheiten*, xix, p. 42.

PLATHELMINTHES (Flat Worms).

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

FASCIOLIASIS.

Fasciola hepatica.

The symptoms of disease evoked by *Fasciola hepatica* are rarely observed in our part of the world, whereas Kermogant[1] states them to be of frequent occurrence in Tonkin[2]; the parasites are there called "Douves." In our experience they are only accidentally found *post mortem* in a certain number of cases, as no changes are manifested during life which would permit of any conclusion being drawn as to the presence of these parasites. In three cases (Bierner,[3] Bostroem[4] and Sagarra[5]) icterus was present; in a fourth case, recorded by Duffek,[6] the parasites had led to a severe and acute distomiasis of the liver, combined with chronic purulent and ulcerative cholecystitis, with purulent cholangitis and dilation of the bile-ducts and numerous small abscesses of the liver. The total number of flukes found in these cases amounted to about fifty. The parasites passed from the duodenum into the bile-ducts, and first obstructed the flow of bile and then set up icterus, followed by cholecystitis and cholangitis.

As regards localization of the liver fluke in the pharynx, see p. 242.

The treatment must be directed to the principal symptoms; prophylaxis is especially important in districts where distomiasis is of frequent occurrence. As the embryos live in water, only boiled or filtered water should be drunk. The attempts of Tappeiner[7] to discover an effective remedy against liver-fluke disease (liver rot), so prevalent among sheep, were unsuccessful.

Fasciolopsis buski.

This parasite lives in the intestine, not in the liver of man; it produces bloody stools and typical symptoms—high fever and a condition of apathy (Odhner).[8]

---

[1] Kermogant, *Soc. méd. des Hôp.*, February 7, 1905.

[2] [The distomiasis of Tonkin is due to *Clonorchis sinensis* and not to *F. hepatica*.—J. W. W. S.]

[3] Bierner, *Schweiz. Zeitschr. f. Heilk.*, 1863.

[4] Bostroem, *Deutsch. Arch. f. klin. Med.*, 1883.

[5] Sagarra, quoted by Duffek.

[6] Duffek, *Wien. klin. Wochenschr.*, 1902, xxx.

[7] Tappeiner, *Münch. med. Wochenschr.*, 1900, l.

[8] Odhner, *Centralbl. f. Bakt.*, 1902, xxxi.

PARAGONIMIASIS.

Paragonimus ringeri.

The disease produced by the lung fluke is specially endemic in Japan, also in isolated parts of China, Formosa and Korea. The fact that the lung-fluke disease is most frequently found in mountainous districts (Katsurada[1]) is worthy of special attention. The onset of pulmonary paragonimiasis is generally insidious (Looss[2]); generally the only symptom is a slight cough, occurring at first at longer, and later at shorter intervals; it is accompanied by the expectoration of discoloured sputum, frequently blood-stained. Though now and then severe hæmorrhages result, up to the present no case has been established in which they have been the direct cause of death.

Examination of the thorax frequently fails to reveal anything

This section, except for minor corrections, is practically a translation of the original.

To Binder: face p. 638.

symptoms in these tracts.

The most dangerous locality is in the brain. Otani,[5] Inouye,[6] Yamagiva,[7] and recently also Taniguchi,[8] have found *post mortem* the worms and their ova in tumours of the brain, or in areas of softening in cases of Jacksonian epilepsy; in Taniguchi's case the eggs were found in masses in the inflammatory areas of softening. In the nineteen cases of paragonimiasis of the brain collected by Inouye, the following symptoms were observed: general convulsions on eight occasions, unilateral convulsions on six occasions, convulsions with paralysis on the same side and hemiplegia, five times each;

---

[1] Katsurada, Ziegler's *Beitr. z. path. Anat.*, 1900, xxviii.

[2] Looss, "Handb. d. Tropenkrankh.," von Mense, 1905, i.

[3] Inouye, quoted by Looss.

[4] Scheube, "Die Krankh. d. warm. Länder," 1896.

[5] Otani, quoted by Looss.

[6] Inouye, quoted by Looss.

[7] Yamagiva, quoted by Looss

[8] Taniguchi, *Arch. f. Psych. u. Nervenkrankh.*, xxxviii.

PLATHELMINTHES (Flat Worms).

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

FASCIOLIASIS.

Fasciola hepatica.

The symptoms of disease evoked by *Fasciola hepatica* are rarely observed in our part of the world, whereas Kermogant[1] states them to be of frequent occurrence in Tonkin[2]; the parasites are there called "Douves." In our experience they are only accidentally found post-mortem in a certain number of cases, as no changes are

prevalent among sheep, were unsuccessful.

Fasciolopsis buski.

This parasite lives in the intestine, not in the liver of man; it produces bloody stools and typical symptoms—high fever and a condition of apathy (Odhner).[8]

---

[1] Kermogant, *Soc. méd. des Hôp.*, February 7, 1905.

[2] [The distomiasis of Tonkin is due to *Clonorchis sinensis* and not to *F. hepatica*.—J. W. W. S.]

[3] Bierner, *Schweiz. Zeitschr. f. Heilk.*, 1863.

[4] Bostroem, *Deutsch. Arch. f. klin. Med.*, 1883.

[5] Sagarra, quoted by Duffek.

[6] Duffek, *Wien. klin. Wochenschr.*, 1902, xxx.

[7] Tappeiner, *Münch. med. Wochenschr.*, 1900, l.

[8] Odhner, *Centralbl. f. Bakt.*, 1902, xxxi.

PARAGONIMIASIS.

Paragonimus ringeri.

The disease produced by the lung fluke is specially endemic in Japan, also in isolated parts of China, Formosa and Korea. The fact that the lung-fluke disease is most frequently found in mountainous districts (Katsurada[1]) is worthy of special attention. The onset of pulmonary paragonimiasis is generally insidious (Looss[2]); generally the only symptom is a slight cough, occurring at first at longer, and later at shorter intervals; it is accompanied by the expectoration of discoloured sputum, frequently blood-stained. Though now and then severe hæmorrhages result, up to the present no case has been established in which they have been the direct cause of death.

Examination of the thorax frequently fails to reveal anything abnormal. Inouye[3] states that the most frequently observed changes consist in retraction of the thorax and in a contraction of its infrascapular portion. Scheube[4] repeatedly observed that the one side, presumably that which harboured the worm, moved less freely than the other. The physical changes are not uniformly spread over the whole lung, but are localized. The disease may come to a standstill for long intervals and then set in again, lasting on the whole from ten to twenty years. In addition to paragonimiasis of the lungs, cysts are frequently found on the eyelids, which occasionally extend deeply into the orbit and hinder the movements of the eyes. *Post mortem*, cysts the size of hazel nuts containing one, two, or three adult worms are found in the lungs, and in addition, not uncommonly there exist pulmonary emphysema and bronchiectasis. Besides being present in the lungs and in the eyelids, the parasites have also been found in the pleura, the liver, the intestinal wall, the peritoneum, the cervical glands, and in the scrotum, without actually occasioning any actual symptoms in these tracts.

The most dangerous locality is in the brain. Otani,[5] Inouye,[6] Yamagiva,[7] and recently also Taniguchi,[8] have found *post mortem* the worms and their ova in tumours of the brain, or in areas of softening in cases of Jacksonian epilepsy; in Taniguchi's case the eggs were found in masses in the inflammatory areas of softening. In the nineteen cases of paragonimiasis of the brain collected by Inouye, the following symptoms were observed: general convulsions on eight occasions, unilateral convulsions on six occasions, convulsions with paralysis on the same side and hemiplegia, five times each;

---

[1] Katsurada, Ziegler's *Beitr. z. path. Anat.*, 1900, xxviii.

[2] Looss, "Handb. d. Tropenkrankh.," von Mense, 1905, i.

[3] Inouye, quoted by Looss.

[4] Scheube, "Die Krankh. d. warm. Länder," 1896.

[5] Otani, quoted by Looss.

[6] Inouye, quoted by Looss.

[7] Yamagiva, quoted by Looss

[8] Taniguchi, *Arch. f. Psych. u. Nervenkrankh.*, xxxviii.

in Taniguchi's case, attacks of cortical epilepsy, choreiform twitchings in the right extremities, which gradually become athetotic. The following were symptoms of rarer occurrence: paresis of the right upper extremity, vertigo, dementia, and amnesic aphasia, disturbances of vision. Paragonimiasis of the brain appears to arise by embolism from a primary pulmonary lesion.

The diagnosis depends upon the finding of ova in the sputa; if together with ova in the sputa, cerebral disturbances make their appearance, in all probability the cause is the presence of worms or ova in the brain.

The prognosis of pulmonary paragonimiasis is favourable; on the other hand, that of cerebral paragonimiasis is very doubtful.

The treatment of the pulmonary lesion consists only in paying attention to the general condition (good food, rest, cough remedies), as all attempts to destroy the worms in the lungs by means of vermicidal drugs administered internally or by way of inhalation have so far been without result. The treatment of the cerebral lesion is entirely hopeless. Trephining has been proposed for cases the condition of which is more favourable, but it has not reached the stage of performance.

Prophylaxis consists in general management: cleansing and if need be boiling of everything that is eaten or drunk.

Clonorchis sinensis.

According to our present knowledge *Clonorchis sinensis* is only found in China and Japan; even the *post-mortem* case reported by Laspeyres[1] was that of an Asiatic sailor who was admitted into the General Hospital St. George, Hamburg, in a moribund condition with the clinical diagnosis of beri-beri. The bile-ducts are the usual site of the parasite, though Katsurada[2] has found them also in the pancreatic ducts. In addition, it is found not uncommonly in the upper portion of the small intestine, especially in the duodenum, also, though decidedly rarely, in the stomach. As these sites, however, do not afford the conditions necessary to life, they are only found here on their way out of the body of the host.

The initial stage of infection with this fluke generally runs a symptomless course; in proportion as the worms multiply the following symptoms are manifested: First there is a morbid sense of hunger and irregularity in defæcation; at the same time the patient experiences a feeling of pressure and pain in the epigastrium and right hypochondrium, or just a dull pain. Pressure increases the pain considerably. The liver appears to be enlarged, sometimes the

[1] Laspeyres, "Dissert. Kiel," 1904.

[2] Katsurada, Ziegler's *Beitr. z. path. Anat.*, 1900, xxviii.

enlargement is specially perceptible over the left lobe of the liver. The patients maintain a proportionately good general state of health in this state for a long time and may hope to recover. In severe cases there occurs copious and generally bloody diarrhœa, also icterus. The next stages are anæmia, emaciation, epistaxis, ascites, enlarged spleen, and cachexia, to which the patient finally succumbs. In general the course of the disease is very chronic and irregular; in winter and spring there is generally improvement, in the summer and autumn the patient gets worse. At *post-mortem* the bile-ducts are enlarged and thickened, there is interstitial hepatitis with enlargement of the liver, but not to such an extent as in hypertrophic cirrhosis. After the initial enlargement contraction of the liver sets in, the peritoneal coat and capsule proper of the liver become more or less thickened in places. In the pancreas also dilatation and thickening of the ducts occur, as well as interstitial inflammatory processes. Obstructions in the portal circulation may lead to catarrhal changes in the stomach.

The diagnosis is based on the demonstration of ova in the fæces.

As a radical treatment is still unknown, consequently it can only be purely symptomatic. Prophylaxis consists in the prohibition of drinking unboiled water or eating uncooked molluscs, fish, etc., of canal water. Leaving the epidemic region may bring about gradual recovery.

BILHARZIASIS.

Schistosoma hæmatobium.

The symptoms of bilharziasis are manifested chiefly in the urinary apparatus, and above all as hæmaturia, at the outset without any special troubles. Later, however, it is accompanied by subjective symptoms in the shape of feelings of pain, and of vague pains in the perinæum and lumbar region, and of burning in the urethra during the passing of urine. All the symptoms are usually aggravated after excesses in eating and drinking, and after considerable bodily exertion. Another condition found, but not often mentioned, is lipuria (Stock[1]); the highest amount has been 2 per cent. fat in the urine. Stock found 6 to 20 per cent. of eosinophile cells in ten cases examined by him. They appear to be increased, especially in the early cases; Kautsky[2] also called attention to the excessive degree of eosinophilia, whilst Goebel[3] expresses the opinion that a specific toxic action on the organism generally is not developed in bilharziasis. Kautsky[4] assumes a toxic anæmia as in the case of ancylostomiasis. English authors also have called attention to the eosinophilia and to a considerable

[1] Stock, *Lancet*, September 29, 1906.
[2] Kautsky, *Wien. klin. Rundschau*, 1903, xxxvi.
[3] Goebel, *Arch. f. Schiffs- u. Tropen-Hyg.*, 1903, vii.
[4] Kautsky, *Wien. klin. Rundschau*, 1903, xxxv

amount of leucocytosis (Balfour,[1] Douglas and Hardy[2]). The severe forms occur almost exclusively in men; symptoms of catarrh of the bladder make their appearance, vesical calculi are frequently found, whilst the formation of stone in the kidneys and ureters is rare. Urethral fistula occurs in bilharziasis, often without stricture, and if granulations occur the fistula is distal to them. Goebel[3] regards the bilharzia fistula as a chronic burrowing of pus, caused by the irritation set up by the ova as foreign bodies and consecutive restricted suppuration; and secondly as due to the passage of urine through the defect in the epithelium or the wall of the urethra. The fistulæ, which are generally situated at the neck of the bladder and at the membranous portion, are very tortuous and frequently very numerous; they often lie embedded in well-marked tumours—in fact, in granulation tumours with marked inclination to excessive formation of cicatricial tissue. The opening generally is in the perineal and scrotal regions. In the case of a patient, aged 21, from the Transvaal, Kutner[4] found by cystoscopic examinations the whole summit and walls of the bladder covered with large and small tumours. In addition to smooth glistening tumours, others were more or less disintegrated, and scattered large and small cauliflower-like growths occurred. Like malignant growths, the tumours were inclined to break down, the process extending from within outwards towards the surface. Whether the hydrocele so frequent in Egypt has any connection with bilharzia is not known. A frequent sequela of bilharziasis is complete sexual impotence (Petrie[5]).

Bilharziasis of the rectum is manifested by symptoms of dysentery; the repeated violent attempts at defæcation lead in time to prolapse of the rectum, which sooner or later induces septic infection and so death. In the mucosa of the rectum, polypoid growths similar to those in the bladder are met with, due to the ova of the parasites in the mucosa and submucosa. In the case of a man, aged 36, who had lived for a long time in South Africa, Burfield[6] found in the excised vermiform appendix ova of *Schistosoma hæmatobium*; he assumed this to be a gradual secondary infection of the appendix, whilst Kelly[7] mentions a case of primary bilharziasis of the appendix; the eggs lay in the submucosa directly above the muscularis. Tumours containing numerous ova are frequently found in the region of the genitalia, thighs and scrotum. In one case Symmers[8] found numerous male schistosomes in the portal blood and a copulating

---

[1] Balfour, *Lancet*, December, 1903.
[2] Douglas and Hardy, *ibid.*, October, 1903.
[3] Goebel, *Centralbl. f. d. Krankh. d. Harn u. Sexualorgane*, xvii.
[4] Kutner, *ibid.*, xvi.
[5] Petrie, *Brit. Med. Journ.*, July, 1903.
[6] Burfield, *Lancet*, February 10, 1905.
[7] Kelly, quoted by Burfield.
[8] Symmers, *Lancet*, January 7, 1905.

pair in the left lung. Though schistosome eggs have been found by some observers in the lung tissue, this is nevertheless the first case in which living parasites have been found in the lesser circulation. Perhaps they got there by way of the external iliac vein from the veins of the bladder and rectum.

In the female sex bilharziasis is incomparably rarer than in the male and is generally limited to hæmaturia. Bilharziasis of the vagina, which takes the form of an acute vaginitis, is frequent according to Milton.[1] Horwood[2] found in one case a polypoid tumour of the cervix uteri, and in the connective tissue of the tumour Schistosoma ova, both in masses and singly. It could not be established whether the ova reached the vagina and thence the cervix directly, or through the urine from the bladder.

The course of the disease is chronic, and in slight cases, provided fresh infections do not occur, is not unfavourable; in severe cases the cachexia caused by loss of blood, or intercurrent diseases to which the patients easily succumb—*e.g.*, pyelitis, pyelonephritis, pyæmia, or uræmia—lead to a fatal issue.

In regions in which *Schistosoma hæmatobium* is endemic, or in patients from such regions, the diagnosis is easy by microscopically finding the eggs in the urine.

As regards the treatment of the affection this much must be said, that so far there is in existence no certain remedy. In countries where bilharziasis is endemic copaiva balsam is considered a specific. Kutner (*loc. cit.*), however, in the case of his patient who for a long time had taken no inconsiderable amounts of copaiva, had no success worth speaking of to record. Urotropin (three times daily, 1 grm.) has similarly failed, salol (0·75 grm. several times daily) perhaps affords relief in affection of the bladder (Milton). Methylene blue, oil of turpentine with extract of male fern (Brock[3]), or the latter alone and santonin given in small doses for a week at a time, in the morning, are said by Petrie[4] to be of value. Sandwith[5] and Harley[6] were not very successful. By way of experiment Kutner for some time used collargol *per rectum*, proceeding on the assumption that this preparation, which has proved of such remarkable service in bacterial infection, would perhaps render a continuance of life difficult for the bilharzia worms. But this hope proved illusory. In order so far as possible to limit the loss of blood, Kutner regularly employed stypticin for long periods (three times daily, two tabloids of 0·01 grm.)

---

[1] Milton, quoted by Looss, "Handb. d. Tropenkrankh.," v. Mense, 1905, i, p. 95.
[2] Horwood, *Brit. Med. Journ.*, March 10, 1906.
[3] Brock, *Journ. of Path. and Bact.*, 1893.
[4] Petrie, *loc. cit.*
[5] Sandwith, *Annal. of Surgery*, 1904, xxxix.
[6] Harley, *Lancet*, 1870.

with undoubted success, in so far that the hæmorrhages became considerably less in amount. As two patients in the course of enteric fever lost their hæmaturia, Stock accordingly recommends subcutaneous injections of Wright's typhoid vaccine. In the early stages of the rectal lesion suppositories of iodoform, ichthyol, or narcotics might possibly be of use. In the case of urethral fistulæ, division, excision and scraping out of the granulation tissue are recommended; in cystitis with formation of tumours high resection with curetting of the tumours or their destruction with the cautery; in the case of vesical calculi, high resection, curetting the bladder, and then drainage. Tumours of the rectum must also be removed by operation.

Prophylaxis is important; it should be extended to all modes of using water, only filtered water being drunk, and only boiled water being used for washing. This advice should be given to tourists who travel through the infected districts, and is also recommended to soldiers and officials who are despatched to the Colonies. The favourable influence of change of climate can only show itself where fresh infections are avoided.

CESTODES.

GENERAL.

It seems advisable to preface the section on the Cestodes with some general observations on the symptoms of disease provoked by tapeworms, especially so far as they relate to the question of toxic effects, and to include the Nematodes in this discussion. After this will follow a brief exposition of the most important intestinal lesions causally connected with intestinal parasites.

It is known to every experienced practitioner that the different intestinal parasites can give rise to a series of nervous symptoms, slight or severe, and produce, above all, blood changes—anæmia of the most varied nature, to the extent of severe progressive anæmia. These symptoms are regarded by many authors as reflex, or, as in the case of ancylostomiasis, the main feature from the loss of blood caused by the habit of life of the intestinal parasites. More frequently, however, they are regarded as toxic conditions produced by the parasites. In view of this divergence of opinion there appears to be some advantage in defining clearly the present position as to the toxic action of parasites. Most interesting in this respect are *Dibothriocephalus latus* and *Ancylostoma duodenale*.

We are indebted to the clinic at Helsingfors for our most detailed knowledge of bothriocephalus anæmia. Reyher[1] was the first to

---

[1] Reyher, *Deutsch. Arch. f. klin. Med.*, 1886, xxxix.

demonstrate that this parasite under certain circumstances can produce a severe, progressive and sometimes fatal anæmia, which can be cured, generally in a surprisingly short time, by expulsion of the worm. Among the various hypotheses which have been advanced as to the mode of origin of bothriocephalus anæmia, the greatest importance has been attached to the assumption already mentioned by Reyher, but definitely expressed by von Shapiro,[1] to the effect that *Bothriocephalus latus* produces a poison which is absorbed by the intestine and exercises a deleterious influence on the composition of the blood, especially on the erythrocytes, perhaps also on the blood-forming organs. This assumption is supported by no slight number of clinical and experimental investigations. Podwissotsky[2] observed severe blood changes in a child, aged 4½, affected with *B. latus*. In the case reported by Pariser[3] the severe anæmia in a girl disappeared fairly soon after expulsion of the worm. In that reported by Schaumann[4] high fever accompanied the bothriocephalus anæmia; he also proved the hæmolytic properties of the broad tapeworm. The case reported by F. Müller[5] was one of severe anæmia. Also, in the first of the cases described by Kurimoto[6] of *Diplogonoporus grandis* there were present the same symptoms of anæmia as in the case of *B. latus*. Meyer[7] observed severe anæmia in two youths caused by *B. latus*. Rosenquist[8] has discussed the proteid metabolism in anæmia. The presence of *B. latus* produces in the majority of cases an increased proteid consumption, to which the blood change generally corresponds—toxic anæmia; in a further communication he reports on twenty cases of bothriocephalus anæmia, nineteen of which were cured by expulsion of the worms, while one case proved fatal, and he again emphasizes the toxic properties of the intestinal parasites. In the case reported by Bendix,[9] that of a girl, aged 4½, the anæmia was moderate, whilst in the case of Zinn[10] (a woman, aged 30) the anæmia was so excessive that the patient succumbed five days after expulsion of six bothriocephalus heads. Isaac and van den Velden[11] have established that in the serum of patients who suffer from anæmia due to *B. latus*, parasitic products are dissolved,

---

[1] von Shapiro, *Zeitschr. f. klin. Med.*, 1888.
[2] Podwissotsky, *Jahrb. f. Kinderkrankh.*, 1889.
[3] Pariser, *Deutsch. med. Wochenschr.*, 1892.
[4] Schaumann, Berlin, 1894, and *Deutsch. med. Wochenschr.*, 1898.
[5] Müller, *Charité-Annal.*, xiv.
[6] Kurimoto, *Zeitschr. f. klin. Med.*, xl, and *Kongr. f. inn. Med.*, Karlsbad, 1899.
[7] Meyer, *Mount Sinai Hosp. Reports*, 1903 and 1904, iv.
[8] Rosenquist, *Verein f. innere Med. in Berlin*, May 6, 1901; and *Zeitschr. f. klin. Med.* xlix.
[9] Bendix, *Deutsch. Aerzte Zeitg.*, 1904, i.
[10] Zinn, *Deutsch. med. Wochenschr.*, 1903.
[11] Isaac and van den Velden, *Deutsch. med. Wochenschr.*, 190 , xxvii.

as shown by a distinct precipitin reaction. Galli-Valerio[1] considers it likely that toxic substances are secreted by the living helminthes which produce a lowering or raising of the body temperature, nervous disturbances and hæmolysis. Tallqvist[2] succeeded in extracting from *B. latus* a lipoid-like body which had a strong hæmolytic action. The experimental anæmia thereby produced differed in no respect from the severe chronic bothriocephalus anæmia of man. The question as to under what special conditions severe, and sometimes fatal bothriocephalus anæmia is developed is answered by Leichtenstern[3] and by Lenhartz,[4] by the assumption that among the Bothriocephali some are toxic, that is, manufacture a poison which, when absorbed by the host, produces a severe anæmia.

Certain factors lead him to conclude that an accumulation of poison, dependent on time and place, occurs in the Bothriocephali.

In the case of ancylostome anæmia, experience so far, according to Leichtenstern,[5] by no means supports the hypothesis of a difference in virulence of the worms according to time and locality, ancylostome anæmia being rather, so far as is known at present, in all races of man, everywhere and at all times, simply and solely dependent on the number of ancylostomes, the duration of the disease and—within certain narrow limits—on the individual capability of resisting the loss of blood and the toxic effect of the parasites. As is shown by a short historical résumé of the toxic action that has to be considered in ancylostome anæmia, we must admit that doubtless here, as in the case of bothriocephalus anæmia, the toxins secreted by the parasites exercise a hæmolytic action, even while admitting Leichtenstern's contention that the significance of the loss of blood due to ancylostomes must not be underrated. The toxic hypothesis acquired a definite standing through a series of experiments of Lussana[6] on rabbits, where he succeded in producing anæmia by injecting urinary extracts of ancylostome patients. Arslan[7] extracted toxins from the urine of two ancylostome patients and injected them into rabbits, which thereupon sickened and showed the same blood changes as the ancylostome patients. Retinal hæmorrhages, so frequent in ancylostome anæmia, which, according to Fischer[8] and Samelsohn,[9] are not due to direct loss of blood, must also be ascribed to a parasitic toxin. A further argument in favour of the toxic hypothesis

[1] Galli-Valerio, *Therap. Monatsh.*, 1905.
[2] Tallqvist, *Zeitschr. f. klin. Med.*, 1907, lxi.
[3] Leichtenstern, "Handb. d. Therap. v. Pentzoldt-Stintzing," 1898, 2nd edition, iv.
[4] Lenhartz, *ibid.*, 1903, 3rd edition, iv, p. 607.
[5] Leichtenstern, *Deutsch. med. Wochenschr.*, 1899.
[6] Lussana, *Rivista Clin. Arch. ital. di clin. Med.*, 1890.
[7] Arslan, *Rev. mens. des Mal. de l'Enfance*, 1892.
[8] Fischer, *Versamml. d. ophthal. Gesellsch.*, 1892.
[9] Samelsohn, *ibid.*

is furnished by the blood changes recorded by Zappert,[1] Müller and Rieder,[2] Bücklers,[3] and Neusser,[4] which must be regarded as the expression of toxic action, especially with reference to eosinophilia. The striking increase in proteid destruction in ancylostomiasis observed by Bohland,[5] and which ceased after the parasites had been expelled, also gives additional support to the assumption of toxic action. The observation of Daniels[6] also deserves consideration in this connection, according to which the presence of yellow pigment in the liver and kidney cells is to be attributed to blood destruction by a verminous toxin absorbed from the gut. Looss[7] considers it not at all improbable—in fact, almost certain—that Ancylostoma, in addition to withdrawing blood, exert a kind of toxic action on their host.

Scheube[8] attributes almost equal importance to the loss of blood, the digestive disturbances, and the intoxication induced by certain metabolic products of the parasites. According to v. Jaksch[9] ancylostome anæmia is not induced solely by loss of blood, but by the fact that the parasites produce a ferment which has a toxic action and produces stimulation in those organs in which the eosinophile cells arise. The hæmolytic action of ancylostomes has frequently been observed by Galvagno[10] in men employed in sulphur mines. According to Loeb and Smith[11] the anterior half of the body of ancylostomes contains a substance which probably causes anæmia. Bauer[12] found in the urine of ancylostome patients glycuronic acid, which he considers to be a sign of metabolic disturbance due to parasitic toxins. As has been demonstrated by Allessandrini,[13] the secretion of glands in the anterior part of the body has a distinct hæmolytic effect on the erythrocytes. While the worm attaches itself to the mucosa by means of its teeth, these glands discharge their secretion, producing hyperæmia. The extravasated blood is acted on by this secretion, so that it can serve as food for the parasites. Hynek[14] attributes eosinophilia (up to 20 per cent.) to a toxic action. Goldmann[15] expresses a similar opinion, though he

---

[1] Zappert, *Wien. klin. Wochenschr.*, 1892.
[2] Müller and Rieder, *Deutsch. Arch. f. klin. Med.*, xcviii.
[3] Bücklers, *Münch. med. Wochenschr.*, 1894.
[4] Neusser, *Wien. klin. Wochenschr.*, 1892.
[5] Bohland, *Münch. med. Wochenschr.*, 1894.
[6] Daniels, *Lancet*, No. 3,725.
[7] Looss, *Centralbl. f. Bakt.*, 1897.
[8] Scheube, "Die Krankh. der warm. Länder," 1896.
[9] v. Jaksch, *Münch. med. Wochenschr.*, 1902.
[10] Galvagno, *Arch. di Patol. e Clin. inf.*, 1902-1904.
[11] Loeb and Smith, *Centralbl. f Bakt.*, xxxvii.
[12] Bauer, *Wien. klin. Wochenschr.*, 1904.
[13] Allessandrini, *Policlinica*, 1904.
[14] Hynek, *Klin. Chron.*, 1904.
[15] Goldmann, *Wien. klin. Rundschau*, 1905.

assumes that the anæmia is secondary, as the toxin of the cephalic glands, as the parasites bite, penetrates the mucosa and thence into the blood, where it dissolves the red blood corpuscles. Romani[1] discusses the agglutinating hæmolytic action of the serum of ancylostome patients. Whether Ancylostoma produce toxins and what is their nature, or whether the loss of blood causes the anæmia, Liefmann[2] was unable definitely to determine; hæmolytic substances do not appear to take any part in it.

Berti[3] also is inclined to attribute the anæmia to metabolic products of the ancylostomes; he found, in fact, that a serum obtained from a sheep (after subcutaneous injections of the culture fluid of ancylostome larvæ) was efficacious in the treatment of ancylostome anæmia. Peiper[4] likewise assumes that the parasite secretes a cell toxin. Löbker[5] at the present day still maintains that the cause of the disease must be looked for really, if not perhaps entirely, in the continued withdrawal of blood by the parasites; the secretion of toxins by ancylostomes has not yet, in his opinion, been conclusively proved. Except in the case of *Bothriocephalus latus*, referred to previously, toxic action appears to be of quite subordinate importance for the other Cestodes occurring in man—especially *Tænia solium* and *T. saginata*, which are most frequently found; thus Cao[6] flatly denies the presence of toxins in the body of Tæniæ, while others, such as Messineo and Calmida,[7] Jammes and Mandoul,[8] consider they are justified from their investigations in concluding that Tæniæ contain a specific toxin. Messineo[9] injected, with all bacteriological precautions, extracts of Tænia, dissolved in physiological salt solution. He invariably obtained severe motor disturbances and frequently death. The observation by Pereira[10] of a case of chorea in which rheumatic and cardiac symptoms were absent and which after expulsion of a Tænia was quickly cured, also favours the view of a toxic action. Barnabo,[11] however, was unable to obtain a toxin from *Tænia saginata*. Gagnoni,[12] on account of a marked eosinophilia which, after expulsion of a *Tænia saginata*, fell within fourteen days to 1 per cent., assumes the formation of a Tænia toxin. Dirksen's[13] observation has reference to a sailor affected with serious anæmia, who, after expulsion of twelve pieces of *Tænia solium*, was rapidly

[1] Romani, *Gaz. d. Osp.*, 1904.
[2] Liefmann, *Zeitschr. f. Hyg.*, 1905, l.
[3] Berti, *Gaz. d. Osp.*, 1906.
[4] Peiper, *Deutsch. med. Wochenschr.*, 1897.
[5] Löbker and Bruns, *Arb. aus dem kaiserl. Reichsgesundheitsamt*, 1906, xxiii.
[6] Cao, *Riforma Med.*, 1901.
[7] Messineo and Calmida, *Centralbl. f. Bakt.*, xxx.
[8] Jammes and Mandoul, *Acad. des Sciences*, 1904.
[9] Messineo, *Giorn. med. del regio eserc.*, 1905.
[10] Pereira, *Lancet*, September, 1903.
[11] Barnabo, *Sperimentale*, 1906, v.
[12] Gagnoni, *Pediatric.*, 1903.
[13] Dirksen, *Deutsch. med. Wochenschr.*, 1903.

cured. A portion of the worm was already breaking down, the absorption introducing into the body highly toxic hæmolytic products, to which the anæmia must be ascribed. How far the serious disturbances of the nervous system, frequently to be observed in cases of *Hymenolepis nana*, are to be considered as of purely reflex nature or toxic must remain an open question; the same applies to *Dipylidium caninum*, in which case Brandt[1] observed serious central nervous symptoms. Caution is necessary in judging as to any connection between worm stimulus and nervous symptoms in cases of Ascaris infection. Peiper[2] is inclined to regard such nervous symptoms not as reflex, but rather as due to a toxin contained in the helminthes, or metabolic in origin.

In cases of pernicious anæmia when the symptoms disappear after expulsion of *Ascaridæ* a toxic action must be assumed (Demme[3]). Additional clinical observations do not, indeed, lead to any definite conclusion as to the question whether *Ascaridæ* produce a toxin which is capable of causing more or less injury either to the nervous system or to the blood, yet it may be worth while to give a brief review of this question. In a case of Kutner's,[4] that of a girl, aged 12, there was a hæmolysis which was cured after expulsion of twenty-four *Ascaridæ*. Attacks of opisthotonos in a girl, aged 16, ceased after seventy-eight *Ascaridæ* had been expelled (Lutz[5]). Unusually serious disturbances were observed in a man, aged 26, who was rapidly cured by Drouillard[6] by the removal of a great number of *Ascaridæ*. The observations on pseudomeningitis are of especial interest; they are evidently toxic in origin as in the case of Annaratone,[7] of a man who was taken ill with gastro-intestinal symptoms and who died with meningitic symptoms. *Post mortem* the brain was normal, but the stomach contained a great coil of *Ascaridæ*. The cases of Delille,[8] Mériel,[9] Papi[10] (the occurrence of Cheyne-Stokes respiration has been ascribed to the action upon the centre in the medulla oblongata of the products of the *Ascaridæ*), and Taillens[11] related to children in which the meningitic symptoms (meningismus), partly serious, disappeared with the removal of the *Ascaridæ*. Máreo[12] designates this disease helminthiasis meningitiformis, which exhibits all the symptoms

---

[1] Brandt, quoted by Pollak in *Centralbl. f. Bakt.*, 1889, v.

[2] Peiper, *vide* Seifert, "Lehrb. d. Kinderkrankh.," 1897, p. 243.

[3] Demme, *vide* Seifert, *ibid.*

[4] Kutner, *Berl. klin. Wochenschr.*, 1865.

[5] Lutz, *Centralbl. f. Bakt.* [6] Drouillard, *Journ. de Méd.*, 1900, xi.

[7] Annaratone, *Giorn. med. del regio eserc.*, 1900.

[8] Delille, *Journ. de Méd.*, May 10, 1907.

[9] Mériel, *Annal. de Méd. et Chir. inf.*, 1900.

[10] Papi, *Gaz. d. Osp.*, 1901. [11] Taillens, *Arch. de méd. d'Enf.*, 1906.

[12] Máreo, *Allg. Wien. med. Zeitg.*, 1902.

of meningitis, but which is caused by the metabolic products of *Ascaridæ*.

Schupfer,[1] Duprey[2] (observations in the West Indies, where such symptoms are said to be of very frequent occurrence), Naab[3] (the flow of water from the mouth at night is mentioned as a remarkable fact), and Hammiss[4] assume the action of an Ascaris toxin in the clinical observations made by them, mostly children with fever and intestinal symptoms. Schupfer assumes in such cases, as he observed it once in a man, aged 23, that the disease termed *Lombricoise à forme typhoïde* by Chauffard was due to *B. coli* of marked virulence due to the action of the *Ascaridæ*. The Widal reaction was negative. Koneff[5] reports a case in which acute attacks of cramp, trismus, and rigidity of the pupil disappeared after expulsion of seven *Ascaridæ*. Tetanus, as observed by Buchholz[6] in a girl, aged 17, and rapidly cured after expulsion of sixteen *Ascaridæ*, is manifestly rare, since only Rose[7] mentions this as a cause in his article on Tetanus. Only a few experimental data exist. Cattaneo[8] could detect only a very weak toxin in Ascaris, while Messineo,[9] by injecting into animals extracts in physiological salt solution, invariably succeeded in producing serious motor disturbances and frequently death. Interesting also are the observations of Huber,[10] who, after working with *Ascaridæ*, suffered from itching of the head and neck, blisters, swelling of the ear, conjunctivitis, ecchymosis and troublesome palpitation in the head. He consequently assumes that *Ascaridæ* can induce irritation by chemical (toxic) means.

In the case of *Trichocephalus dispar* no more than in the case of *Ascaris lumbricoides* can we speak with certainty of a toxic effect, even though a number of observations are available which might justify such an assumption as regards these intestinal parasites. Barth[11] found the brain normal in a man who had died with meningitic symptoms, but the intestines were full of *Trichocephalus dispar*; Gibson[12] records the rapid cure of serious cerebral symptoms after expulsion of Trichocephalus, so also Pascal,[13] Burchhardt[14] and Rippe.[15] Moosbrugger[16]

---

[1] Schupfer, *Gaz. d. Osp.* 1901.
[2] Duprey, *Lancet*, 1903.
[3] Naab, *Münch. med. Wochenschr.*, 1902.
[4] Hammiss, *Wien. med. Wochenschr.*, 1904, iii.
[5] Koneff, quoted by Liesen, "Dissert. Bonn," 1904.
[6] Buchholz, *Norsk. Mag. for Läge*, 1903.
[7] Rose, Billroth and Pitha, "Chirurgie."
[8] Cattaneo, *Arch. f. Kinderheilk.*, xliv.
[9] Messineo, *Giorn. med. del regio eserc.*, 1905.
[10] Huber, *Deutsch. Arch. f. klin. Med.*, 1870, vii.
[11] Barth, reported by Valleix, Paris, 1845.
[12] Gibson, *Lancet*, 1862.
[13] Pascal, quoted by Kahane, *Korrespondenzbl. f. Schweizer Aerzte*, 1907, viii.
[14] Burchhardt, *Deutsch. med. Wochenschr.*, 1880.
[15] Rippe, *St. Petersb. med. Wochenschr.*, 1907, i.
[16] Moosbrugger, *Med. Correspondenzbl. f. Württemberg*, 1890.

was the first to draw attention to grave anæmic conditions induced by Trichocephalus, Morsasca[1] and Becker[2] to progressive grave anæmia (trichocephalus anæmia is accompanied by marked reduction of the number of red blood corpuscles, of the specific gravity and of the hæmoglobin, well-marked morphological changes of the red cell, micro-, macro-, and poikilocytosis and nucleated red cells). Sandler,[3] in his case of a boy, aged 11, who died of anæmia, assumes a trichocephalus toxin to be the cause of the disease, and Kahane also reports on anæmic conditions induced by Trichocephalus. Girard,[4] in addition to symptoms in the gastro-intestinal tract, calls attention to those arising in the blood—anæmia and its sequelæ—and also to nervous symptoms: cerebral phenomena, headache, giddiness, aphonia, symptoms of meningitis. In a case of Schiller's[5] high fever was present, which probably set in when the Trichocephali present in the gut in great numbers commenced their parasitic activity. Hausmann,[6] in order to explain the adaptability of Trichocephalus, assumes that according to the *locus minoris resistentiæ,* at one time the reflex at another the toxic action is effective, now on one organ, then on another; anæmia being present in most cases, frequently general and local neuroses and cerebral symptoms of various kinds.

With regard to the toxic action of Oxyuris there is only the single record of Hartmann,[7] who noticed the disappearance of epileptic fits and psychic disturbances in a girl, aged 13, after the removal of Oxyuris. Nervous disturbances and blood changes can but rarely be attributed to Strongyloides. Silvester[8] and Valdes[9] report on giddiness, headache and anuria in cases observed by them; whether the eosinophilia recorded by Bücklers[10] and Bruns[11] is due to the toxin of Strongyloides must remain an open question.

Reference has already been made to the possibility that intestinal ciliates (*Balantidium coli*) can also produce toxins.

The contents of echinococcus cysts appear to contain a substance only moderately toxic, giving rise to urticaria, in a series of cases where the fluid has escaped into the abdominal cavity (during puncture). D. Müller[12] has collected nine such cases out of the literature, to which may be added six cases of Finsen[13] in which the

---

[1] Morsasca, abstract in *Centralbl. f. innere Med.*, 1897.
[2] Becker, *Deutsch. med. Wochenschr.*, 1902.
[3] Sandler, *ibid.*, 1905.
[4] Girard, *Annal. de l'Inst. Pasteur*, 1901.
[5] Schiller, *Beitr. z. klin. Chir.*, 1902, xxxiv.
[6] Hausmann, *St. Petersb. med. Wochenschr.*, 1900.
[7] Hartmann, *Naturforschervers.*, Köln, 1889.
[8] Silvester, quoted by Schlüter, "Dissert. Kiel," 1905.
[9] Valdes, quoted by Schlüter, *op. cit.*
[10] Bücklers, *Münch. med. Wochenschr.*, 1894.
[11] Bruns, *Münch. med. Wochenschr.*, 1907.
[12] Müller, D., "Dissert. Würzburg," 1885.
[13] Finsen, quoted by D. Müller.

escape of fluid into the peritoneal cavity led to severely itching urticaria, which usually disappeared again after one or two days. On one occasion, indeed, urticaria occurred after rupture into the pleural cavity. In the case recorded by Caffarena[1] of echinococcus of the right lobe of the liver, widespread urticaria developed as the result of the exploratory puncture. In the case of an echinococcus of the liver rupturing into the abdominal cavity La Spada[2] ascribed the symptoms leading to death to toxic influence while the peritoneal symptoms were less marked. Eosinophilia in hydatid disease is slight according to the investigations of Bindi[3] and Santucci,[4] and is, according to Welsh and Barling,[5] no certain sign of echinococcus; it is independent of the age, sex and temperature of the patient, but upon rupture of the cyst eosinophilia invariably sets in.

The question as to the importance of helminthes in relation to certain diseases of the gut requires special discussion, but it concerns only *Ascaris lumbricoides, Oxyuris vermicularis,* and *Trichocephalus dispar,* and the question of appendicitis first of all. The entrance of intestinal parasites into the vermiform appendix was already known to medical men in the fifties of last century, as is shown by the works of Merling[6] (1836), Zebert[7] (1859), Platonor[8] (1853), and Schachtinger[9] (1861). Most of these authors have considered intestinal worms, together with other foreign bodies, to be the cause of appendicitis. As regards the part played by these intestinal parasites in the etiology of appendicitis, so much discussion has taken place during the last few years that it is worth while to give a résumé of the later views on this question, even though at the outset it must be admitted that the matter is not cleared up. Bergmann[10] records a case in which an Ascaris perforated the appendix and got into the peritoneal cavity.

Strümpell[11] reckons among the symptoms of Trichocephalus the possibility of a "typhlitis." On account of the marked sensitiveness of the ileo-cæcal region, Boas[12] mentions the possibility of confusing it with appendicitis. Still[13] regards Oxyuris as a principal cause of catarrhal affections of the appendix. Arboré-Rally[14] regarded severe symptoms of appendicitis in a boy, aged 10, as due to Ascarides. In all cases of appendicitis Metschnikoff[15] requires a microscopical examination to be made for eggs, and considers treatment for worms

---

[1] Caffarena, *Convers. clin. Genova*, 1902. [2] La Spada, *Gaz. d. Osp.*, 1904.
[3] Bindi, *ibid.*, 1907. [4] Santucci, "Clinica moderna," 1905.
[5] Welsh and Barling, *Scot. Med. and Surg. Journ.*, 1907.
[6], [7], [8], [9] quoted by Rostowzeff, *Bobritsch. Gaz. Botkina*, 1902.
[10] Bergmann, *Prag. med. Wochenschr.*, 1890.
[11] Strümpell, "Lehrb. d. spez. Path. u. Therap.," 1894.
[12] Boas, *Deutsch. med. Wochenschr.*, 1895. [13] Still, *Brit. Med. Journ.*, 1899.
[14] Arboré-Rally, *Arch. de Méd. des Enf.*, 1900. [15] Metschnikoff, *Bull. méd.*, 1901.

carried out otherwise as a cause of the frequency of perityphlitis. Matignon[1] does not agree with this opinion, as in spite of the extraordinary frequency of intestinal worms in China, he has only seen one case of appendicitis in four and a half years, and Des Barres[2] expresses himself in similar fashion. Out of twenty-one cases of appendicitis Kirmisson[3] discovered the ova of Trichocephalus eighteen imes and the ova of Ascarides in three of these cases; in twelve cases of enteric fever the examination for eggs was negative nine times. Moty[4] considers Oxyuris to be the sole cause in his three cases of appendicitis. Girard[5] ascribes to Trichocephali the *rôle* of more or less septic foreign bodies which may bring about the entry of intestinal bacteria into the appendix, and Triboulet[6] describes a case of appendicitis which he considers was due to Ascaris. In Morkowitin's[7] case numerous Oxyuris had clearly caused the appendicitis. von Genser[8] records the case of a boy, aged 5, who was operated on for appendicitis, and who passed through the operation wound a living Ascaris on the eighteenth day after the operation. In the first case communicated by Schiller[9] the disappearance of the typhlitic swelling after the discharge of the Ascarides pointed to the etiological significance of the parasites, and the same obtained in a further case published at an earlier date by Czerny and Heddäus.[10] In a case abstracted by Kaposi[11] Trichocephali appear to have been a contributory cause in the production of the appendicitis. In a further case reported by Schiller, where the appendix was removed, was shown that Oxyuris had given rise to a pronounced appendicular colic. In a girl, aged 13, who died from diffuse peritonitis, Schwankhaus[12] found that an Ascaris had perforated the appendix. Ramstedt[13] found in an extirpated appendix a whole "tangle" of Oxyuris, and believes in the possibility of their having provoked the inflammation; he recommends an examination for entozoa before the operation, without, however, after Metschnikoff's example, substituting worm treatment for the operation. Rostowzeff[14] ascribes only a minimal direct etiological significance to intestinal worms

---

1 Matignon (abstract), *Münch. med. Wochenschr.*, 1901.

2 Des Barres, *Gaz. des Hôp.*, 1903. 3 Kirmisson, *Annal. de Méd. et Chir. des Enf.*, 1901.

4 Moty abstract), *Münch. med. Wochenschr.*, 1901, p. 910.

Girard, *Annal. de l'Inst. Pasteur*, 1901.

6 Triboulet, *Soc. méd. des Hôp. de Paris*, 1901.

7 Morkowitin (abstract), *Centralbl. f. d. Grenzgebiete*, 1902.

8 v. Genser, *Wien. med. Wochenschr.*, 1901.

9 Schiller, *Beitr. z. klin. Chir.*, 1902, xxxiv.

10 Czerny and Heddäus, *ibid.*, xxi.

11 Kaposi, *ibid.*, xxviii. 12 Schwankhaus, *Amer. Pract.*, 1901.

13 Ramstedt, *Deutsch. med. Wochenschr.*, 1902.

14 Rostowzeff, *Russ. med. Rundschau*, 1903.

in the origin of appendicitis; in 163 cases he found worms in three instances. Wirsaladze[1] expresses himself in a similar fashion. Oppe[2] observed Oxyuris six times in excised appendices, and emphasizes the opinion that in appendicitis the question of a worm cure ought to be taken into consideration. Ascaris and Oxyuris, if no contra-indication exists, may be expelled, but in the case of Trichocephalus, which frequently defies all expulsive treatment, no attempt should be made, but operation proceeded to forthwith. In a case briefly reported by Hanau[3] Oxyuris was undoubtedly the etiological starting-point; in a case of Galli-Vallerio[4] Oxyuris and Trichocephalus. In the opinion of Ssaweljews[5] in some cases of appendicitis, in addition to other causes, intestinal parasites play a prominent part. The case recorded by Nason[6] is an interesting one; in this an Ascaris in the appendix became twisted with it round a coil of gut, causing obstruction. Spieler[7] argues against the under-estimation by many authors as to the part played by intestinal worms in producing appendicitis, although he also does not regard them as a frequent, to say nothing of an exclusive, cause of the disease. In a case recorded by Bégonin[8] fifteen Oxyuris were found in the excised appendix (the mucosa showed some ulceration), and in another recorded by Putnam[9] twenty Oxyuris were present in the appendix, in which there was no evidence of any change. The standpoint Schilling[10] takes is to the effect that entozoa irritate the mucosa and can increase an already existing inflammation, but he considers it very questionable whether they can produce appendicitis. Blanchard[11] assumes the possibility of a secondary infection arising from lesions of the mucosa produced by helminthes (Ascaris and Oxyuris). Moore[12] considers Trichocephalus the excitant of the appendicitis in his case. In a second case of appendicitis recorded by Auley[13] operation became unnecessary owing to the passage of the *Ascaridæ*. Page's[14] case is an interesting one; it was that of a man who came up for operation with a diagnosis of appendicitis. On incising the abdominal wall numerous Ascarides were found at the base of the

---

1 Wirsaladze, *Bcbritsch. Gaz. Botkina*, 1902. 2 Oppe, *Münch. med. Wochenschr.*, 1903.
3 Hanau, *ibid.*, 1903.
4 Galli-Vallerio, *Centralbl. f. Bakt.*, 1903, p. 1094.
5 Ssaweljews, *Deutsch. med. Zeitg.*, 1903.
6 Nason, *Journ. Amer. Med. Assoc.*, 1904.
7 Spieler, *Wien. klin. Wochenschr.*, 1904.
8 Bégonin, *Journ. de Méd. de Bordeaux*, July, 1902.
9 Putnam, quoted by Spieler. 10 Schilling, "Würzb. Abhandl.," 1905; v.
11 Blanchard, *Acad. de Méd.*, July 3, 1904.
12 Moore, *Brit. Med. Journ.*, August 18, 1906.
13 Auley, *ibid.*, 1906.
14 Page, *New York Med. Journ.*, January 20, 1906.

wound, lying in cavities; even after eight days Ascarides escaped from the wound. The author assumes there was a perforation of the gut wall; it is strange that the worms were able to exist a proportionately long time in the muscular tissue. Schoeppler[1] states that there is the danger of an appendicitis even after the death of an Oxyuris that has found its way into the appendix. Oui[2] met with two specimens of Trichocephalus which had become embedded by their thin ends deep in the mucosa. Frangenheim[3] is not in a position to pronounce any opinion as to what part intestinal parasites play in the etiology of appendicitis. In a case recorded by Kahane[4] many Trichocephali were found partly free in the appendix and partly embedded in the mucosa; microscopically appendicitis was diagnosed. At a laparotomy for salpingitis Heekes[5] found the appendix elongated, thickened, and containing about eleven Oxyuris without the mucosa being in any way changed. In one case Andrews[6] claims Ascarides to have been the direct cause of the appendicitis. The literature dealing with this question, so important in our time, has been collected almost without any omissions, but, unfortunately, no decisive opinion as to the significance of parasites in appendicitis can be inferred from it. The vexed question whether intestinal parasites, especially Ascaris, are able to penetrate the intestinal wall is just as little finally decided. Leuckart,[7] Heller,[8] Mosler and Peiper,[9] Henoch,[10] Davaine,[11] Küchenmeister,[12] and Bremser[13] are opposed to the idea that the healthy intestinal wall can be penetrated by intestinal worms, especially Ascarides, whilst a whole series of other authors are of the opinion that even the healthy intestinal mucosa can be perforated. Among these is numbered Mondière,[14] who is of the opinion that Ascaris, by violent pressure against the mucosa, forces it so much apart that it is enabled to escape through the gap thus formed into the peritoneal cavity; this opinion is shared by v. Siebold.[15] Rokitansky[16] considers perforation of the gut by Ascaris

---

[1] Schoeppler, *Centralbl. f. Bakt.*, 1906.
[2] Oui, *Rev. prat. d'Obstét. et de Paed.*, 1906.
[3] Frangenheim, *Samml. klin. Vortr.*, 1906, No. 424.
[4] Kahane, *Schweiz. Korrespondenzbl.*, 1907, viii.
[5] Heekes, *Brit. Med. Journ.*, March 16, 1907.
[6] Andrews, *ibid.*, 1906.
[7] Leuckart, "Die Parasiten des Menschen."
[8] Heller, "Handb. d. spez. Path.," v. Ziemssen, vii.
[9] Mosler and Peiper, "Spez. Path. u. Ther.," v. Nothnagel, vi.
[10] Henoch, "Vorlesungen über Kinderkrankheiten."
[11] Davaine, "Traité des Entozoaires."
[12] Küchenmeister and Zürn, "Die Parasiten des Menschen."
[13] Bremser, "Lebende Würmer im lebenden Menschen."
[14] Mondière, *Schmidt's Jahrb.*, 1840.
[15] v. Siebold, "Parasiten" in Wagner's "Handwörterbuch," 1845.
[16] Rokitansky, "Path. Anat."

as at least a rare occurrence. Gerhardt[1] does not doubt that the worms can actively perforate the intestine. Cases like those of Abrault,[2] Apostolides,[3] Marcus[4] (recorded by Perls as a valid example of "ascaridophagous" gut perforation), Wischnewsky,[5] Galvagno,[6] Salieri[7] certainly show that perforation of the healthy gut wall cannot be denied, but at the same time that this occurrence, compared with the frequency of *Ascaridæ*, should be regarded as exceedingly rare. It is another matter as to whether it is possible for the worms to penetrate an intestinal wall already diseased, especially when ulcerated; a whole series of observations are in favour of this. In Lini's[8] case (fifty-six Ascarides escaped from the umbilicus of a girl, aged 7), in Gräffe's[9] (eighty Ascarides escaped from an inguinal tumour), in Nicolino's[10] (perforation of the intestinal wall with strangulated hernia), in Liesen's[11] (a living Ascaris in the peritoneal cavity in a woman suffering from a peritoneal abscess)—in these it is clear that disease processes in the intestine preceded the exit of the worms. In a case described by Boloff[12] the Ascarides appear to have produced, by forming a tight coil, necrosis of the gut with perforative peritonitis. In a case recorded by Lutz[13] the perforative peritonitis was without doubt provoked by Ascaris, and in one by Schiller[14] the Ascaris had clearly gained access to the peritoneal cavity through a gunshot wound opening. In a case observed by Rehn[15] the worm probably entered through a gangrenous portion of the intestine in a hernial sac. Broca[16] is unable to determine whether in his case the intestinal perforation was primary (a worm escaped from the abdominal wound about two months after a laparotomy for suppurative peritonitis). The case reported by Lutz[17] is of special interest: it was that of a young man who had shot himself in the region of the abdomen, and who died after fifteen days. At the *post-mortem* two Ascarides were found in the pulmonary artery; they had probably escaped from the intestine, and had gained access to the inferior vena cava. Froelich[18] assumes that in his case

[1] Gerhardt, quoted by Liesen, "Dissert. Bonn."

[2] Abrault, quoted by Seifert, "Lehrb. d. Kinderkrankh."

[3] Apostolides, *Lancet*, 1898.

[4] Marcus, quoted by Seifert, "Lehrb. d. Kinderkrankh."

[5] Wischnewsky, quoted by Seifert, *ibid.*

[6] Galvagno, *Arch. de Patol. et Clin. inf.*, 1902.

[7] Salieri, *Rif. med.*, 1902.

[8] Lini, *Schmidt's Jahrb.*, 1838.

[9] Gräffe, *Protokoll d. Ges. f. Natur u. Heilkunde*, Dresden, 1853.

[10] Nicolino, *Clin. mod.*, 1902.

[11] Liesen, "Dissert. Bonn," 1904.

[12] Boloff, quoted by Seifert, "Lehrb. d. Kinderkrankh."

[13] Lutz, *Centralbl. f. Bakt.*

[14] Schiller, *Beitr. z. klin. Chir.*, xxxiv, p. 200.

[15] Rehn, *see* Schiller, *loc. cit.*, p. 201.

[16] Broca, *Rev. mens. des Mal. de l'Enf.*, 1904.

[17] Lutz, *Wien. klin. Wochenschr.*, 1905, xv.

[18] Froelich, *Rev. mens. des Mal. de l'Enf.*, 1897.

(a boy, aged 11) the Oxyuris were able to penetrate the whole intestinal wall, but Vuillemin[1] considers this improbable, and is more inclined to think that the Oxyurides penetrated the rectum at small ulcerated points, and thus gained access to the perirectal connective tissue. In females Oxyuris not only have the power of penetrating far into the sexual organs (Marro[2]), and perhaps causing a parasitic endometritis (Simons[3]), but also clearly of gaining access to the peritoneal cavity by way of the tubes, as is to be assumed in the case recorded by Kolb[4] (that of a woman, aged 42, in whom *post mortem* nodules were found over the peritoneum of Douglas's pouch, in which the pressure of encapsuled Oxyuris could be demonstrated), in that reported by Chiari[5] (adult Oxyuris in Douglas's pouch) and by Schneider[6] (an Oxyuris encapsuled in the pelvic peritoneum). Sehrt's[7] case is worthy of attention; in this an abscess was found in the omentum with numerous Ascaris ova in the pus and a *nodular* lesion of the peritoneum, with Ascaris ova encapsuled in the nodules. Massive accumulation of Ascarides may give rise to a complete occlusion of the gut. Such an occurrence is not so surprising as might be thought when one reflects that the number of Ascarides in one individual may amount to several hundreds. For instance, one boy evacuated within a single day 600 Ascarides (Fauconneau-Dufresne[8]) and within three years 5,126 worms. In the case recorded by Tschernomikow[9] a boy, aged 2½, evacuated during a day 208 worms, partly through the stomach, partly through the intestine. Coil-formation of such masses of Ascarides renders possible not only constipation, but also complete obstruction with symptoms of ileus, as shown by the five cases quoted by Mosler and Peiper,[10] as well as from observations made by Raie,[11] Schulhof,[12] Rehberg,[13] Rocheblave,[14] Heller,[15] Leichtenstern,[16] Huber,[17] and Wilms.[18] In two cases of Black[19] and Parkinson[20] the intestinal obstruction was caused by a coil of tapeworms.

In the earlier history of medicine the helminthes played a great part as the excitants of many intestinal diseases and of enteric as well. Even if to-day they no longer be regarded as such, the conception that they represent the predisposing factor in typhoid

[1] Vuillemin, *Centralbl. f. Bakt.*, 1902.
[2] Marro, *Arch. per le Sci. med.*, 1901.
[3] Simons, *Centralbl. f. Gynäk.*, 1899.
[4] Kolb, *Centralbl. f. Bakt.*, 1902.
[5] Chiari, *Prag. med. Wochenschr.*, 1902.
[6] Schneider, *Centralbl. f. Bakt.*, 1904.
[7] Sehrt, *Beitr. z. klin. Chir.*, li.
[8] Fauconneau-Dufresne, quoted by Seifert.
[9] Tschernomikow, quoted by Seifert.
[10] Mosler and Peiper, *loc. cit.*
[11] Raie, *Lancet*, 1899.
[12] Schulhof, *Münch. med. Wochenschr.*, 1903.
[13] Rehberg, "Dissert. Königsberg," 1907.
[14] Rocheblave, *Gaz. des Hôp.*, 1898.
[15] Heller, *loc. cit.*
[16] Leichtenstern, "Ziemssen's Handb.," vii.
[17] Huber, quoted by Rehberg.
[18] Wilms, *Deutsch. Zeitschr. f. Chir.*, xlvi.
[19] Black, *Brit. Med. Journ.*, 1872.
[20] Parkinson, quoted by Rehberg.

infection through the injury they inflict on the mucosa (Guiart,[1] Blanchard,[2] Vivaldi and Tonello[3]) must not be summarily rejected. Vivaldi and Tonello found helminthes in 80 per cent. of their typhoid patients, numbering among these *Trichocephalus dispar, Oxyuris vermicularis, Ancylostoma duodenale,* and *Ascaridæ.* The report of Leuckart[4] is here worth citing, to the effect that Thiebault never failed to find Trichocephalus in his cholera patients at Naples. Blanchard[5] goes so far as to express the desire that in every febrile affection of the intestine an anthelmintic treatment with thymol should be undertaken as early as possible, even before learning the results of serum diagnosis.

The lesions of the liver and pancreas due to *Ascaridæ* are briefly discussed in the chapter on Ascariasis (p. 687).

A discussion of the intestinal helminthes from the clinical and therapeutical point of view follows these general considerations.

Dibothriocephalus latus.

From what is known as to the development of *Dibothriocephalus latus,* the way by which man is infected is self-evident : infection can only take place through the ingestion of insufficiently cooked fresh-water fish (pike, burbot, perch, grayling and vendace) ; what degree of temperature is necessary to kill the larval forms is still unknown. *Dibothriocephalus latus* lives in the small intestine of man, alone or in some numbers, frequently also together with *Tænia solium.* The proglottides are passed always united in large pieces, the ova are deposited through the uterine pore, while the worm is still in the intestine, so that they are easily found in the fæces. The proglottides are so characteristic that they cannot be confused with those of other species. In reference to whether age or sex is spared by *D. latus,* it is not possible to make any definite statement, especially so far as the endemic area is concerned, whether a person resides n it continuously or visits it, so long as his habit of life is in accordance with those of the country. Bendix[6] certainly emphasizes the fact that early childhood is as a rule immune : his case was that of a child, aged 4½ years.

---

[1] Guiart, *Compt. rend. Soc. de Biol.*, Paris, March 16, 1901.
[2] Blanchard, *Arch. d. Par.*, 1901.
[3] Vivaldi and Tonello, *Gaz. d. Osp.*, October 29, 1905.
[4] Leuckart, quoted by Kahane. [5] Blanchard, *Acad. de Méd.*, October 18, 1904.
[6] Bendix, *Verein f. innere Med.*, Berlin, June 16, 1902.

Sparganum mansoni.

According to our present knowledge (Miyake[1]) the disease occurs almost exclusively in China and Japan. On the main island it occurs in all districts, though rarely under observation. It is especially frequent in the neighbourhood of Kioto and Osaka; these places are very near together, and between them there is mutually active intercourse, so that taken together they may be regarded as one district infested by this worm disease. As regards localization in the body, there appears to exist a certain predisposition for definite regions, for instance, the eye and genito-urinary tract. In some cases the parasite manifested the peculiarity of wandering about the body and of appearing at certain favourite points (musc. quadriceps femoris) (Hashimoto[2]). Most patients complain more or less of the onset of attacks of pain and of sensitiveness to pressure. In those cases in which the patients evacuated the worm during micturition, the symptoms were variable; sometimes there was tenesmus of the bladder, sometimes pains in the inguinal region, sometimes hæmaturia. None of these troubles is characteristic of the disease, and does no more than represent the symptoms that follow a mechanical irritation that any kind of foreign body may produce. Besides the onset of attacks of pain, swelling of the regions affected, if superficial, may often be recognized, when a superficial diffuse soft tumour can be felt which often gives pseudo-fluctuation. Sometimes a peculiar crackling can be detected internally, as in the making of a snowball. During the further course an abscess not infrequently forms around the worm. When the situation of the worm is superficial, "an inflammatory tumour with a tendency to migrate" is stated by Omi[3] to be an important diagnostic sign. That, however, is not always the case, as the observation made by Inoye[4] shows. It would be better to add to this sign the onset of paroxysmal pain and the temporary change in volume of the tumour. When once the parasite is removed, the wound heals just as satisfactorily as any other fresh wounds made at operation.

Dipylidium caninum (*Tænia cucumerina*).

This species belongs to parasites of rare occurrence. Up to the year 1905 Bollinger[5] collected thirty-six cases from the literature, twenty-nine of which were children and seven adults. Since then

---

[1] Miyake, *Mitteil. aus d. Grenzgebiete*, 1904, xiii.
[2] Hashimoto, quoted by Miyake. [3] Omi, *Iji-Shinshi*, Tokio, 1898.
[4] Inoye, *ibid.*, 1897.
[5] Bollinger, *Deutsch. Arch. f. klin. Med.*, 1905, lxxxiv.

some further cases have come to light, so that the number now observed amounts to ninety, and among them only eight adults. The youngest child was 6 weeks old (Köhl[1]), in which the first proglottides were passed when the child was 40 days old. This preponderating occurrence in children is clearly connected with the close intercourse between children and dogs, and also cats. Bollinger believes that *D. caninum* in reality occurs more frequently in adults than has hitherto been supposed. In addition, it must be mentioned that this species is quite unknown to many physicians, and is occasionally confused with *Tænia solium*. One notices almost daily a large quantity of cucumber-seed-like bodies, reddish or whitish-grey, about 1 cm. long and 2 mm. broad, discharged with the stools. Lindblad[2] remarks that these bodies have lively movements, that they perish rapidly in fresh water, and become white and smooth. These Cestodes, in isolated cases, are parasitic in the intestine in large numbers. Sonnenschein[3] expelled four fragments in the case of a boy, aged 4 months; Asam[4] three fragments in the case of a child, aged 19 months; and Zschokke[5] as many as five or six in that of a boy, aged 4. They do not always produce such striking symptoms as occurred in Pollak's case.[6] In other cases gastro-intestinal disturbances with or without fever (Krüger[7]), emaciation (Zschokke), or even nervous symptoms of central origin in the form of convulsions (Brandt[8]) have been observed. From the nature and mode of infection children must be kept from close contact with dogs and cats as much as possible to ensure prophylaxis. The appropriate treatment, as it mainly affects children, deserves special mention, whilst the expulsion of the remaining Cestodes may be described in this connection. Among the drugs one may mention flor. kousso 1·0 grm., pulpa tamar. depur. 2 grm., syrup of sugar 50·0 grm., one-third to be taken every hour (Lindblad). Kamala appears to have no effect, although Huber[9] recommends it in small doses according to age from 0·5 to 3·0 grm. He warns against *Filix mas* preparations, which otherwise, even in early childhood, under careful dosage gives the best results. Young children are given 1·0 to 2·0 grm. extr. fil. maris, with mint syrup or raspberry syrup 30·0 grm., in the morning twice an hour by the mouth, or 1·0 grm. extr. fil. maris is mixed with syrup

---

[1] Köhl, *Münch. med. Wochenschr.*, 1904. [2] Lindblad, *Hygiea*, xlv.

[3] Sonnenschein, *Münch. med. Wochenschr.*, 1903.

[4] Asam, *Münch. med. Wochenschr.*, 1903.

[5] Zschokke, *Centralbl. f. Bakt.*, 1905.

[6] Pollak, *Wien. klin. Wochenschr.*, 1907.

[7] Krüger, *St. Petersb. med. Wochenschr.*, 1887.

[8] Brandt, *Centralbl. f. Bakt.*, 1889.

[9] Huber, suppl. to Asam, *Münch. med. Wochenschr.*, 1903.

of mint, and given by means of a stomach tube (Rosenberg[1]). A few hours afterwards a mild laxative may be taken—one to two tablespoonfuls of aqueous tincture of rhubarb (Asam)—or an enema may be given. In a case reported by Sonnenschein decoction of pomegranate root had no effect, as it was vomited up.

Hymenolepis nana.

This species, very rare in Central and Northern Europe, inhabits the small intestine, especially of children; it burrows very deeply into the mucosa. Not uncommonly several thousand have been found in one case (Nicolo,[2] E. Stoerk and Haendel[3]). It is remarkable that these Cestodes have been found so frequently *post mortem* and after vermifuges given for other reasons. Thus the clinical symptoms must often be very indefinite (Stoerk and Haendel), so that one may assume that only a slight percentage of cases of *Hymenolepis nana* come under observation and are published as such. On the other hand, it is certainly conceivable that with the large number of parasites that frequently occur in one individual a whole series of symptoms, in part quite severe, are capable of being produced. These are partly symptoms of intestinal catarrh, consisting of abdominal pains, constipation, alternating with attacks of diarrhœa, perverse appetite, and boulimia, abdominal pains of a cramp-like nature, followed by emaciation, headache, sleeplessness, pallor, lassitude, and in part nervous symptoms—epileptiform attacks without loss of consciousness, weakness of memory, melancholia, irregular febrile attacks (Lutz[4]). Possibly, too, *Hymenolepis nana* infects the urinary organs, producing true chyluria (Predtetschensky[5]). Stoerk and Haendel are inclined to think that this species, unlike other Cestodes parasitic in man and domestic animals, needs no intermediate host for its development, and that the larval forms (cysticercoid) live in the same host as the adults. The diagnosis is based on the demonstration of ova in the stools. As far as expulsion of this Cestode is concerned, santonin, kamala, kousso flowers and thymol appear to have no effect of importance; whilst extract of male fern, recommended by Grassi[6] as a result of his considerable and successful experience, has been given, with the result that the worms really are expelled, and that after the treatment neither worms nor ova are any longer demonstrable in the stools of patients. In his cases of chyluria Predtetschensky prescribed ol.

---

[1] Rosenberg, *Ges. f. innere Med.*, February 16, 1904. [2] Nicolo, *Gaz. d. Osp.*, 1904.
[3] Stoerk, E., and Haendel, *Wien. klin. Wochenschr.*, 1907, xxix.
[4] Lutz, *Centralbl. f. Bakt.*, 1894. [5] Predtetschensky, *Zeitschr. f. klin. Med.*, xl.
[6] Grassi, *Centralbl. f. Bakt.*, 1887.

terebinth. 20 drops three times daily for a fortnight, then acid. gallic. 0·5 grm. three times a day for two days, then 1·0 grm. three times a day; the urine became clear, but whether permanent cure resulted remained doubtful.

Hymenolepis diminuta, H. lanceolata, Davainea asiatica, and *D. madagascarensis* possess no actual clinical interest; with regard to the latter it need only be pointed out that Bordier[1] in studying a case of chyluria found this species in the kidneys of a person in Madagascar.

Tænia solium.

Tænia solium inhabits the small intestine of man; single proglottides or whole worms may get into the abdominal cavity and the bladder through fistulæ, and penetrating the abdominal wall escape outwards or become discharged with the urine. Symptoms of intestinal stenosis are certainly very rare, as in the case recorded by Steinhaus[2] of a child, aged 9, the stenosis ceasing after the expulsion of the segments. The usual position of the worm in the small intestine is with the head closely adherent to the mucosa and the proglottides lying along the intestine; from time to time portions are discharged with the fæces *per rectum.* Its position can also be reversed, and the proglottides in the gut become thus discharged by vomiting.

The diagnosis depends upon the proglottides being generally discharged in pieces in the stools, or eventually an examination for eggs. Larval infection (*Cysticercus cellulosæ*) occurs also in man through auto-infection or through food.

Cysticercus cellulosæ of the skin and subcutaneous tissue occurs very seldom singly; as a rule they are found in hundreds and thousands in the same individual. They occur in different parts of the body, especially on the flexor surfaces of the extremities (generally symmetrically), small globular swellings, the size of a pea or a hazel nut, smooth, of a tough cartilaginous consistence, fairly movable under the skin, in the muscles less so. They never degenerate or cause the surrounding skin to lose its colour. It is an interesting fact that in the case described by Posselt[3] nodules on the face, namely in the neighbourhood of the left cheek and behind the left ear, reformed. The following are, according to Posselt, characteristic for cutaneous tumours due to cysticerci: (1) the position in the subcutaneous connective tissue (and almost always simultaneously in the muscles); (2) the approximately equal size and regularly

---

[1] Bordier, quoted by Predtetschensky, *loc. cit.*, p. 95.

[2] Steinhaus, *Deutsch. med. Wochenschr.*, 1903.

[3] Posselt, *Wien. klin. Wochenschr.*, 1899.

rounded oval form; (3) the peculiar density, almost reminding one of cartilage in its hardness and the sensation of tightly distended thick-walled bladders; (4) proportionately slight mobility; (5) with painlessness, absence of any cutaneous reaction (hyperæmia or swelling of the skin or pigmentation). The very gradual appearance generally of the tumours supports the diagnosis, and in addition to this evidence we may emphasize the preponderating liability of the upper part of the body to attack and the symmetrical arrangement of the nodules. Cutaneous and muscular cysticerci cause the most varied symptoms, sensory disturbances, abnormal sensations, depression and a feeling of weariness whenever the diseased parts are moved, weakness in the lower extremities, pains in the course of the sciatic nerve, in addition to those which simulate cramp in the calves, numbness in the hands, pains upon their being moved. In the case of a cysticercus situated in the elbow-joint, painful dragging sensation in the course of the ulnar nerve persisted. In other cases the arm was almost paralysed, or it could not be completely extended; stiffness and bending of the little finger were noticed. Cysticerci of the gluteal muscle cause trouble upon sitting and upon defæcation. Remittent unilateral headaches were present in the case of a cysticercus of the region of the right eyebrow; pains of a neuralgic character radiated from the diseased temporal region. The cysts may be inflamed and may suppurate; this especially happens in the case of solitary cutaneous and muscle cysticerci. The best treatment consists in puncture of the cysts with a Pravaz syringe and subsequent injection of a drop of 1 per cent. sublimate solution. Tincture of iodine has similarly been proposed (Wolff[1]). Frangenheim[2] recommends early extirpation (this, however, only in the case of solitary cysts). Pelagutti[3] believes that in his case diminution in the size of the cysts was obtained by the use of anthelminthic remedies continued over a long period combined with potassium iodide and calcium salts (internally). Cysticercus is very rarely found in the tongue; there the worms generally lie in front of the sulcus terminalis, corresponding to the middle of the tongue, according to Glas.[4] In the case recorded by Gaetano[5] (a boy, aged 10) there was a nodule on the left side of the tongue which grew very rapidly till it reached the size of a nut; it was embedded in the muscle and covered over by normal mucosa. Cysticerci are just as rare in the pleuræ, in the lungs, in the intestinal submucosa, in the submucosa of the small

---

[1] Wolff, "Lesser's Encyclop. d. Haut- u. Geschlechtskrankh.," 1900.

[2] Frangenheim, *Volkm. klin. Vortr.*, No. 424.

[3] Pelagutti, *Giorn. ital. delle mal. vener.*, 1900.

[4] Glas, *Wien. klin. Wochenschr.*, 1905.

[5] Gaetano, *Giorn. int. delle Sci. med.*, 1904.

intestine, in the mesenteric glands, in the liver, pancreas, spleen and kidneys, in the mamma, in the heart, in the bones and in the great vessels (Huber[1]). Cysticercus of the eye deserves special mention; in rare cases the cysticercus has been met with in the subcutaneous cellular tissue of the eyelid, once in the muscle bundles of the musculus orbicularis. Subconjunctival cysts are found chiefly in youthful individuals. Their position is most varied, generally in the neighbourhood of the inner angle of the eye. Dilated vessels pass right over the cysts, which are generally movable, together with the base they rest upon, producing a spherical protrusion. The head of the worm can sometimes be seen shining through as a whitish speck. The only symptoms are those of a slight irritation of the connective tissue and some difficulty in closing the lid; larger cysts dislocate the globe. The diagnosis has the rapid growth of the cystic tumour to support it; there is the possibility of its being mistaken for a foreign body (Kaldrovils[2]). After division of the connective tissue capsule extraction is easily performed. It is most rare for the cysticercus to occur in the orbit. Suppuration of the cyst may have serious consequences for the eye. It is only exceptionally that the cysticerci gain access to the anterior chamber of the eye.

Subretinal cysticerci or those localized in the vitreous are more frequent. Upon examination with the ophthalmoscope there is seen in the vitreous a bluish bladder with a smooth surface. The head is seen as a white patch, and the circle of hooks and the suckers also come into view, also the frequent movements which the head and neck make in the vitreous. Operation generally yields good results; in rare instances the globe is atrophied and must be enucleated.

Formerly cysticerci in the brain were met with in fair frequency, but the number of such cases has generally decreased of late years in a remarkable way, in correspondence with the diminution of cysticerci, which is to be attributed to compulsory meat inspection. Whilst, for example, the *post-mortem* records of the Pathological Institute in Berlin before the year 1875 showed 20 per cent. cysticerci affecting the brain, this number declined later to 16·3 per cent., and of late years has fallen to 1 per cent. (Orth[3]). Nevertheless even now cysticercus still plays no inconsiderable part in the etiology of cerebral diseases. For example, in the clinic of de Amicis at Naples, among seven cases of cysticerci of the skin, they were found four times also in the brain (Sipari[4]). Cysticerci may occur in the dura mater, arachnoid, pia mater, choroid plexus, the surface of the cerebral

[1] Huber, "Bibliographie der klin. Helminthologie," 1891, pt. 2.
[2] Kaldrovils, *Wien. med. Wochenschr.*, 1902.
[3] Orth, *Berl. med. Ges.*, June 29, 1904.
[4] Sipari, "Angelo Trani Neapel," 1900.

hemisphere, the medullary substance, the ventricles, the aqueduct, the corpus striatum, corpora quadrigemina, the pineal gland, the pons, the cerebellum, the olfactory trigone, the bulb, the medulla oblongata, and the olive. They are most frequently found in the cortical substance and in the ventricles; the frequency of the latter situation may be explained by the flow of the fluid (Henneberg[1]). The severity of the symptoms is not always in proportion to the number of cysticerci. Cases have been known in which ten, twenty and forty cysticerci have been found (Hagen-Thorn[2]), and yet the clinical symptoms have been remarkably slight. On the other hand, solitary cysts may both run a course completely without symptoms and also cause the severest symptoms when located in specially important parts of the brain (crus, pons, central convolutions). In the case mentioned by Jacobson[3] the invasion of the brain by cysticerci was immense; the largest cyst was found in the cerebral cortex. The chief symptoms of cysticercus of the brain substance consist in the onset of cortical epilepsy, which sometimes runs a very pernicious course, frequently with psychical disturbances, whilst paralyses are absent. Perhaps, too, the localization of pain, spontaneous and on pressure, corresponding with the points observed on the cranium, is of importance. Cysticerci may also change their position in the brain; patients who had earlier suffered from epileptiform convulsions later showed intra-ocular cysticerci after the cerebral symptoms had completely disappeared. Treatment can only be surgical; v. Bergmann[4] operated in two cases with well-marked improvement. Parasites in the ventricles are especially dangerous, more especially so when free in the ventricles, and so capable of giving rise to the danger of sudden closure of the foramen of Majendie (Simmonds,[5] Versé[6]). Stern[7] states the symptoms of cysticercus in the fourth ventricle to be the following: general cerebral pressure symptoms (headache, vertigo, vomiting, somnolence, congested disc caused by internal hydrocephalus); in addition, there are symptoms which point to disease of the hind-brain—pain and stiffness in the neck, vertigo and cerebellar ataxy, violent and persistent vomiting, slowness of pulse; and lastly those rare but certain symptoms of a lesion of the bulb, such as diabetes, respiratory disturbances and paralysis of cerebral nerves, especially of the abducens. These are far less marked than the general symptoms of cerebral pressure. One characteristic is the remarkable alternation between severe general

[1] Henneberg, *Berl. klin. Wochenschr.*, 1906, xxxii.
[2] Hagen-Thorn, abstract by Posselt. [3] Jacobson, *Berl. klin. Wochenschr.*, 1906.
[4] v. Bergmann, quoted by Frangenheim, *loc. cit.*, p. 470.
[5] Simmonds, *Münch. med. Wochenschr.*, 1907, xxvii.
[6] Versé, *Münch. med. Wochenschr.*, 1907, xi. [7] Stern, *Zeitschr. f. klin. Med.*, lxi.

symptoms and periods of complete sense of well-being; in this way a functional nervous affection may be simulated (Jolasse[1]). Brun's symptom (in the widest sense, sudden onset of violent cerebral symptoms upon change of head-posture) is a specially characteristic sign of free cysticercus in the fourth ventricle; the disease generally terminates with sudden death from cessation of the heart's action. Defects in motor power, convulsions, implication of other nerves, are rare and unessential complications (Hartmann[2]). Carefully carried out, lumbar puncture may possess some diagnostic and therapeutic value. Treatment is purely symptomatic, or eventually Neisser's ventricle puncture may be considered.

At the base of the brain the cysticerci, as a rule, assume that form which is designated as *C. racemosus*, and consists of rows of delicate grape-like bladders in groups, sometimes also markedly branched, but generally sterile, which develop in the meshes of the soft meninges and may envelop the nerves and vessels of the base of the brain. Such tumours bring about hydrocephalus and chronic leptomeningitis, which must be regarded as the causes of the clinical disturbances (cysticercus meningitis), attacks of loss of consciousness, dementia and apathy, dulness and confusion and headaches. In the case recorded by Meyer[3] symptoms which resembled paralysis agitans were noteworthy, and defects in speech in the case recorded by Durst[4] (*C. racemosus* in the region of the left Sylvian fossa). According to Markwald[5] *C. racemosus* of the fourth ventricle is said to represent a characteristic clinical picture: violent headaches, attacks of vertigo followed very soon by deep coma and death in a few days. Treatment in *Cysticercus racemosus* is ineffectual. In the diagnosis of cerebral cysticerci in general the recognition of multiple cysticerci in the skin and muscle and of the tapeworm is of importance. In cases of cerebral diseases in which cysticerci may be a possible cause, Remmert[6] recommends that the skin of the whole body should be palpated.

Cysticercus in the spinal cord and in the vertebral column is occasionally observed; as a rule, other organs, above all the brain and its membranes, are simultaneously affected. Here, too, the cysticercus occurs in two forms—sometimes the cysts are roundish or oval, solitary or multiple, and at other times *Cysticercus racemosus* occurs.

---

[1] Jolasse, *Münch. med. Wochenschr.*, 1896.
[2] Hartmann, *Wien. klin. Wochenschr.*, 1902.
[3] Meyer, *Deutsch. med. Wochenschr.*, 1906.
[4] Durst, *Liečn. viestnik*, 1902.
[5] Markwald, *Münch. med. Wochenschr.*, 1895.
[6] Remmert, "Dissert. Berlin," 1893.

Tænia saginata.

Occurs in the small intestine of man. It is characteristic of the habit of life of this parasite that once it has become mature its proglottides are dropped off daily in increasing numbers because its growth is extraordinarily rapid. The joints are discharged generally spontaneously during the whole day without a stool. An extraordinarily unpleasant sensation is produced by the damp, cool joints slipping down into one's lower garments and over one's legs when walking; women especially, in whom the proglottides slip through their petticoats on to their legs, complain bitterly of this troublesome symptom. Another unpleasant symptom is superadded in the shape of the proglottides tickling the rectum, and this excites irritable people to the last degree. Different species of tapeworms are not mutually exclusive. *B. latus* and *T. solium* frequently occur side by side, so also *T. solium* and *T. saginata*—for instance, in a butcher's assistant we once expelled twelve *T. solium* and one *T. saginata* at the same time. The greatest number of Tæniæ which have been observed at one time amounted to forty *T. solium* (Kleefeld[1]). Even though the cysticercus of *T. saginata* is not, as in the case of *T. solium*, particularly dangerous to man, a parasite, nevertheless, which requires so much nutrient material during its rapid growth, and thereby sets up manifold disturbances in the general condition of health, ought to be expelled as rapidly and thoroughly as possible.

Tapeworms are found not uncommonly with other intestinal parasites, such as Ascaris, Oxyuris, Trichocephalus or Ancylostoma. Prunac[2] described a case in which a woman passed a Tænia through the anus while she vomited a *Fasciola hepatica*.

The symptomatology of these three large species of Cestodes, *Dibothriocephalus latus*, *Tænia solium*, and *T. saginata*, may very well be summarized together, as, apart from some peculiarities, the clinical symptoms, especially so far as their localization in the intestine is concerned, are practically the same for all three species. In a large number of cases the hosts have no suspicion whatever that they are harbouring a tapeworm; they feel quite well and free from any disquieting symptoms whatever, and only become aware of the fact that they are the carriers of a tapeworm when the discharge of the segments takes place; on the other hand, it is often difficult to rid people of the idea that they are harbouring a Tænia (Küchenmeister calls such *Tænia imaginata*); usually it is undigested fibrous shreds of beefsteak which are regarded by the patients as proglottides of tæniæ.

---

[1] Kleefeld, *see* Seifert *loc. cit.*

[2] Prunac, *see* Eichhorst, "Handb. d. spez. Path. u. Therap.," ii, p. 281.

In a large number of cases, disturbances of the intestinal tract set in, *e.g.*, sense of pressure in the abdomen, which sometimes becomes constant on one and the same side, or sometimes changes, now at the umbilicus and again at the epigastrium; here and there colicky pains are present. Derangements of appetite and digestion are frequently complained of; the most frequent are the sensations of morbid hunger or irregular appetite, nausea and vomiting. Thus, at the Third Congress of Internal Medicine, Senator recorded a case in which there were symptoms of nervous dyspepsia, cured after a successful vermifuge. There is either constipation or diarrhœa, so that many of such patients are brought for treatment with the diagnosis of "chronic intestinal catarrh" and correspondingly treated. As to the treatment of toxic action of the Tæniæ when such arises, *see* the special section on the subject (bothriocephalus anæmia, p. 644). The frequent disturbances of the general condition, so-called reflex phenomena, so far as the action of toxic substances is not in question, may be explained by the fact of their occurrence in specially sensitive individuals who are affected by such phenomena. The proof that a diseased condition is produced by a tapeworm will be forthcoming with some degree of certainty if the symptoms cease immediately after the removal of the parasites. As a whole series of troubles, which certainly have nothing to do with them, are erroneously ascribed to the tapeworm, as is frequently assumed, one will do well to be somewhat critical in this respect.

The treatment is of a threefold nature: prophylactic, symptomatic and radical.

Under any circumstances, the best prophylaxis is that which consists in only eating the flesh of those animals in which any of the three larval forms occur (pig, cattle, salmon, pike, burbot, etc.) so prepared that the larval forms have been destroyed and the food thus rendered innocuous. For domestic and public use the rule prescribed by Küchenmeister is under all circumstances most easily understood, namely to roast or boil till the flesh appear greyish-white and sufficiently done by reason of the coagulation of the albumen and decolorization of the blood. The general prophylaxis simply concerns the tapeworm carriers trying to limit as far as possible the further extension of the parasites in the animal world by carefully rendering the expelled segments and worms harmless (pouring sulphuric acid over the fæces and burning the worms) and also by strictly adhering to official regulations. The official system of meat inspection in this respect has been of immense service, and much can still be done by means of thorough official control over cleanliness in abattoirs and butchers' shops. Galli-Valerio[1] very

[1] Galli-Valerio, *Therap. Monatsh.*, 1900.

rightly desires the abolition of the custom of manuring fruit-plants such as strawberries, vegetables and salad with the contents of privies, and would extend the use of privies in the country.

Symptomatic treatment consists, in the case of those Tæniæ which resist radical attempts at expulsion, of repeated use of drugs injurious to the worm as soon as ever new proglottides are formed, or in special cases, as in the case of persons weakened by diseases or operations, or frail old people, or patients with severe heart failure, gastric or intestinal carcinoma, or in pregnancy, in effecting the expulsion of a large chain of proglottides by the mildest measures possible.

Radical treatment of the Tænia is not always equally easy in all three species, even when the means used are the same; the easiest to expel is *T. solium*, then *D. latus*, and the most difficult *T. saginata*. That as yet no certain cure exists for Cestodes is clear from the large number of drugs recommended from time to time, and the increase of bungling treatment in this respect; in addition, there is no department in which there is so much quackery as in vermifuges. The treatment proper should always be preceded by thorough preparatory treatment, the purpose of which is to render the gut as empty as possible once for all, and on the other hand to put the worms themselves into a diseased condition. How far the host himself has been made ill by such preliminary cures (herring, pickle, garlic, onions, preserved strawberries), many a person who has had to do with such things can recount. In the opinion of Fischer[1] strict preparatory treatment appears to favour the development of toxic substances, or else it disposes to vomiting; as a rule it causes the patient far more discomfort than the treatment itself. In recent times far less weight is attached to these preparatory treatments than to carefully prepared and correctly dosed drugs; the preparation is generally limited to relieving the intestine in a simple way, the day before the treatment, of the densest fæcal masses, by a simple aperient or water enema.

We recommend the following, which has always proved itself to be the best and simplest remedy against *T. saginata*. The patient takes early in the evening before the treatment nothing but a plate of soup or a glass of milk, and then takes a laxative (electuar. lenit or infus. sennæ compos. or an enema), so that later in the evening one to two stools are passed. In this connection we fail to agree with Grawitz[2] and Boas,[3] who consider that at least preliminary evacuation of the intestines can be dispensed with. On the following

[1] Fischer, Stockholm, Nordin and Josephson, 1904.
[2] Grawitz, *Münch. med. Wochenschr.*, 1899.
[3] Boas, *Deutsch. med. Wochenschr.*, 1889.

morning the patient should take a cup of black coffee or tea without anything else, and half an hour later the vermifuge.

The best drug is extract. filicis maris æther., which also forms the main constituent of most of the secret remedies recommended for tapeworms. Earlier mishaps with this preparation had their origin principally in insufficient dosage. Also, in addition to correct dosage, extract. filic. maris needs very careful preparation if satisfactory results are to be attained. If preparations with the trade mark "Helfenberg" or "Wohnar" are not used, but the male fern extract has been prepared by a chemist, one must make certain that the roots of the *Aspidium filix-mas* have been collected in May or October, and only green sappy specimens selected, and that the attached paleæ have been separated, that they have been broken up small and ether poured over them with a little spirits of wine while quite fresh. The whole mass is to be kept in a cool place, but not too closely covered. If at any time a certain quantity is to be used, it is taken out, the ether carefully distilled in a retort till the extract has a suitable fluid consistency. Fischer attaches great importance to the direction in the Pharmacopœia being exactly followed, to the effect that the extract is to be carefully stirred before prescribing, as the active substances undergo partial crystallization if kept for any length of time and sink to the bottom, so that the preparation has a different strength and toxicity in different layers. Of this extract 10 to 12 to 15 grm. are to be taken in gelatine capsules within half an hour. We consider it unjustifiable to give greater doses than 15 grm. to adults, as many cases are known in which to some extent severe toxic symptoms have followed, such as headache, sensation of giddiness, dyspnœa and cyanosis, yellow vision (xanthopsia), delirium, stupor, the most severe cramps in the extremities, rapidly fatal trismus and tetanus. The most serious are defects of vision of various kinds, which may end in amblyopia and amaurosis, with permanent blindness. A complete collection of toxicological literature up to the year 1903 is to be found in Marx's[1] Dissertation. Since that time further instances of such intoxications have been made known. Nagel[2] observed them only in severe cases. O. Meyer[3] lays special stress on the bad prognosis of the disturbances of vision evoked by poisoning with extract. filicis maris. Studt[4] has seen two cases of optic neuritis, one with circumscribed, the other with diffuse retinal œdema. Uhthoff[5] has only seen one case; in that reported by Noiszewski[6] the toxic retinitis was cured; in Viereck's[7] case bilateral concentric limitation

[1] Marx, "Diss. Würzburg," 1903.
[2] Nagel, *Deutsch. med. Wochenschr.*, 1903.
[3] Meyer, O., *Berl. klin. Wochenschr.*, 1905.
[4] Studt, *ibid.*, 1905.
[5] Uhthoff, *ibid.*, 1905.
[6] Noiszewski, "Postepokuhs'," 1906.
[7] Viereck, *Arch. f. Schiffs- u. Tropen-Hyg.*, 1906.

of the field of vision followed three days after taking 8·0 grm. extract. filicis maris. Stuelp[1] attributes the amaurosis occurring after taking filix mas to a toxic action on the muscularis of the central retinal artery; there followed paralysis of the vessel, vascular engorgement, and thereby nutritional defects of the nervous elements followed. In children one has to diminish the dose correspondingly, as with them, still more so than with adults, severe disturbances arise. Huber[2] claims that this drug should not be given to children indiscriminately. The view is frequently expressed that a combination of extractum filicis maris with fatty oils in which the active constituents are soluble favours intoxication. Marx[3] also argues from this standpoint and assumes that the ideal preparation, free from objection, would be got if from filix-mas extract a preparation free from fatty oils could be made, and he considers it advisable to limit the use of castor oil as an aperient before and after taking the "cure," and to prescribe instead a saline laxative, such as Epsom salts or Glauber's salts. Sonnenschein[4] also advises against the simultaneous exhibition of extractum filicis maris with oleum ricini, as is the case with Helfenberg's capsules, and Boas[5] is likewise anxious that ol. ricini should be avoided. Lenhartz[6] appears to consider the warning against the simultaneous combination of the extract with fats or ethereal oils, and especially against the employment of castor oil as an after-treatment, as without justification, and we, too, in the course of our many filix treatments, have never yet witnessed any unfavourable effect from the use of castor oil in the after-treatment. The surest way of obviating the toxic effects of extractum filicis is to give a laxative (ol. ricini) as soon as the extract has left the stomach, say, about half an hour, so that it need not stay longer than necessary in the gut and become absorbed. Perhaps in most cases of poisoning, transgressions against this rule have been the cause of the toxic action. The nausea that sets in the day after taking the drug and the inclination to vomit are best resisted by giving iced coffee, iced tea, iced pills, peppermint tea, cognac, one to two wafer powders of menthol and sacch. lactis āā 0·2 grm. (Apolant[7]) half an hour before the drug is taken. Fischer[8] considers that lying still in the horizontal position is the best remedy. Boas[9] recommends the injection of the drug into the stomachs of patients who tolerate extractum filicis badly, in the form of a thin emulsion (with gi. arab.). In the case of children the extract

---

[1] Stuelp, *Arch. f. Augenheilk.*, 1906, li.
[2] Huber, *Münch. med. Wochenschr.*, 1903.
[3] Marx, *loc. cit.*
[4] Sonnenschein, *Münch. med. Wochenschr.*, 1903.
[5] Boas, *loc. cit.*
[6] Lenhartz, *loc. cit.*
[7] Apolant, *Deutsch. med. Wochenschr.*, 1905, xliv.
[8] Fischer, *loc. cit.*
[9] Boas, *loc. cit.*

is prescribed with honey as an electuary. The method recommended by Fowler[1] is without doubt too detailed; he prescribes before the treatment two to three to four days' rest in bed; special diet, tablets of cascara sagrada three times daily, on the fourth day senna infusion, and then to give the extractum filicis maris in capsules in four doses, to be taken every quarter of an hour.

Under Jaquet's[2] direction, Kraft has prepared an amorphous acid from the fern root extract which is designated filmaron. As a vermifuge the drug is prescribed for children of 2 to 5 years of age in doses up to 0·2 to 0·3 grm., for children of from 8 to 12 years in doses up to 0·5 to 0·7 grm., and for adults up to 0·7 to 1·0 grm., so as to expel the parasites. Bodenstein[3] gives the filmaron oil introduced into commerce by the firm of Boehringer (one part filmaron and nine parts castor oil) in still greater dosage, either fasting or, in the case of sensitive patients, one hour after a cup of tea; he gives peppermint tablets against possible nausea. Brieger[4] tested the preparation in twenty-three cases; in twenty-one of these he prescribed it as an ether-castor oil mixture, and in two as capsules. The action always took effect in from two to five hours, and only in three cases were unpleasant after-effects in the shape of colic observed; in sixteen cases the result was positive, in seven negative.

The attempts made by Goldmann[5] to prepare from the bark of *Musenna abyssinica*, a plant of the order *Myrsinaceæ*, indigenous to Persia, the active substance, namely sebirol, have shown that when this is given alone it certainly acts as a vermicide, but not as a vermifuge; on the other hand, the results of a combination of sebirol with thymol and salicylates were surprisingly good; this mixture has been introduced into commerce as tæniol, in the shape of pastilles prepared with chocolate for children. The method of giving tæniol is as follows: On the day before the administration a light diet and thorough purging with calomel are ordered; and then on the day of the treatment itself, after a breakfast consisting of a cup of tea, in the case of adults, thirteen to fifteen tæniol pastilles are taken in some red wine at intervals of ten minutes respectively. In the middle of this treatment an interval of some hours is interposed. After the pastilles have been taken a calomel purge is again given. The results obtained by Liermberger[6] are sufficiently encouraging to be put to further test.

Fischer[7] has tested in some of his cases extracts of some new species of fern root; he employed the extract from the rhizomes of

---

[1] Fowler, *Brit. Med. Journ.*, 1906.
[2] Jaquet, *Therap. Monatsh.*, 1904.
[3] Bodenstein, *Wien. med. Presse*, 1906.
[4] Brieger, "Therap. d. Gegenwart.," 1905.
[5] Goldmann, *Wien. klin. Wochenschr.*, 1905.
[6] Liermberger, *Berl. klin. Wochenschr.*, 1905.
[7] Fischer, *loc. cit.*

Aspidium spinulosum and *A. dilatatum*, two fern roots indigenous to Sweden, and obtained remarkable results (doses of 4 grm.). Laurén[1] had previously recorded similar results, and recently Friedjung,[2] using extr. aspid. spinulos.

Cortex radicis granati as fresh bark is a very good drug, and is usually given as a decoction: 180·0 bark to 1,000·0 water, boiled for forty hours to 240·0, and a small cupful to be given every half an hour; colic, vomiting and diarrhœa, are, however, easily induced. The chief constituent of the granate root, pelletierinum, possesses vermicidal properties, and is much recommended, especially in France. Sequelæ easily arise (vertigo, hazy vision, malaise, vomiting, quickened heart's action, muscular tremors, cramps in the calves), especially in delicate persons and children, so that one should refrain from giving it to the latter especially (Drivon[3]). Sometimes, judging by the experience of Sobotta[4] and Boas,[5] the action is problematical. Where it is desired to employ it in the case of adults, the following is prescribed: pellet. sulfur. 0·3 to 0·4 grm., acid. tannic. 0·5 grm., sir. rub. jd. 30·0 grm., to be taken at one time, and a quarter to half an hour after a purgative (senna infusion). In the case of children it is better to employ semina cucurbitæ maximæ instead of extractum filicis maris. Sixty to 100 pumpkin seeds are pounded up with sugar, which yield a pleasant-tasting electuary, and which are taken all at once; half an hour afterwards a laxative is taken (Storch,[6] Pick[7]). Jungklauss's preparation is nothing else than a pumpkin extract; its action is favourable; it is, however, too expensive (Ritter[8]). Flores kousso up to 15 to 20 grm. in compressed form or in sugar or honey in the form of electuaries (children 2·0 to 10·0 grm. according to age) is not to be relied upon; kussin, prepared from kousso flowers (Bedall, Munich), is not a pure body; when taken it is divided into four parts up to 1·0 to 2·0 grm. with elæosaccharum menthæ, at half-hourly intervals; it is said to be less unpleasant than treatment with flores kousso (Liebreich and Langgard[9]). Kosinum crystallisatum (dose 1·5 to 2·0 grm.) is prepared by the firm of Merck. Kamala is the least potent of the tapeworm drugs in use, and is principally to be recommended in the treatment of children: 1·5 to 3·0 grm. in electuaries. According to Leichtenstern[10] and White[11] chloroform, even in toxic doses, cannot

---

1 Laurén, *Therap. Monatsh.*, 1899.
2 Friedjung, *Ges. f. innere Med.*, Wien, March 8, 1906.
3 Drivon, *Lyon méd.*, 1902. 4 Sobotta, *loc. cit.* 5 Boas, *loc. cit.*
6 Storch, *see* Lenhartz, *loc. cit.*
7 Pick, *Ges. f. innere Med.*, Wien, March 8, 1906.
8 Ritter, *Prag. med. Wochenschr.*, 1904, v.
9 Liebreich and Langgard, "Kompendium der Arzneiverordnung," 1907.
10 Leichtenstern, "Therap. der Gegenwart.," 1899.
11 White, *Scot. Med. and Surg. Journ.*, 1900.

do any harm to the tapeworm, nevertheless it has been recently recommended by Carratû[1]; chloroform 6·0, sirup. 60·0, one teaspoonful to be taken every hour (fasting). Salol is recommended by Galli-Valerio[2] as an absolutely harmless tapeworm drug; thymotal (a derivative of thymol) by Pool,[3] 3 grm. to be given up to three to four times on four consecutive days.

The drug well known long ago, cuprum oxyd. nigr., has been recently brought into fresh notice by Dörr.[4] It is also the chief constituent of the tapeworm drug introduced into commerce by the firm of Dehlsen (Itzehoe) (Koch[5]). The coconut is absolutely ineffectual, also naphthalin, croton-chloral, ether, gallanol, strontium lactate, glycerine and bromide of potash.

Where possible one should endeavour to discover the head or the heads of the tapeworm in the stools, so as to make certain whether the treatment has been successful; this search is best carried out by immediately and carefully pouring water over the total quantity of evacuations collected in the night stool, without stirring them up, till only the tapeworm is found lying at the bottom of the vessel.

NEMATODES.

Strongyloides stercoralis.

The pathological significance of this intestinal parasite is not yet fully demonstrated. In Seifert's[6] observation, on what Leichtenstern[7] called the celebrated Würzburg case, the patient had suffered many times from attacks of blood-stained diarrhœa with tenesmus, as in Zinn's[8] case of a three year old boy who had bloody purulent diarrhœa. Schlüter[9] speaks of a hæmorrhagic enteritis produced by Strongyloides. In other cases besides diarrhœa (either with or without blood) there were noted: pains in the body (Schlüter), tenderness of the abdomen, loss of appetite, gastric troubles of a general kind, headache, giddiness, fainting attacks, anæmia (Silvestri,[10] Valdes,[11] and Trappe[12]), so that even if in isolated cases (Fülleborn[13]) symptoms are absent, some significance cannot be denied these parasites as a matter of course

---

[1] Carratú, *Giorn. med. del regio eserc.*, 1903.
[2] Galli-Valerio, *Therap. Monatsh.*, 1900.
[3] Pool, *Med. Woche*, 1901. [4] Dörr, "Therap. der Gegenwart.," 1901.
[5] Koch, *Med. Klinik*, 1907.
[6] Seifert, "Sitzungsberichte der phys.-med. Ges. in Würzburg," 1883.
[7] Leichtenstern, *Arbeiten aus d. kaiserl. Gesundheitsamte*, 1905, xxii.
[8] Zinn, *Berl. klin. Wochenschr.*, 1900, xlix.
[9] Schlüter, "Diss. Kiel," 1905. [10] Silvestri, *see* Schlüter *loc. cit.* [11] Valdes, *ibid.*
[12] Trappe, *Deutsch. med. Wochenschr.*, 1907.
[13] Fülleborn, *Biol. Abt. d. ärztl.-Vereins in Hamburg*, October 14, 1902.

(Bruns,[1] Leichtenstern[2]). According to Kurlow,[3] in Siberia there is a form of sporadic bloody diarrhœa which has its origin in the presence of *Strongyloides stercoralis*. The parasite does not live only in the intestinal lumen, but also in the intestinal wall, where it causes abscesses, fistulæ and effusions of blood.

Diagnosis is easily made by the detection of the actively moving larvæ in the stools.

Treatment is rather difficult, as it is not always successful in getting rid of the parasites. Authors differ as to the effectiveness of extr. fil. maris. Goldmann[4] still considers this preparation as the most effective; he recommends preliminary treatment with calomel 0·2 grm. and tuber. jalapæ 0·5 grm. a day before the special treatment, which consists of gelatine capsules of 15·0 grm. extr. fil. maris (to be taken in the course of four hours); afterwards rectified oil of turpentine in gelatine capsules. The thymol treatment (*vide* Ancylostomiasis, p. 682), thymol alone or in combination with calomel (Schlüter,[5] Valdes,[6] Soussino,[7] Goldmann[8]), has often caused diminution of the number of larvæ, but also often remains resultless. Teissier[9] maintains that by degrees he procured complete cure by the administration of mercury in the form of blue pill. In our case neither thymol nor calomel, santonin, extr. fil. maris, decoct. rad. granat., had any result whatever. Davaine[10] believes he attained decrease and final disappearance of the larvæ by protracted milk-cure. Santonin, tannalbin and other preparations seem ineffectual. Tannin enemata (Mildner[11]), high injections with starch enemata (Schlüter[12]), may alleviate in persistent diarrhœa. Travellers who are visiting regions the native home of Strongyloides must exercise the most extreme care and scrupulous cleanliness, and these are also necessary in patients already suffering from Strongyloides, to prevent auto-reinfection (Trappe[13]).

Dracunculus medinensis (Dracontiasis).

The guinea worm develops in the dermis of human beings without any symptoms; only when it is completely grown does it form boil-like, extremely painful abscesses, in the greater majority of cases in the legs, in the region of the ankle, and is accompanied by general disturbance and a feeling of heaviness, dragging and pricking of the

---

[1] Bruns, *Münch. med. Wochenschr.*, 1907, xix.
[2] Leichtenstern, *Deutsch. med. Wochenschr.*, 1898.
[3] Kurlow, *Centralbl. f. Bakt.*, 1902.
[4] Goldmann, *Deutsch. Aerzte-Zeitg.*, 1903.
[5] Schlüter, "Diss. Kiel," 1905.
[6] Valdes, *loc. cit.*
[7] Soussino, *see* Schlüter *loc. cit.*
[8] Goldmann, *loc. cit.*
[9] Teissier, *Arch. d. Méd. exp.*, 1895.
[10] Davaine, *see* Seifert, *Deutsch. med. Zeitg.*, 1885.
[11] Mildner, *Berl. med. Ges.*, July 24, 1907.
[12] Schlüter, *loc. cit.*
[13] Trappe, *loc. cit.*

affected part; it occurs more rarely in the arms, certain parts of the back, the head, neck, scrotum and penis; in a superficial position the worm can occasionally be felt through the skin. In most cases there is only one worm and one abscess, but here and there one finds patients with three, four or even up to eight worms, and very exceptionally still more, as in the cases described by Poupée-Desportes[1] (fifty worms) and by Harington[2] (seventeen worms).

Diagnosis offers no difficulty when the worms are presenting or can be felt under the skin.

The inhabitants of the native home of the guinea worm, as a rule, quietly wait till it has got so far out that it can be conveniently grasped; it is then bound round with thread and fastened between the tips of a split piece of wood and slowly wound out. In ten to twelve days it can be wound out in this way. Emily[3] makes injections of a 1 in 1,000 solution of sublimate either in the neighbourhood of the worm or directly into its body. Mense[4] managed to remove the worm in one sitting by laying a wad of cotton wool soaked in chloroform on the exposed portion, thus stupefying it. Our therapeutic observations (Frangenheim[5]) favour the free laying open of the existing abscess and the consequent complete extraction of the worm.

Prophylaxis depends on care in the use of water in the guinea worm countries, especially dangerous being permanent waters infested by *Cyclops* sp.

Filaria bancrofti.

The parasitism of this filaria leads to the formation of lymphangitis, elephantiasis, chyluria, orchitis, chylocele, abscesses, lymphatic varices, perhaps also to chylous ascites and chylous diarrhœa.

Lymphangitis usually attacks the extremities, beginning generally with a rigor and swelling of the lymphatic vessels with adjoining lymph glands. The lymphatics become hard, knotty and extremely painful, the overlying skin red and swollen in longitudinal lines (Looss), high fever sets in with, to some extent, severe general disturbance. After some days the attack subsides, the swelling then partially disappears, but not completely, and often abscesses develop in consequence of the lymphangitis. Children, as a rule, suffer from such lymphangitic attacks (Finucane[6]).

Diagnosis is not easy, for many other causes frequently produce lymphangitis.

---

[1] Poupée-Desportes, *see* Looss, "Handb. d. Tropenkrankh.," 1905, i.
[2] Harington, *Brit. Med. Journ.*, 1906. [3] Emily, *see* Looss *loc. cit.* [4] Mense, *ibid.*
[5] Frangenheim, Volkmann's *Samml. klin. Vorträge*, 424.
[6] Finucane, *Lancet*, 1907.

Treatment consists in rest, raising the affected limb, applications of vinegar and alum or liquor plumbi, in some cases incisions into the swollen part under antiseptic precautions.

Elephantiasis (*Arabum*) is usually situated in the lower extremities, in men in the scrotum and penis, in women in the labium pudendi, mons veneris, and the mammæ; more rarely it attacks the upper extremities or, indeed, the head. The disease develops during repeated attacks, which occur at irregular intervals of weeks, months or years, of fever accompanied by symptoms of lymphangitis and erysipelas (*elephantoid fever*), and especially as the result of different accidental occurrences such as chills, bodily exertions, external irritation. The extremities become shapeless, heavy cylinders, the scrotum occasionally a colossal tumour, the female genitalia and the mammæ smaller or larger tumours; the penis often shares in the general thickening, the inguinal glands form large hard prominent masses, and enormous deformity is caused. The cause is more often seen in men than women, rarely in children over 10, never in younger children.

Treatment of elephantiasis of the extremities consists in raising the affected part, massage, bandaging, vapour baths ; the large elephantoid tumours of the genitalia and mammæ can only be treated by operative removal.

Chyluria (hæmato-chyluria), as a rule, begins by a series of attacks and often ceases for weeks or months, the attacks being accompanied by fever, pain in the back and lumbar region, about the kidneys and in the perinæum. The attacks are separated by intervals of months' or even years' duration, a continuous chyluria being quite rare. The disease may last many years without the constitution being markedly weakened, but in other cases anæmia and debility ensue and result in death from marasmus. In chyluria the urine becomes completely opaque like milk ; but sometimes, from the presence of blood, is of a peach-like redness : the sediment contains clotted blood, and microscopically one finds fine dust-like fat granules and red cells and leucocytes, and usually, but not always, filaria larvæ. Sclerodermia may possibly be caused by Filaria (Bancroft[1]).

Treatment consists in administration of ol. santali, methylene blue (0·12 grm. dose several times daily), ichthyol (in pills from 0·5 to 1·5 grm. per day), ol. terebinthinæ (0·5 to 1·5 gr. per day), thymol (Ziemann[2] had no result from either thymol or methylene blue), together with absolute rest in bed, diminution of all fatty nourishment and administration of light purgatives.

Orchitis is in acute attacks a relatively frequent symptom in the East ; the chylocele is rarely marked; the fluid usually shows

[1] Bancroft, *Lancet*, 1885. [2] Ziemann, *Deutsch. med. Wochenschr.*, 1905, xi.

numerous larvæ; in the case of abscesses they are generally caused directly by the adult parasites, as they have often been found in them; varices of the lymphatic vessels are either superficial or deep; lymphorrhagia arises from rupture of the dilated vessels; chylous ascites and chylous diarrhœa may also be produced by Filariæ.

Loa loa.

Loa loa, according to modern investigations, is a parasite of the subcutaneous connective tissue of man, and its appearance in the conjunctiva somewhat accidental; in earlier times it seems to have been less common (Ziemann[1]). A number of cases are seen in Europe of patients who have lived in filaria regions, and on return have been found to have this Nematode in the subconjunctival tissue. Pick,[2] in the case of a man who had lived in the Cameroons, found the parasites in active motion under the connective tissue of the eyeball right over the cornea; extraction was easy. Ziemann[3] noted three cases of *Loa loa* in the eye accompanied by temporary migratory swellings in different parts of the body. In one case, observed by Wurtz and Cleri[4] (a woman from the French Congo), *Loa loa* was the cause of intermittent elastic swellings in the subcutaneous and subconjunctival tissue (marked eosinophilia). In the case recorded by Pollack[5] (for thirty years police commissioner in the Cameroons) the worm under the connective tissue of the left eye by its snake-like movements caused an unpleasant itching. With cocaine and adrenalin the worm can be made visible, and by means of a strabismus hook can be drawn out of a small wound in the connective tissue. Martens[6] exhibited a Filaria extracted from the eyelid under local anæsthesia.

Trichuris trichiura.

Whilst many authors consider the whip-worm as a harmless parasite of the large intestine (Leichtenstern,[7] Eichhorst,[8] Askanazy[9]), the number of severe and even fatal cases of diseases caused by it (trichocephaliasis) increase so much that the *Trichuris trichiura* must be excluded from the group of harmless intestinal parasites. (For disturbances of the nervous system and of the blood

---

[1] Ziemann, *Deutsch. med. Wochenschr.*, 1905.
[2] Pick, *ibid.* [3] Ziemann, *loc. cit.*
[4] Wurtz and Cleri, *Arch. Méd. expér.*, 1905, ii.
[5] Pollack, *Berl. ophthal. Ges.*, May 17, 1906.
[6] Martens, *Berl. med. Ges.*, July 24, 1907.
[7] Leichtenstern, "Handb. d. Therap. v. Pentzoldt-Stintzing."
[8] Eichhorst, "Handb. d. Spez. Path. u. Therap."
[9] Askanazy, *Deutsch. Arch. f. klin. Med.*, 1896.

[anæmia] from trichocephaliasis, *see* p. 650). Infection in human beings results from the eggs that have developed outside the body, which probably reach the digestive tract on the hands soiled with dirt or earth, or possibly through drinking water. (Moosbrugger[1] and Kahane[2] mention in their cases that the children had an absolute passion for earth-eating.) Possibly, too, patients reinfect themselves anew, as an intermediate host is not necessary.

The anterior part of the body of the parasite is usually fixed in the mucous membrane, and according to Askanazy feeds on the blood of its host. Moosbrugger,[1] Schulze,[3] Kahane,[2] Vix,[4] Girard[5] and Blanchard[6] all found changes in the mucous membrane of the gut, showing that the parasites had been in the gut for a considerable time. Kahane[2] had an opportunity of seeing at the Pasteur Institute Trichocephali with the anterior part of the body penetrating not only the mucosa but also deep into the muscularis of the gut wall. From this mode of attachment to the wall it is easily understood how Trichocephali, especially when they are numerous in the gut, cause local irritation and inflammatory conditions consisting of frequent attacks of diarrhœa, sometimes twenty times a day, lasting for months, resisting all remedies, and often accompanied by colicky pains and symptoms of peritonitis. The stools often have blood mixed with the fluid, very glassy, jelly-like mucus, more or less abundantly as in the cases of Moesasca, Moosbrugger,[1] Kahane,[2] Girard,[5] Poledne,[7] and Rippe.[8] Nausea and vomiting are rarer symptoms.

Diagnosis as a rule can only be made by microscopical examination of the stools; together with the eggs, regular and beautifully formed Charcot-Leyden crystals occur.

The prognosis is unfavourable in severe infections, in slighter cases, where only a few worms are present, the danger of important symptoms is less. Treatment consists in administration *per os* of vermicides and in local treatment of the large gut. A remedy which was once much used was calomel, which is much lauded by Gibson and given as follows: calomel 0·06 grm., rheum. 0·3 grm., tinct. ferri sesquichlor. 1·2 c.c., aq. dest. 90·0 grm., six dessert-spoonfuls three times daily. Rippe appears to have got no result from the use of this prescription. Thymol, especially in conjunction with local treatment of

---

[1] Moosbrugger, *Med. Corresp.-Bl. f. Württemburg*, 1890.
[2] Kahane, *Korrespondenzbl. f. Schweiz. Aezte*, 1907, viii.
[3] Schulze, *Deutsch. med. Wochenschr.*, 1905.
[4] Vix, *Zeitschr. f. Psychiat.*, xvii.
[5] Girard, *Annal. d. l'Inst. Pasteur*, 1901.
[6] Blanchard, *Acad. de Méd.*, July 3, 1906.
[7] Poledne, *Wien. med. Wochenschr.*, 1906.
[8] Rippe, *St. Petersb. med. Wochenschr.*, 1907.

the large intestine, had unquestionably some effect in certain cases, such as those of Girard, Poledne, Hausmann, Kahane and Schiller. The local treatment of the large bowel is most effectual when high injections of water and benzine are given. Becker[1] obviously used too much benzine (1 dessert-spoonful to 1 litre of water), for severe irritation was set up, whilst Peiper[2] used only a few drops of benzine, 5 drops to 1 litre of water being enough (Schiller). Instead of benzine enemata, garlic, 1 per cent. thymol solution, and physiological saline injections have been used, but the benzine enemata seem to be far and away the most effective. In Schiller's case 2,000 worms came away on the first day as the result of such a combined treatment (thymol internally and benzine enemata).

Trichinella spiralis.

Trichinosis is, happily, becoming so much rarer that many doctors get no opportunity, either in their student days or in private practice, of seeing this severe disease; we ourselves remember having observed one typical case of a peasant, aged 17, from Metz in Med.-Rat Merkel's clinic in Nuremberg in the year 1879. In the description of the disease we follow Merkel's[3] observations.

The eating of flesh containing Trichinæ is often followed, if not invariably so, by gastric disturbances of different kinds, especially by vomiting and diarrhœa, with colic, great muscular fatigue, œdema of the eyelids, muscular swellings with hardness and extreme painfulness, disturbance of ocular movements, of deglutition and of breathing, hoarseness, aphonia, intestinal hæmorrhage, bleeding of the nose, ecchymosis of the skin and mucosæ, prurigo, herpes, miliaria, pustules, boils, severe sweating, œdema of the extremities, and, finally, desquamation of the skin; more rarely there is considerable decubitus, bronchial catarrh, hypostatic and catarrhal pneumonia, with dry and purulent pleurisy, and in severe cases symptoms of collapse with delirium close the scene. Slight cases last from three to six weeks, severe ones for several months, and in the latter convalescence is very slow. It is remarkable that in cases of trichinosis of long duration, cancer of the breast was observed at the same time (Klopsch,[4] Langenbeck,[5] Babes[6]). Death during epidemics occurred in 30 per cent. of all cases. The disease begins

[1] Becker, *Deutsch. med. Wochenschr.*, 1902.
[2] Peiper, quoted by Seifert, *loc. cit.*, p. 248.
[3] Merkel, "Handb. d. Therap. v. Pentzoldt-Stintzing," i.
[4] Klopsch, quoted by Babes.
[5] Langenbeck, *ibid.*
[6] Babes, *Centralbl. f. Bakt.*, 1906, xlii.

generally from one to ten days after eating trichinous flesh, yet there have been cases noted in which the disease began several weeks after.

Diagnosis in the presence of several cases, or in epidemics, is not difficult, but in isolated cases, on the other hand, it is not easy. If there is a suspicion of trichinosis, from the muscular fatigue and the œdema of the eyelids, the diagnosis can be made by excision of a piece of muscle and by finding the Trichinæ in the tissue, taken with the results of the examination of the previously eaten sausage or meat. In contradistinction to this circumstantial process, there is the examination of the blood, which, according to Schleip[1] (Homburg trichinosis epidemic, August 19 to 26, 1903, 130 cases), is the most valuable method of diagnosing trichinosis when the Trichinæ have not yet penetrated the muscles, for a blood examination shows a large increase in the numbers of the eosinophile cells; Stäubli detected his seven cases in this way, four of the severe ones showing a marked hyperleucocytosis, and a combination of Kernig's sign with absence of the patellar reflex. On account of the rarity of these two signs in combination in other infective diseases, they have a certain diagnostic value. Stäubli[2] also observed in trichinosis the constant appearance of a remarkably strong positive diazo-reaction of the urine.

Prophylaxis in trichinosis is fully considered under *Trichinella spiralis* (p. 429).

Treatment consists in those cases where it is known that trichinous flesh has been swallowed in the first place of washing out the stomach, but still more in a thorough evacuation of the bowels, for which calomel (0·5 grm.), ol. ricini (a dessert-spoonful till the action becomes marked), infusion of senna with sulphate of magnesia and large enemata are employed, and should be repeated at intervals during the first few weeks. Alcohol (cognac up to 250 c.c. a day) is recommended by some, also glycerine (150 grm. at a dose) and large doses of dilute hydrochloric acid. Beside these, a large number of other remedies are recommended, of which, perhaps, benzine and thymol, especially in the form of enemata, are worthy of notice.

When the disease is fully developed the treatment should be symptomatic; a protracted practically continuous luke-warm bath is especially useful.

Eustrongylus gigas.

Eustrongylus gigas is most frequently found in the pelvis of the kidney. Infection in the majority of cases leads to pyelitis. The

---

[1] Schleip, *Deutsch. Arch. f. klin. Med.*, lxxx.

[2] Stäubli, *ibid.*, lxxxv.

inflammation extends to the capsule from the pelvis, resulting in a purulent nephritis. In infections of longer duration, the affected kidneys become changed into so-called kidney sacs, while the kidney itself continuously shrinks. Owing to the worm fixing its posterior end in the ureter, and owing to an inflammatory swelling of the mucosa of the ureter, the passage of urine becomes very difficult.

The symptoms resemble those caused by a foreign body, *e.g.*, kidney pain, suppression of urine, dysuria, discharge of blood and pus with the urine. But these symptoms are not sufficient for a diagnosis; this can only be established by finding eggs or the parasite itself in the urine.

Moscato[1] records a case with chyluria, pain in the region of the right kidney, and hysterical symptoms. During an hysterical attack a specimen of *Eustrongylus gigas* was discharged in the urine, and the chyluria and nervous affections disappeared. In a case described by Stuertz[2] of an Australian with chyluria due to *Eustrongylus gigas* the chyluria had existed for seven years. In the urine the eggs of *Eustrongylus gigas* were found. The cystoscopic examination showed that turbid urine was discharging from the left ureter. Nephrectomy was considered.

Ancylostoma duodenale (Ancylostomiasis).

Whilst up to quite modern times it has been generally maintained that the great majority of worm diseases cause more or less marked symptoms, the exact investigations of the last few years have made it plain that the great majority of people with worms are not only perfectly healthy, but the most careful clinical observations show no single sign of any ill-effect of the intestinal parasites on the health of the host (Löbker and Bruns[3]). If infection has led to the development of only a few ancylostomes, then injury to the general health is, as a rule, scarcely noticeable. In order to produce severe illness the presence of several hundred worms in the intestine is necessary, and in general the intensity of illness varies in exact proportion to the number of worms. Then the duration of the infection comes into play: the longer the human organism is submitted to the injurious effect of the parasite, the clearer is the effect on the host. Besides, the resistance of the individual has to be considered. Whilst a more robust person can harbour without ill-effect for a longer time a larger number of ancylostomes, the symptoms of the disease become more markedly and much sooner apparent in weakly persons or in those weakened by other diseases.

---

[1] Moscato, quoted by Predtetschensky, *Zeitschr. f. klin. Med.*, xl.
[2] Stuertz, *Ges. d. Charité-Aerzte in Berlin*, June 26, 1902.
[3] Löbker and Bruns, *Arb. aus. dem. kaiserl. Gesundheitsamte*, 1906, xxiii.

The first symptom is disturbance of the digestive system ; more often there is a feeling of pain in the epigastrium, more severe upon pressure, heartburn, nausea, vomiting of mucus or food at different times of the day (occasionally ancylostome ova have been found in the vomit). Whether the eggs which reach the frontal sinus with the vomit can develop into larvæ there is questionable, but the records of v. Ziemssen[1] and Huppertz,[2] to the effect that in some instances ancylostomes have been discharged from the frontal sinus, are of interest. The five cases recorded by the latter had a fatal termination from œdematous swellings of the face with severe inflammation of the meninges. The tongue is furred, and extensive catarrhal stomatitis and ptyalism are recorded. The appetite is variable, increasing or diminishing, there is loathing of nourishment or a marked longing for acid food and unripe fruit, whilst ordinary meals are rejected. At first there is often constipation, later diarrhœa with abundant mucus, and often blood in the stools; microscopically eggs and Charcot-Leyden crystals were found.

In the further course of the disease symptoms due to increasing anæmia predominate ; the hæmoglobin of the blood diminishes from one-fourth to one-fifth of the normal (Baravalle[3]), the eosinophile cells increase considerably (Boycott,[4] Lohr[5]), yet in regard to diagnosis eosinophilia cannot be regarded as of equal value to a microscopical examination of the fæces (Bruns, Liefmann, and Meckel[6]). The disturbances of the circulatory system take the form of more or less severe palpitation, pain in the region of the heart, quick pulse, œdema of the eyelids, of the face, of the lower limbs, and even of the whole body. Disturbance of the sexual functions (impotence, irregular menstruation, delayed onset of puberty) are not infrequently observed.

Infection in human beings takes place by the mouth, if uncleansed vegetables are eaten—in Japan especially, where human fæces are used—and articles of food are not sufficiently carefully cleaned (Inouye[7]), or from putting food into the mouth with dirty hands. Looss[8] does not think that drinking water is dangerous as a rule, for the larvæ sink to the bottom in standing water, and are only brought to the top by shaking. Looss has done most valuable service by discovering that infection can arise also through the skin. During the last few years so many authors have confirmed this at first doubted source

---

[1] v. Ziemssen, quoted by Haenisch, "Diss. Strasburg," 1901.
[2] Huppertz, quoted by Haenisch, "Diss. Strasburg," 1901.
[3] Baravalle, *Progresso medico*, 1903.
[4] Boycott, *Journ. of Hygiene*, 1904. [5] Lohr, *Zeitschr. f. Heilk.*, xxvi.
[6] Bruns, Liefmann and Meckel, *Münch. med. Wochenschr.*, 1905.
[7] Inouye, *Arch. f. Verdauungs Krankh.*, 1905, xi.
[8] Looss, "Handb. f. Tropenkrankh.," v. Mense, i, p. 129.

of infection, that one must accept this source of infection now, even though it is undecided which mode of infection is the more prevalent, by the mouth or through the skin. Some authors have described the changes induced in the skin by the penetration of the larvæ; for instance, Looss and Schaudinn,[1] itching papules in their own skin, and Dieminger[2] a skin affection in the Graf Schwerin mine which was called the "Schweriner itch," and a skin affection not unlike scabies in the tea plantations of Assam and South America; panighao (water itch) (Dubreuilh[3]); the penetration of the larvæ through the skin also explains the frequent appearance of boils and itching purulent eczema in miners in infected pits (Goldmann[4]).

The absolute diagnosis of ancylostomiasis depends on the detection of the ancylostome eggs in the fæces, and presents no difficulties.

Prophylaxis is of the greatest importance, especially to miners. The spread of ancylostomiasis seems to depend only on fæces deposited in damp places, so that on the one hand the deposition of fæces must be prevented, and on the other the fæces must be rendered as far as possible harmless; in addition, there is the individual prophylaxis.

General prophylaxis requires:—

(1) Examination immediately for ancylostomes of miners seeking work and of those newly taken on five to six weeks after.

(2) Indentured workers who are infected with worms are not allowed to work underground until a medical certificate in writing is brought to the effect that they are no more infected with eggs (the same procedure applies to workmen in brick kilns) (Goldmann[5]).

(3) Indentured workers infected with worms must submit themselves to the prescribed treatment, and after its completion further submit their stools to three examinations at intervals of about four weeks.

(4) Special supervision of miners and brick-makers coming from the Italian frontier.

(5) Workmen must be given instructions, both by word of mouth and in writing in their mother tongue, as to the infectivity and danger of ancylostomiasis both to themselves and others.

(6) Orders are to be given as to washing, baths, and changing of clothes at the end of the work.

(7) During the hours of working in the pits, taking of food is strictly forbidden without thorough and entire washing.

---

[1] Schaudinn, *Deutsch. med. Wochenschr.*, 1904.

[2] Dieminger, *Klin. Jahrb.*, 1905, xiv. [3] Dubreuilh, *La Presse méd.*, 1905, xxx.

[4] Goldmann, *Wien. med. Presse*, 1905, ii.

[5] *Ibid.*, "Die Hygiene des Bergmannes." Halle: W. Knapp, 1903.

(8) All privies must be so arranged that the vessels used for the reception of the excreta must not leak, must be protected by a cover, and easily transportable. The emptying of these vessels must be carried out in specially constructed impenetrable pits.

(9) Defæcation in any other place than a privy is forbidden (alike for miners and brick-makers).

(10) The manure of horses used in the mines is to be regularly removed; possibly infection takes place in this way also. [This is impossible.—J. W. W. S.]

How far it is possible to disinfect a mine already severely infected is a matter of question; Tenholt,[1] Goldmann,[2] and Dieminger[3] recommend washing out with freshly prepared lime water with the addition of caustic soda; Calmette[4] and Manouriez[5] spraying with salt water. Theoretically spraying with hot water or steam should be done every now and again for the destruction of the larvæ (Looss[6]). Personal prophylaxis is partially included in the general prophylaxis in so far as it is a case of oral infection, but something more can be done for the individual to avert the danger of cutaneous infection. According to Manson[7] it is advisable in the tropics to cover the naked hands and feet with green Barbados tar, and the tarred parts thickly with flour; Fabre[8] recommends that miners who might come in contact with infected water should anoint the unprotected parts (hands and feet), as then the larvæ cannot penetrate the skin; this last procedure can easily be carried out on account of its simplicity and cheapness.

Among the usual remedies for the expulsion of ancylostomes thymol certainly comes first, introduced by Bozzolo[9] and since used by many other authors, partly with good and partly with less good results. The day before the beginning of treatment one should endeavour to procure a thorough evacuation of the bowels by means of calomel (Lutz,[10] Grünberger,[11] Smith[12]) or cascara sagrada (Mann[13]), only fluid food should be taken the evening before, and on the day of treatment thymol is given in a quantity of 6, 8, 10 or 15 grm., in single doses of 2 grm. with one or two hours' interval, and some hours after an aperient. As a rule, one day of this treatment is not enough.

[1] Tenholt, *Münch. med. Wochenschr.*, 1905.
[2] Goldmann, *Wien. med. Wochenschr.*, 1905, x.
[3] Dieminger, *loc. cit.* [4] Calmette, *Acad. de Méd.*, July 25, 1905.
[5] Manouriez, *Bull. de. l'Acad. de Méd.*, 1905.
[6] Looss, *Zeitschr. f. klin. Med.*, 1905, lviii.
[7] Manson, *Brit. Med. Journ.*, November 5, 1900. [8] Fabre, *Progrès méd.*, 1905.
[9] Bozzolo, *Giorn. del R. Acad. d. Med. di Torino*, 1881. [10] Lutz, *Centralbl. f. Bakt.*
[11] Grünberger, *Wien. med. Wochenschr.*, 1902, lii.
[12] Smith, *Amer. Journ. Med. Sci.*, 1903.
[13] Mann, *Deutsch. Arch. f. klin. Med.*, lxxiv.

(Prowe[1]), but one is compelled to repeat it on two consecutive days, or even oftener, with subsequent intervals of many days. Thymol is either given in wafers, gelatine capsules or mixed with sugar. Caution should be used in giving brandy at the same time or bodies which dissolve thymol (oil, fat) and thereby considerably favour its absorption. It has been shown in many cases from toxic phenomena that thymol is by no means an indifferent drug; violent burning in the stomach and alimentary canal, lowering of the temperature, shortness of breath and feeble pulse, giddiness, delirium and fainting have all been observed. Sandwith[2] and Thornhill,[3] as well as Leichtenstern,[4] even record cases of death after the use of thymol; 4 grm. thymol caused severe symptoms of poisoning in Grünberger's[5] case. The black colour of the urine (thymoluria) which so often sets in after the first dose is quite harmless, and is no contra-indication to the continuance of the cure. Now and again there are traces of albumin in the urine, but it is very seldom there is any severe acute inflammation of the kidneys. Thymol is contra-indicated in advanced old age and in debility, also in cases with a tendency to vomiting, in gastritis, dysentery, heart or kidney affections.

The combination recommended by Goldmann[6] under the name of taeniol, already mentioned under the treatment of tapeworms, and which consists of thymol, sebirol and salicylate, appears also to render good service in the treatment of ancylostomiasis (Goldmann[7] and Liermberger[8]).

A carbonate of thymol, thymotal, from which thymol separates off in the intestine, is given three to four times a day, in doses of 3 grm. per diem (children up to 1·0 grm.) on four consecutive days, and at the end of the treatment a purge (Pool,[9] Bauer[10]); Leonardi[11] speaks well of thymol essence (4·0 c.c. per diem) in an emulsion with plenty of water.

The next drug for the expulsion of ancylostomes is extractum filicis maris, which is to be employed as in tapeworm treatment, but has not always had the desired result, whilst in such cases as resist the fern extract, thymol attains the desired effect (Mann[12]), whilst the reverse is frequently observed (Grünberger[13]). Nagel[14] prescribes extr. fil. 8 to 10 grm., chloroform 10 to 15 drops, syr. sennæ 16 grm.; before taking, the glass must be placed in hot water, otherwise the

---

[1] Prowe, *Virch. Arch.*, clviii.
[2] Sandwith, quoted by Looss.
[3] Thornhill, *ibid.*
[4] Leichtenstern, *Deutsch. med. Wochenschr.*, 1887.
[5] Grünberger, *loc. cit.*
[6] Goldmann, *Ges. f. innere Med. in Wien*, March 8, 1906.
[7] Goldmann, *Wien. med. Wochenschr.*, 1905, x.
[8] Liermberger, *Berl. klin. Wochenschr.*, 1905.
[9] Pool, *Med. Woche*, 1901.
[10] Bauer, *Wien. klin. Wochenschr.*, 1904.
[11] Leonardi, *Gaz. d. Osp.*, 1904.
[12] Mann, *loc. cit.*
[13] Grünberger, *loc. cit.*
[14] Nagel, *Deutsch. med. Wochenschr.*, 1903.

contents will not pour freely. Zinn[1] prefers extract. filicis maris (freshly prepared) to all other drugs. Warburg[2] considers the treatment with extr. fil. to be all the more certain the more thoroughly the preliminary treatment is carried out. Filmaron 0·7 grm., thymol 5·0 grm., chloroform 1·5 grm, ol. ricini 20·0 grm. gave good results after being given two to three times (Nagel[3]). Opinions are divided as to the combination of thymol and extractum filicis maris (Hynek,[4] Stockman,[5] Boycott and Haldane,[6] Adams[7]). As regards other remedies, eucalyptus oil is well spoken of by Philips[8] and Hermann[9]: ol. eucalypti 2·0 grm., chloroform 3·0 grm., ol. ricini 30·0 grm., to be taken at one time or in three separate doses in the morning (on the previous evening a saline purgative). Neumann[10] recommends podophyllin, to be taken twice on three consecutive days in doses of 0·035 grm. Podophyllin appears to produce quite a peculiar condition of the intestinal mucosa which is very prejudicial to the Ancylostoma adhering to it. Bentley[11] regards β-naphthol as the best drug; after previous examination of the bowels he gives it two or three times at two-hourly intervals, in doses up to 1·0 grm. (*Vide* also the Appendix, p. 754, for other drugs.) For the treatment of the anæmia, which often persists very obstinately, good and abundant food, iron and arsenic preparations, Levico water (Goldmann,[12] Liermberger[13]) are suitable.

Ascaris lumbricoides (Ascariasis).

Ascaris lumbricoides is one of the most frequent parasites that occur in man, both in adults as well as in children; as a rule, indeed, it most frequently infects children of medium age. The normal situation is the small intestine; this, however, is frequently left, and the Ascarides travel into the stomach, œsophagus, pharynx, bronchi, the nasal cavities and still other regions. It is a peculiarity of the Ascarides that they are prone to glide into narrow canals; for example, Clason[14] records that in the case of an idiot whose custom it was to swallow glass beads, the Ascarides showed a predilection for sticking in the beads and were passed in the fæces. The disturbances which Ascarides occasion in the intestine itself vary; isolated species do not

---

[1] Zinn, "Therap. der Gegenwart.," 1903.
[2] Warburg, *Münch. med. Wochenschr.*, 1904.
[3] Nagel, *loc. cit.* [4] Hynek, *Sbornik Kliniky*, v.
[5] Stockman, *Brit. Med. Journ.*, 1904.
[6] Boycott and Haldane, *Journ. of Hyg.*, ix.
[7] Adams, *Arch. of Pediat.*, 1901. [8] Philips, *Lancet*, 1906.
[9] Hermann, *La méd. moderne*, 1905. [10] Neumann, *Deutsch. med. Wochenschr.*, 1904.
[11] Bentley, *Indian Med. Gaz.*, 1904.
[12] Goldmann, *Deutsch. Aerzte-Zeitg.*, 1903. [13] Liermberger, *loc. cit.*
[14] Clason, *see* Seifert, *Deutsch. med. Zeitg.*, 1885.

give rise to any symptoms at all, whereas a large number may eventually give rise to severe local symptoms, or those of a toxic or reflex nature which have been discussed in the General Section.

Among the local symptoms are the following: loss of appetite, excessive appetite, perverted sense of taste, fœtid breath, sensitiveness to pressure over the abdomen, colicky pains and irregularity of the bowels. The appearance and state of health suffer; the patients, children in especial frequency, become remarkably pale; their complexions undergo rapid change, and rings of grey or bluish-brown are seen about the eyes. Children may become so reduced by this rare condition, enteritis verminosa, due to Ascarides in large numbers, that suspicion of the existence of intestinal tuberculosis arises. Emaciation to a skeleton, excessive meteorism, and evacuations of thin gruel-like stools, sometimes blood-stained, are observed in these cases. Even in the case of adults, chronic uncontrollable vomiting with severe inanition due to the Ascarides has been observed. When the Ascarides escape spontaneously *per anum*, they frequently cause an exceedingly troublesome irritation in the anal region (pruritus ani).

The most disagreeable symptoms and those most dangerous to life arise from the migrations of Ascarides when they invade the bile-ducts; no inconsiderable number of cases of this kind are recorded in the literature (summarized, up to the year 1901, in Sick's[1] Dissertation). Penetration *post mortem* (or shortly before death) of the worms into the bile-ducts cannot be considered as a rarity; the laxity of the muscular orifices easily allows of this invasion also in other directions on the part of the parasite in its escape from the body of its dead host. The occurrence of the worm in the biliary passages in the living is to be regarded as still less frequent, but nevertheless often enough according to the records in literature. Sick[2] was able to collect as many as sixty-one such cases, to which he added two further fresh cases from the Tübingen clinic, that is, from the material provided by his father. In the year 1891 Borger[3] collected fifty-nine cases relating to the invasion by *Ascaridæ* of the bile-ducts and passages, and Dauernheim's[4] Dissertation treats of this question as well. A further case of Ascaris in the ductus choledochus (choledochotomy) is recorded by Neugebauer.[5] In the case of Schupper[6] (woman, aged 52), all the biliary passages were distended and filled with fourteen living *Ascaridæ* (perhaps as they were living they had not led to a septic infection of the biliary passages); in the case

[1] Sick, "Diss. Tübingen," 1901.
[2] Sick, *ibid.*, 1901.
[3] Borger, "Diss. München," 1891.
[4] Dauernheim, "Diss. Giessen," 1900.
[5] Neugebauer, *Arch. f. klin. Chir.*, 1903, lxx.
[6] Schupper, *Gaz. d. Osp.*, 1904, xxxiii.

communicated by Schiller,[1] an Ascaris had gained access to the biliary passages after an operation for cholelithiasis (with distension of the gall-bladder and formation of a fistula); it had kept itself alive here eighteen days and was extracted from the fistulous opening. Epstein[2] confirms the correctness of the explanation of the mark of strangulation in an Ascaris in Mertens'[3] case (in a woman, aged 30, there was first icterus, later ascites, anasarca, swelling of the liver, then the discharge of two dead *Ascaridæ*, one of which exhibited a constriction somewhat behind its centre; after that there was rapid improvement in all the symptoms); in his case there was icterus in consequence of closure of the ductus choledochus by an Ascaris. After the discharge of the worm the symptoms persisted; one of the *Ascaridæ* had a typical strangulation mark. From the observation recorded by Vierordt[4] it follows that, without doubt, mature females can penetrate into the liver and there deposit eggs; in addition, that such eggs appear exceptionally to undergo segmentation. A unique feature in this case consisted in the exclusive discharge of immature worms almost regularly throughout an interval of nine weeks; this cannot be explained from our present knowledge of the biology and pathology of the *Ascaridæ*. These worms clearly make their way from the intestine outwards, through the opening into the duodenum of the common bile-duct, and unquestionably the fully developed Ascarides, with the aid of their conical head end, are enabled gradually to penetrate the wall of the ductus choledochus (Quincke[5]), and gain access to the gall-bladder, the hepatic duct and its branches.

The changes in the biliary passages and the liver are, on the one hand, the mechanical results of a partial or total obstruction to the flow of the bile, and, on the other, of inflammatory processes. The blocking of the common bile-duct and of the trunk of the hepatic duct leads to the well-known symptoms of biliary engorgement; protracted continuance of this condition has, as its sequela, general distension of the whole biliary system and degenerative destruction of the liver-cells. If the Ascaris is situated at some other part of the biliary system, its presence causes a partial arrest of the flow of bile, with the corresponding sequelæ. Many Ascarides perish in the ductus choledochus, and here and in the gall-bladder they may supply the nucleus of a gall-stone; deeper in the liver this does not appear to happen; the dead *Ascaridæ* here undergo a kind of maceration, disintegrate, and may be completely absorbed; in many cases the worms

---

[1] Schiller, *Beitr. zur klin. Chir.*, 1902, xxxiv.

[2] Epstein, *Deutsch. Arch. f. klin. Med.*, 1904, lxxxi.

[3] Mertens, *Deutsch. med. Wochenschr.*, 1898, xxiii.

[4] Vierordt, Volkmann's *Samml. klin. Vortr.*, No. 375.

[5] Quincke, "Nothnagel's Spez. Path. u. Therap.," 1899, xviii.

continue to live for a very long time in the biliary passages. When the worms infect the biliary passages through the invasion of intestinal bacteria, liver abscesses arise (Dauernheim,[1] Saltykow[2]). Leer[3] goes so far as to maintain that *Ascaridæ* may be the second most frequent cause of liver abscesses. That Ascaris in the pancreas may simulate liver abscess in a remarkable fashion is shown by Vierordt's[4] observation, which is quite unique, while *Ascaridæ* have been found to occur in isolated instances in the excretory ducts of the pancreas and in its branches, where they have remained living for a long time.

It is no rare occurrence for *Ascaridæ*, in consequence of their migration into the stomach, to be ejected by the act of vomiting, and in such way to gain access into the upper air passages, or to find their way during sleep into the nose or accessory sinuses (Mosler and Peiper[5]) without giving rise to special symptoms. For example, Troja[6] found in the frontal sinus of a cadaver a large coiled-up Ascaris which occupied the whole cavity. Wrisberg[7] made the same observation in the cadaver of a boy. Deschamps[8] and Fortessin[9] mention an Ascaris being met with in the antrum of Highmore. Observations of the discharge of living or dead Ascarides from the nose are frequently recorded. To this class belongs the case mentioned by Albrecht,[10] in which an Ascaris was removed from the nose of a girl, aged 7; also the case recorded by Benievini,[11] from the nose of one of whose friends a worm escaped; he had suffered from the most violent headaches, fainting fits, dimness of vision and vomiting; after the escape those untoward symptoms disappeared. Similar records have been made by Forest,[12] Lanzoni,[13] Langelott,[14] Tulpe,[15] Reisel,[16] Fehr,[17] Bruckmann,[18] Bahr,[19] Slabber,[20] Lange,[21] and Chiari.[22] A rarer case is that recorded by Haffner,[23] that of a

---

[1] Dauernheim, *loc. cit.*
[2] Saltykow, *Prag. Zeitschr. f. Heilk.*, 1900.
[3] Leer, *Brit. Med. Journ.*, 1906.
[4] Vierordt, *loc. cit.*
[5] Mosler and Peiper, "Nothnagel's Handb.," 1894, vi.
[6] Troja, Napoli, 1771.
[7] Wrisberg, *see* Blumenbach, Göttingen, 1907.
[8] Deschamps, *see* Blass, "Diss. Strasburg," 1902.
[9] Fortessin, *see* Bardeleben, "Lehrb. d. Chirurgie," 1875.
[10] Albrecht, *Commer. Noricum. T. I. Annal.*, 1739.
[11] Benievini, "Prol. Anat. d. Sin. front.," Göttingen, 1779.
[12] Forest, *see* Tiedemann, Mannheim, 1844.
[13] Lanzoni, *idem.*
[14] Langelott, *idem.*
[15] Tulpe, *idem.*
[16] Reisel, *idem.*
[17] Fehr, *idem.*
[18] Bruckmann, *Commer. Noric.*, 1739.
[19] Bahr, *idem.*
[20] Slabber, *idem.*
[21] Lange, "Blumenbach's Med. Bibl.," Göttingen, 1788.
[22] Chiari, "Krankh. d. Nase," 1902.
[23] Haffner, *Berl. klin. Wochenschr.*, 1880.

child, aged 4, in whom an Ascaris reached the nasal cavity through the act of vomiting, and from there it gained access through the naso-lachrymal duct and the inferior lachrymal sac into the lower punctum lachrymale, from which half of it protruded.

Among the rarer causes of the occurrence of strange bodies in the pharynx and naso-pharyngeal cavity, Jurasz[1] mentions in the first place vomiting, which may afford opportunity for the more solid bodies of the stomach contents, and even parasites of the digestive tract, especially *Ascaridæ*, to become firmly lodged in the pharyngeal or naso-pharyngeal cavity. *Ascaridæ* may obtain access from the naso-pharyngeal cavity to the middle ear by way of the Eustachian tube, as has been observed by Reynolds[2] and Wagenhäuser[3]; in the case recorded by Turnbull (girl, aged 8, with pains in her ear) the Ascaris apparently reached the external auditory meatus by the same route.

The irritation of the larynx and air passages by *Ascaridæ* is far more dangerous than their penetration into the nose and naso-pharyngeal cavity, because not only are attacks of suffocation, but sudden suffocation thereby induced. Oesterlein[5] records a fatal attack of choking from *Ascaridæ* in the trachea. In a case recorded by Smyly[6] of a boy, aged 3½, tracheotomy for extreme asphyxia was performed without relief. At the *post-mortem* the cause of the asphyxia was found to be an Ascaris in the trachea. Fürst[7] collected twenty-five observations of invasion of the larynx and trachea by Ascaris. Mosler[8] reports the case of a patient with aphonia and dyspnœa from whose larynx an Ascaris was removed. Donati[9] reports a case of four Ascarides in the larynx, and Cerchez[10] of asphyxia from Ascarides in the larynx or trachea. Wagner[11] records the case of a boy, aged 8, in whom a coil of worms was ejected from the stomach by vomiting; the mass blocked the entrance to the larynx and led to death from suffocation. A case similar to that recorded by Smyly is communicated by Rabot[12]; it was that of a child who underwent tracheotomy for diphtheria, and who was not relieved by the operation; when, however, an Ascaris appeared in the cannula and the parasite was removed the child breathed well. In Negresco's[13] case, that of a boy, aged 3, an Ascaris gained access to the larynx and from there into the trachea, and a fatal issue from asphyxia resulted.

---

[1] Jurasz, Heymann's "Handb. d. Laryngol. u. Rhinol.," iii.
[2] Reynolds, *Lancet*, 1880. [3] Wagenhäuser, *Arch. f. Ohrenheilk.*, 1889, xxvii.
[4] Turnbull, *Virchow-Hirsch Jahresbericht*, 1880.
[5] Oesterlein *Deutsch. Klin.* 1851. [6] Smyly, *Dubl. Journ.*, 1867.
[7] Fürst, *Wien. med. Wochenschr.*, 1879. [8] Mosler, quoted by Liesen.
[9] Donati, *Ann. Univ. de Méd. et Chir.*, Milano, 1875.
[10] Cerchez, *Clinica*, 1891, iv. [11] Wagner, *Deutsch. med. Wochenschr.*, 1902.
[12] Rabot, *Soc. de Sci. méd. de Lyon*, September 9, 1904.
[13] Negresco, *Soc. de Méd. légale*, November 9, 1903.

The route by which *Ascaridæ* obtain access to the urinary passages must remain undecided. Schlüter[1] treated a woman, aged 60, with retention of urine. Upon catheterization the hinder end of an Ascaris hung out from the catheter opening; the anterior end was fixed in the tube and the lumen was obstructed. Perhaps in the female sex *Ascaridæ* travel from the gut into the vulva and from there into the bladder, as they have already been observed in the vagina, where they cause troublesome symptoms (pruritus pudendi).

The diagnosis of ascariasis is not in general difficult; now and then the worms are discharged spontaneously; if not, the ova, which cannot be mistaken, can easily be detected in the fæces upon microscopical examination. Epstein's[2] method—namely, on every occasion to obtain fresh material for examination—is much to be recommended. This consists in introducing a Nelaton's catheter into the rectum with a rotatory motion and then drawing it out. A small portion of fæces forced into the catheter opening is more than sufficient to demonstrate the presence of ova of the parasites upon microscopical examination of a preparation.

In spite of all pressure on the part of relatives, treatment directly against *Ascaridæ* should not be carried out until the diagnosis is certain.

As regards prophylaxis, much can be done by not throwing the worms, when expelled, on to the dung-hill or into the privy, but straightway into the fire. Metschnikoff[3] has issued a warning against the consumption of unboiled or badly washed vegetables, salad, strawberries, etc., and also against drinking polluted water.

For the expulsion of the worms flores cinæ were formerly considered the most useful means; now, however, santonic lactone—santonin—which is prepared from them, is almost universally preferred. By many, especially in practising among children, flores cinæ are still recommended in the form of Stȯrk's worm electuary (consisting of flores cinæ, rad. jalapæ, valerian and oxymel simplex). Guermonprez[4] recommends them because he thinks that santonin only excites the worms and consequently causes unpleasant symptoms. Besides, in the form of the above-mentioned electuary, flores cinæ can also be given several times daily with raspberry jelly up to 0·5 grm. to 2 grm. (children and adults).

Santonin is prescribed either in single doses from 0·03 to 0·05 to 0·1 grm. with sugar in the form of powder, or else in oily solution. When given in the latter form the absorption of the santonin in the

---

[1] Schlüter, *Münch. med. Wochenschr.*, 1902.
[2] Epstein, *see* Seifert, "Lehrb. d. Kinderkrankh.," p. 273.
[3] Metschnikoff, *Gaz. hebd. de Méd. et Chir.*, 1901.
[4] Guermonprez, *see* Seifert, *Deutsch. med. Zeitg.*, 1885.

stomach is excluded and the whole quantity introduced is thus enabled to reach the worms in the intestinal canal. Küchenmeister[1] has already recommended combination of santonin with ol. ricini. Lewin,[2] however, states that ol. morrhuæ, ol. olivarum, ol. cocos and ol. cinæ can also be taken. In prescribing santonin in oily solution Henoch[3] also prefers the combination with ol. ricini. According to Lewin's direction the prescription would run as follows :—

℞	Santonin	0·2 grm.
	Ol. ricini.	20·0 grm.
	Ol. cinæ æth.	gtt. iv.

M.,d.s.

S., one tablespoonful to be taken two to three times.

If the patients should manifest a repugnance to castor oil, Starke's ricinus paste may be selected:—

℞	Santonin	0·2 grm.
	Ol. ricini	20·0 grm.
	Ol. cinæ æth.	gtt. iv.
	Sacch. albi.	q.s.

Pasta mollis.

S., to be used for two days.

If necessary the first-mentioned mixture might be given in gelatine capsules. Small children should be given 0·025 grm. santonin in warm olive oil slightly sweetened with sugar (a teaspoonful) in the morning; if in the course of the forenoon specimens of Ascaris escape, a second dose should follow in the afternoon about two hours after the meal. Older children should be given santonin in combination with castor oil or calomel :—

℞	Santonini	0·01 to 0·02 to 0·03 grm.
	Calomelan	0·025 grm.
	Sacch. albi...	0·5 grm.

M.f.p. D. tal. dos. x.

S., one powder about six, seven, and eight o'clock on three consecutive days.

As santonin causes slight toxic symptoms such as urticaria, vomiting, retention of urine, headache, vertigo, yellow vision (xanthopsia), it is in every case advisable to follow with a laxative to expel the drug from the body as speedily as possible. The urine is coloured yellow from one to two days and assumes a scarlet red colour upon the addition of alkalis ; this, however, soon disappears, while it persists in the case of rhubarb and senna.

In the place of santonin iodoform in the form of a powder mixed

[1] Küchenmeister, *loc. cit.* [2] Lewin, *see* Seifert, *Deutsch. med. Zeitg.*, 1885.
[3] Henoch, *idem.*

with bicarbonate of soda is given by Schidlowsky[1] in doses up to 0·01 to 0·06 grm. three times daily, and a dose of castor oil on the day after the iodoform is given. Thymol in addition to thymol enemas may be tried, in doses up to 0·5 to 2·0 grm. per diem (Calderone,[2] Hausmann[3]), also β-naphthol up to 0·45 grm. three times daily (Du Bois[4]), and—

℞	Benzo-naphthol	2·0 grm.
	Semin cinæ...	1·0 grm.
	Sacch. albi...	0·5 grm.

M.,f.p. Divide in part. æq. xxii.
S., three to five powders daily.

(Ferran[5]), filmaron oil 1·0 to 2·0 to 3·0 grm. in gelatine capsules, according to age (Bodenstein[6]). Brüning[7,8] recommends the so-called American worm-seed oil, derived from a plant native to the United States, *Chenopodium anthelminticum*, Gray. It is given in emulsion (ol. chenopodii anthelm. 10·0 grm., vitelli ovi unius, ol. amygd., gi. arab. pulver. āā 10·0 grm., aq. destill. 200 grm.; f. emulsio) up to 0·25 to 0·5 grm. three times daily at one to two-hourly intervals, or as a pure oil from 8 to 15 drops in sugar and water; to be followed an hour after the last dose by oleum ricini or pulvis curellæ. If no action takes place by the afternoon, a laxative should again be given. The treatment frequently must be repeated the next day. Thelen[9] appears to have had good results from this drug.

Corsican moss (mousse de Corse), kamala, *Artemisia absinthium*, valerian, semen sabadillæ, have all been supplanted by santonin and at most are used as adjuvants for the latter.

Oxyuris vermicularis (Oxyuriasis).

Oxyuridæ do not remain at rest in the gut, but leave it, generally at night time, to migrate around the anus, into the gluteal folds, and in females into the vulva and vagina and still higher up, giving rise in these different sites to a whole series of irritative symptoms. In the rectum, also, *Oxyuridæ* give rise to such symptoms, which are manifested in the form of catarrhal inflammation; numerous chronic intestinal catarrhs are thus explained. The frequent coincidence of hæmorrhoidal troubles with *Oxyuridæ* may be attributed to the fact that the veins of the rectum participate in those changes which have

---

[1] Schidlowsky, *see* Seifert. [2] Calderone, *idem*.
[3] Hausmann, *St. Petersb. med. Wochenschr.*, 1900.
[4] Du Bois, *see* Lenhartz in "Penzoldt-Stintzing's Handbuch," p. 619.
[5] Ferran, *idem*.
[6] Bodenstein, *Wien. med. Presse*, 1906. [7] Brüning, *Med. Klin.*, 1906.
[8] *Idem*, *Deutsch. med. Wochenschr.*, 1907.
[9] Thelen, "Diss. Rostock," 1907.

been described as occurring in the intestinal mucosa. *Oxyuridæ* may also give rise to prolapse of the anus, either by the tenesmus they bring about having such a prolapse as its direct sequel, or the proctitis that supervenes constituting a further etiological factor for its occurrence (Ungar[1]). Anal fistulæ which still further increase the trouble, and even rectal fistulæ, appear to be capable of onset in consequence of the irritation of the mucosa brought about by *Oxyuridæ* (Trendelenburg[2]). The conditions recorded by von Wagener[3] and Ruffer[4] appear to be of interest. At the *post-mortem* on a child, aged 5, the former found fifteen to twenty quite minute nodules on some Peyer's patches, and in several of these *Oxyuridæ* were found upon microscopical examination between the calcareous concretions within the patches. He presumes that the parasites penetrated the follicular ulcers, and after healing of the latter that they died and became calcified. In the case of a man who died from cirrhosis of the liver, Ruffer found in the rectum, at a distance of about 6 in. from the anal orifice, several tumours covered by the intestinal mucosa, the smallest of which was the size of a pin's head and the largest that of a walnut. The tumours looked like calculi overgrown by connective tissue ; under the microscope, countless *Oxyuridæ* ova were found in their interior.

The symptoms of irritation set up by these migrations from the intestine are troublesome to the last degree ; the pruritus thereby induced is often unendurable ; as this irritation from itching comes on with especial severity during the night, the night's rest is grievously interfered with ; many attacks of night terrors appear to be occasioned by these worms. But the general condition suffers as well ; the children become pallid and affected with nervous excitability. Through the act of scratching the irritated parts the ova of the parasites may be conveyed by contaminated fingers directly into the oral or nasal cavities, certainly also into the oral cavity by the contamination of food (auto-infection). In the case of boys the sexual organs may be excited sympathetically through irritation of the sacral nerves of the rectum ; girls may be induced to practise onanism in consequence of the entrance of the worms into the vulva.

As a result of the itching irritation which the scratching gives rise to, and of the irritation due to the parasites migrating to the area surrounding the anus, congestion and inflammatory symptoms may arise in the peri-anal and perineal regions (weeping eczema, Seifert),[5]

---

[1] Ungar, *see* Seifert, "Lehrbuch der Kinderkrankh.," p. 246.

[2] Trendelenburg, *see* Seifert, *idem*.

[3] von Wagener, *Deutsch. Arch. f. klin. Med.*, lxxxi.

[4] Ruffer, *Brit. Med. Journ.*, 1901.

[5] Seifert, "Lehrb. d. Kinderkrankh.," and Lesser's "Encyklop. d. Haut- u. Geschlechts-krankh.," p. 373.

and these do not abate till after the removal of the oxyuriasis. Some authors speak of an oxyuriasis cutanea (Majochi[1]), in the more limited sense of a dermatitis intertriginoides. So far five such cases have been recorded, one each by Szerlecky,[2] Michelson,[3] Majochi,[4] Barbagallo[5] and Vignolo-Lutati.[6] Szerlecky's case was that of a young woman with intertrigo over the thighs (the skin was covered as if with leather); Michelson's case was that of a boy, aged 13, with intertrigo on the skin of the genito-crural fold, of the scrotum and of the thigh; Majochi's was that of a man, aged 38, with the same localization; Barbagallo's case was that of a boy, aged 14, in whom the dermatitis extended to the hypogastrium (rhagades on the scrotum); and Vignolo-Lutati's case was that of a man, aged 24, with intertrigo of the peri-anal and perineal region, of the scrotum and the inner side of the thigh.

On leaving the gut, *Oxyuridæ* frequently migrate to the stomach, to the œsophagus, to the mouth, to the nasopharyngeal cavity, and into the nose (Zarniko[7]) (the localization in the nose has been referred to as associated with the possibility of auto-infection—*see* p. 695 as to the development of embryos from the ova in the moist nasal mucosa). Still the occurrence of *Oxyuridæ* in the nose is among the greatest of rarities. Chiari[8] records the case of a girl, aged 14, who suffered from pains at the root of the nose and in the left side of the forehead; female specimens of *Oxyuris vermicularis* were evacuated from her nose on several occasions. A similar case is recorded by Hartmann[9]; it was that of a girl, aged 13, with epileptiform convulsions and psychic disturbances; numerous Oxyurides frequently escaped from her nose. With their departure the symptoms of irritation of the central nervous system also disappeared. Rheins[10] records a case, that of a woman, in which a specimen of *Oxyuris vermicularis* was discharged from the right nostril during the act of sneezing. Proskauer[11] found in the nose of a woman, aged 30, a conglomerate of from fifteen to twenty very small worms which proved to be Oxyuris embryos.

The diagnosis of oxyuriasis is not difficult to make, as the troublesome sensations in the anus and about the genitals necessarily suggest the presence of *Oxyuridæ*. As a rule the small white worms are

---

[1] Majochi, *Boll. d. Sci. med. d. Bologna*, 1893.
[2] Szerlecky, *Journ. Ann. Med. prat.*, Paris, 1874.
[3] Michelson, *Berl. klin. Wochenschr.*, 1877, xxxiii.
[4] Majochi, *loc. cit.* [5] Barbagallo, *Gaz. d. Osp.*, November 16, 1900.
[6] Vignolo-Lutati, *Arch. f. Derm.*, lxxxvii, pt. 1.
[7] Zarniko, "Die Krankh. d. Nase, u.s.w," S. Karger, Berlin, 1905.
[8] Chiari, "Erfahr. auf d. Gebiete der Hals-u. Nasenkrankh.," Wien, 1887.
[9] Hartmann, *Naturforscherversamml.*, Köln, 1889.
[10] Rheins, "Der prakt. Arzt.," 1893. [11] Proskauer, *Zeitschr. f. Ohrenheilk.*, 1891.

seen crawling about over recently evacuated fæces, or the ova are found upon microscopical examination of soiled matter adhering to the anus, or in scrapings removed with the spatula from the surface of the skin (in the case of oxyuriasis cutanea).

Prophylaxis has to be directed to infection with Oxyurides generally, on the one hand, and, on the other, to the possibility of auto-infection. With reference to the first-mentioned point, Metschnikoff's[1] directions should be borne in mind, to the effect that badly washed vegetables, salad, etc., ought not to be eaten (vegetables to be rinsed with boiling water), and also that the members of the family of the diseased individual should be examined for *Oxyuridæ* and eventually be treated (Heller[2]). With regard to the second point, one has to observe strict cleanliness in general (Barbagallo[3] found ova of the parasites in the layer of dirt under the finger-nails).

Treatment of oxyuriasis must be of a twofold nature; first, medicinal, the administration *per os* of vermicidal drugs in combination with purgatives; and secondly, local treatment of the gut by means of enemata, suppositories and high injections. Following the method prescribed by Ungar,[4] pulv. glycyrrhizæ co. is first given in the case of smaller children, castor oil or calomel in that of those older, in order to evacuate the intestine, and four times daily on two days following one another a dose of naphthalin, not directly after meal-time, but as far as possible in the interval between two meals, and at the same time the ingestion of fatty or oily nutriment is as far as possible to be avoided. After eight days this treatment should be repeated, and under certain circumstances once again after a further interval of a fortnight. The dose varies between 0·05 and 0·1 grm. (children of 1 year old), 0·1 to 0·2 grm. (children of 2 to 3 years old) and 0·2 to 0·4 grm. (children of 4 to 10 years old). Dornblüth[5] employs the same medicament in a form only slightly modified from Ungar's method, Barbagallo[6] gives internally only a purgative (decoct. sennæ cum natr. sulfur). Thymol, santonin, kousso, kamala or valerian may be tried instead of naphthalin. For enemata the following are employed: naphthalin in a solution of 1 in 50, ol. olivar. or thymol 0·1 in 200 aq. destill., diluted solutions of lysol, menthol in $\frac{1}{2}$ per cent. oily solution, salicylate of soda in watery solution, decoctum tannaceti with santonin, with the addition of some drops of ol. terebinth. (Barbagallo). Decoctions of garlic, infusion of valerian, sulphur water (sublimate is to be avoided), aq. calcariæ, ol. olivarum

[1] Metschnikoff, *Med. Klin.*, 1907, xlii, p. 1284.
[2] Heller, *Deutsch. Arch. f. klin. Med.*, lxxvii.
[3] Barbagallo, *loc. cit.*
[4] Ungar, *see* Seifert, "Lehrb. d. Kinderkrankh."
[5] Dornblüth, *Arztl. Zentral-Anzeiger*, 1903.
[6] Barbagallo, *loc. cit.*

camphoratum (Vignolo-Lutati). Santonin 0·1 grm. is the best to employ for suppositories.

For high injections, large quantities of plain water are employed (2 to 4 litres), or soapy water (0·2 to 0·5 per cent. solution of sapo medicatus, Heller,[1] Still[2]), ½ per cent. salicylic acid solution or liq. alum. acet. (one tablespoonful to a litre of water, Dornblüth[3]), or gujanosol (2 to 3 to 4 to 5 per cent. solution, Rahn[4]). The employment of benzine for such high injections is not advisable according to the experience of Senger,[5] owing to the symptoms of poisoning after the external application of benzine, at least not in the case of young children.

That diseases of the intestine which are accompanied by frequent thin fluid evacuations may lead to recovery from oxyuriasis has frequently been observed by us in the case of young children who have suffered from dysentery (Seifert[6]). Inunctions of cod-liver oil appear to be very valuable in the treatment of oxyuriasis (Szerlecky, Vignolo-Lutati), whilst those with mercurial ointment may easily increase the inflammatory symptoms. The luxury recommended by Esser,[7] that patients every evening before going to sleep should have the female *Oxyuridæ* picked from the anal fold in the knee-elbow position is one which is certainly only in the power of a few people to carry into execution.

An essay has been published by Hippius and Lewinson (*Deutsch. med. Wochenschr.*, 1907, xliii.) in which the relationship of *Oxyuridæ* to appendicitis is considered and the treatment of oxyuriasis is discussed. The instructive case recorded appears to show that germs through *Oxyuridæ* gain access to the tissue of the appendix, and, indeed, are carried in by them. In view of this more recent communication as to the part which intestinal parasites play in the etiology of appendicitis, it seemed to me [O. S.] to be worth while to interrogate my surgical colleagues as to this point. About 2,000 appendicectomies have been jointly performed by Drs. Burkhardt, Enderlen, Pretzfelder, Riedinger, Rosenberger and Siber, and in not one of these cases could entozoa be found to be a possible cause of the appendicitis. Such figures without doubt speak in favour of the fact that even if in *individual* cases entozoa might come into reckoning as a possible cause, such an etiological factor must be classed among the greatest of rarities. My colleague, Dr. Ries, who practised for ten years in Mexico, informed me that there practically speaking every Indian without exception harboured parasites of the most varied kind, and that in spite of the very extensive professional standing he enjoyed among these people he never had under observation among them a single case of appendicitis. As far as the observation of the authors in question as to the treatment of oxyuriasis is concerned, it must be energetically directed to the employment of local measures for the intestine ; they maintain that the use of enemata would be irrational, and that it is astonishing that this method has been able to maintain its standing down to the present day.

---

1 Heller, *loc. cit.*
2 Still, *Brit. Med. Journ.*, 1899.
3 Dornblüth, *loc. cit.*
4 Rahn, *Münch. med. Wochenschr.*, 1905.
5 Senger, *Berl. klin. Wochenschr.*, 1907, xxxviii.
6 Seifert, *Deutsch. med. Zeitg.*, 1885.
7 Esser, *Schweiz. Korrespondenzbl.*, 1893.

HIRUDINEI (Leeches).

The only one of the leeches that comes under consideration from the clinical point of view is *Limnatis nilotica* (*Hæmopsis sanguisuga*), which obtains access to the mouth with drinking water, and becomes lodged, even in the case of man, in the pharynx, larynx, trachea, œsophagus and nose.

Amongst the causes of severe hæmorrhage from the pharynx Jurasz[1] mentions the occurrence of leeches in that region: in Northern Europe this must be accounted one of the greatest of rarities, whilst at all times in southern countries, such as South Italy, Spain, Greece, Algiers, Tunis and Egypt, it appears to have been more frequent. Even the physicians of antiquity had much to say about it. Upon the occurrence of blood-stained expectoration, Hippocrates recommends the oral cavity to be examined to see whether a leech is not present in it. Galen speaks of hæmatemesis due to the presence of leeches in the pharynx and stomach. Similar mention is found in the writings of Celsus, Asclepiades, Scribonius Largus, Dioscorides, Aëtius, Oribasius, Paulus Aegineta and others. In recent times, Cortial[2] has published observations relating to this subject which he had the opportunity of making in Constantine. Palazzolo[3] also in Sicily found leeches in two cases in the pharynx, in one case on the posterior wall, in the other in the crypt over the left tonsil. According to Roset,[4] leeches adhere by preference behind the uvula, simulating hæmatemesis and hæmoptysis, and the persistent hæmorrhages they give rise to may lead to severe anæmia. Leeches are found in still greater frequency in the larynx than in the pharyngeal cavity. Huber[5] records several observations of this kind in his historical and therapeutical study. In the case of a man, aged 64, Ramon de la Sota y Lastra[6] observed a leech on the nodulus epiglottidis; this was removed with the forceps. In the case recorded by Photiades,[7] a leech had remained adherent to the vocal cord for more than twenty-two days. Maissurianz[8] records two such cases: in one the leech had remained in the sinus morgagni for three weeks, in the other in the same place for ten days. The case recorded by

---

[1] Jurasz, Heymann's "Handb. d. Laryng. u. Rhinol.," 1899, ii.
[2] Cortial, *Union méd.*, 1886.
[3] Palazzolo, *Bull. del. mal. dell' orecchio, etc.*, 1895.
[4] Roset, *Rev. d. Cienc. méd. de Barcelona*, 1907, ii.
[5] Huber, *Deutsch. Arch. f. klin. Med.*, xlvii.
[6] Ramon de la Sota y Lastra, *Rev. méd. de Sevilla*, 1883.
[7] Photiades, *Int. Zentralbl. f. Laryng.*, 1884.
[8] Maissurianz, *St. Petersb. med. Wochenschr.*, 1883.

Schmolitschew[1] is an interesting one; it was that of a woman who for four days had suffered from violent hæmoptysis, the cause of which was a leech that was fixed on the laryngeal wall of the epiglottis close above the vocal cords. In his case (that of a soldier), Godet[2] was forced to perform thyrotomy to remove the leech from the larynx. Ficano[3] removed a live leech with the forceps from the lower laryngeal cavity in a man, aged 30. Massei[4] reports a similar case. The case reported by Winternitz and Karbinski[5] was that of a peasant girl, aged 16, who suffered from coughing, hoarseness, and blood-stained expectoration; a leech had lodged on the root of the epiglottis. Aubert[6] removed a leech from the larynx of a woman after the performance of tracheotomy. Seifert[7] reports three cases: in the first the leech had become fixed to the left vocal cord, in the second it was found in the lower laryngeal cavity, and in the third on the border of the left ligamentum aryepiglotticum. Leone[8] has published the case of a leech in the larynx, Martin[9] two cases with the leech lodged in the lower laryngeal cavity, Berthoud[10] a similar case, Palazzolo[11] two such cases, Panzat[12] one case (lower laryngeal cavity). Moucharinski[13] reports a case in which the leech had stayed more than twenty days in the larynx. Martin[14] easily removed a leech from the posterior portion of the vocal cord with the forceps. Vieus and Nepeon[15] record a case of a leech in the larynx. It is quite exceptional for leeches to gain access to the trachea; cases of this kind have been recorded by Aubert,[16] Vicano,[17] Ridola[18] and Tapin[19] (the leech was firmly fixed to the bifurcation and caused coughing, hæmoptysis and attacks of asphyxia; it was easily removed by the aid of a tracheal tube). Now and then leeches are found in the nose.

Lusitanus[20] relates the case of a man who suffered from severe headaches. A medical man ordered the application of a leech to the anterior portion of the nostril. Owing to the carelessness of the

---

[1] Schmolitschew, *Wratsch*, 1884.
[2] Godet, *Arch. de Méd. et Pharm. milit.*, 1887.
[3] Ficano, *Rev. de Laryng.*, 1890. [4] Massei, *Int. Journ. of Laryng.*, 1890.
[5] Winternitz and Karbinski, *Prag. med. Wochenschr.*, 1890.
[6] Aubert, *Echo méd.*, 1891. [7] Seifert, *Rev. de Laryng.*, 1893.
[8] Leone, *Boll. del. mal. dell' orecchio, etc.*, 1892.
[9] Martin, *Arch. de Méd. et Pharm. milit.*, 1891.
[10] Berthoud, *ibid.*, 1893. [11] Palazzolo, *Boll. del. mal. dell' orecchio*, 1895.
[12] Panzat, *Arch. de Méd. et Pharm. milit.*, 1896.
[13] Moucharinski, *Wratsch*, 1896.
[14] Martin, *Rev. barcelon de enf. de oido*, 1906.
[15] Vieus and Nepeon, *Monatsschr. f. Ohrenheilk.*, 1884.
[16] Aubert, *Echo méd.*, October 12, 1891.
[17] Vicano, *Boll. del. mal. dell' orecchio, etc.*, 1892, ix.
[18] Ridola, *Arch. ital. di Laryng.*, 1894, ii. [19] Tapin, *Siglo med.*, March 16, 1907.
[20] Lusitanus, *see* Seifert in Heymann's "Handb.," p. 599.

surgeon the leech crawled right into the nose; it was impossible to extract the leech or to kill it, and it produced a severe hæmorrhage which led to the death of the patient within two days. In a case recorded by Sinclair,[1] a leech, *Hæmopsis sanguisuga*, gained access to the nose of a boy, aged 3; it remained there a fortnight; it caused frequent attacks of epistaxis and in the end it was removed by means of forceps. Condorelli-Francaviglia[2] records a case in which severe epistaxis was caused by a leech which had probably entered the anterior portion of the left nostril by way of the pharynx and become tightly fixed there. It was seen by posterior rhinoscopy, and was removed from in front by means of slightly curved forceps. Sota y Lastra[3] mentions the occurrence of leeches in the nose, and Keng[4] reports the case of nasal obstruction from a leech. The removal of leeches is effected by means of injections or by the direct sprinkling of salt or acid solutions on their bodies, which brings about their detachment. When possible a previous attempt should be made to seize them with forceps so as to make their immediate extraction possible. The species of Hæmadipsa (Looss[5]) live in tropical regions in moist places on the ground or in the jungle. They climb bushes and even trees with astonishing rapidity upon the approach of larger animals and also of man (whom they clearly recognize from the vibration of the ground caused by footsteps). From thence they let themselves fall on their victims to suck their blood. Their bites are generally painless, and of themselves not dangerous, but if they are unusually numerous they rapidly accumulate on the body in large numbers and give rise to marked debility and, if the wound become infected, to severe complications and even death. On the other hand, under careful treatment the wounds heal easily and fairly rapidly.

Firm leather and firmly adhering clothes afford no certain protection against the attacks of these leeches, as they know how to force themselves with extraordinary rapidity through the narrowest interstices between the clothes and thus gain access to the skin. When they have sucked their fill—and this may take several hours to accomplish—they fall off of themselves. To effect an earlier removal drops of irritative or corrosive fluids are employed (salt solutions, acids, etc.). Tearing away the leech by force should be avoided, as in this way portions of the leech's body may be left behind in the wound and inflammation be set up.

---

[1] Sinclair, *Brit. Med. Journ.*, June 20, 1885, i.
[2] Condorelli-Francaviglia, Spallangini, 1892.
[3] Sota y Lastra, *Rév. méd. de Sevilla*, 1887.
[4] Keng, *Scot. Med. and Surg. Journ.*, October, 1899.
[5] Looss, "Handb. d. Tropenkrankh.," v. Mense, i, p. 194.

ARTHROPODA.

Leptus autumnalis (Grass, Harvest, or Gooseberry Mite[1]).

In the hot season of the year, that is, during the months of July and August, it is noticed that those people who stray amongst syringa bushes or who pick gooseberries or kidney beans are attacked by the *Leptus autumnalis.* On the uncovered parts of the body there appear numerous red spots and papules, which itch and burn smartly. The itching does not commence diffusely, as in the case of scabies (MacLennars[2]), but is limited to the particular points where the parasite is situated. There are especial outbreaks of itching in the morning, arising perhaps from the hatching of ova in the host after lying in the warmth of the bed.[3] Leptus frequently provokes general erythema, eczematization or severe feverish urticaria, which in France is known by the name of fièvre de grain (Mégnieu, Besnier[4]). If the individual efflorescences be carefully examined, there will be noticed almost without exception a minute boss towards the centre, noticeable by its yellowish-red colour. If an attempt is made to remove it with the point of a needle or to scrape it off the surface, one can often perceive, even with the naked eye, a small reddish creature moving actively about. The treatment of these very troublesome symptoms consists in warm baths with soapy lavages, also lavages with alcohol, spirit salmiac (G. P.), 5 per cent. carbol or creolin solution, diluted vinegar, benzine, emulsions of balsam of Peru, rubbing in sulphur ointment (Sandwith[5]) ; ointments of creosote or eucalyptus are recommended. Other grass and grain mites also occasionally penetrate the skin of man and produce transitory but sometimes very severe eruptions, urticaria and eczema papulosum, as Geber[6] and subsequent to him Josai[7] have reported of the barley mite. In sensitive individuals the skin becomes bright red, to a greater or less extent their temperature is raised and frequently slight febrile affections are present. If the inflammatory

---

[1] There is no reason for calling this the gooseberry mite. It is rarely found on this fruit. The gooseberry mite is *Bryolia pretiosa.*

[2] MacLennars, *Lancet*, 1905.

[3] [This cannot be the case, as *Leptus autumnalis* is the larval form of *Trombidium holosericeum.*—F. V. T.]

[4] Sack, "Handb. d. Hautkrankh.," v. Mraček, 1907.

[5] Sandwith, *Lancet*, 1905.

[6] Geber, "Handbuch d. Hautkrankh.," in v. Ziemssen's "Handbuch d. spez. Pathol. u. Therap.," 1884, xiv.

[7] Josai.

skin symptoms have reached their culminating point after three or four days and no fresh complications arise, they only remain for a short while, the effects of scratching and pigment spots being left.

Kedani, Akaneesch (The Japanese River or Inundation Disease).

This disease is only known in Japan, and is limited to the neighbourhood of some great rivers on the west coast. The people mostly attacked are those who cut the hemp harvest in the infected localities, occasionally those who transport it or come into contact with it (Looss[1]). The disease is frequently manifested in the form of indefinite disturbances of the general condition; it commences generally on the sixth day after the presumed infection with rigors, headaches, feeling of weakness, swelling of the lymphatic glands in the loin or in the arm-pits; in the periphery a black dry scab is formed. In addition there is an intense conjunctivitis, and added to symptoms of fever an exanthema resembling measles that lasts from four to seven days. There is frequent delirium and difficulty of hearing which persist for a long while. Obstinate constipation is a striking symptom. At the end of a fortnight, earlier in slighter cases, the fever commences to abate and a rapid convalescence sets in. In pregnant women abortion with fatal issue is frequent. With regard to prophylaxis, Baelz[2] recommends as rapid a cultivation of the soil as possible, which has led to a speedy disappearance of the disease in districts where it was once dreaded. Treatment is symptomatic. Japanese do not tolerate antipyretic drugs as well as Europeans.

Dermanyssus gallinæ (avium).

During the day the resort of bird mites is in the droppings and in the woodwork, etc., of cages in which canaries, crossbills and parrots are kept; in the crevices of doors, in the chinks between the board planks of bedsteads, so that at night they may seek some domestic animal to suck the blood and so satisfy their hunger. It is by no means rare for young animals, chickens and unfledged pigeons, etc., to perish in consequence of the great loss of blood. This nocturnal habit of life explains why no mites can be found during the day in spite of the most careful examination of the human body, to which they may be transmitted. On the uncovered parts of the body they not only cause severe irritation, but also severe diffuse itching erythema and eczema. Thorough disinfection of the

---

[1] Looss, "Handbuch d. Tropenkrankh.," v. Mense, p. 195.

[2] Baelz, *Virchow's Archiv*, lxxviii.

cages by hot solution of caustic potash, in addition, sprinkling over with tar, red carbolic acid or petroleum, thoroughly powdering over the birds with flores pyrethræ, washing with water containing oleum anisi, washing the walls, doors and bedsteads with soap, disinfection of the mattresses, linen and clothes, will protect against further infection. In the case of man the disease needs no special treatment, as the eruptions generally disappear after some days. Heinecke[1] recommends lavages with 1 per cent. carbolic acid solution. [*Vide* also p. 492 in body of this work.—F. V. T.]

[*Dermanyssus hirundinis*, Hermann, is identical with this species. By far the best treatment is with paraffin or kerosene oil applied to the places where they pass the day.—F. V. T.]

Ixodes reduvius (ricinus).

The female is occasionally transmitted to the human skin, and bores its proboscis deep into it and sucks itself full of blood. At sensitive points of the cutaneous surface—for example over the skin of the penis—a feeling of severe pain is produced. Buy's[2] observations as to the geographical distribution of the *Ixodinæ* show that in all lands in which cattle, horses, sheep and dogs exist, *Ixodinæ* are to be found. Recent observations show that the *Ixodinæ* play an important part in the transmission of Hæmosporidia (*vide* body of work, pp. 493, 494). Sprinkling with oil, vaseline, benzine, ether, petroleum, naphtha, turpentine (Jelgenum[3]), will easily lead to the removal of the parasite; if the body is torn away with violence and the proboscis is left sticking in the skin, the presence of the latter will give rise to inflammation and suppuration.

Sarcoptes scabiei (Scabies).

The disease produced by *Sarcoptes scabiei* shows itself in polymorphous areas, such as accompany eczema, and are produced on the one hand by the Sarcoptes alone and on the other hand by the scratching with the nails. The localization of both kinds of efflorescences is different from those which are produced by the Sarcoptes; they occur as papules, vesicles, pustules and mite-tracks, and their usual situation is between the fingers, on the ulnar border of the hand, on the wrist, on the palm of the hand, on the anterior border of the axilla, on the penis and at the base of the thorax. The excoriations are situated on the forearm, over the thigh, over the abdomen, and may be distributed in greater or less degree over the

---

[1] Heinecke, *Münch. med. Wochenschr.*, 1901.

[2] Buy, "Histoire naturelle et médicale des Ixodes," "Thèse de Lyon," 1906.

[3] Jelgenum, *Med. Weekblad v. Noord- en Zuid-Nederland*, 1901, i, No. 24.

whole body ; the back and the face only remain free. The symptoms consist in violent itching, the onset of which specially takes place at night.

The mite-tracks are fine curving lines, curved like a, u, c, or s, which appear as if they had been scratched with a fine needle. Upon closer examination with the magnifying glass one sees in their course small openings. These openings, in persons who keep themselves clean, are scarcely coloured ; but in patients whose occupations necessitate their being associated with coloured or dirty substances, they are dark. The length of the tracks varies from some millimetres to $1\frac{1}{2}$ to 2 cm. They are at the one end, where the Sarcoptes is embedded in the epidermis, widened like a funnel and slightly exfoliated. The track at this point is sharply defined ; the mite shows through the epidermis as a yellowish round point. In the course of the track there develop papulæ, vesicles or pustules, which raise the level of the track. The intensity of these inflammatory appearances depends upon the susceptibility of the human individual and upon the capability of the reaction of the skin. There are people in whom scarcely any inflammatory symptoms make their appearance ; on the other hand there are some, especially children and lymphatic individuals, in whom severe impetiginous ecthymatous pustules, together with their sequelæ, are set up.

The results produced by scratching consist in papules, which usually bear a small scab of blood, and are arranged in the form of striæ, in eczematous surfaces, weeping or sanguineous scabs, vesicles, pustules, etc. The complications that set in are frequently urticaria and even furuncles, lymphangitis and inflammation of the glands, which now and then is followed by the formation of abscesses in the glands.

The duration of the disease is unlimited ; when untreated it leads to a form of rare occurrence, that of scabies norvegica[1] ; in this the collection of crusts and scales, in which a quantity of dead mites, larvæ and ova are present, may become colossal.

The symptoms of scabies abate in the presence of intercurrent acute diseases and reappear after the malady is over. The fact has for long contributed to the idea of scabies being regarded as a disease capable of being "driven in" upon the internal organs and forming metastases.

The diagnosis is rendered certain upon the discovery of a track. Traces of scratching on the extremities and on the abdomen, papular or pustular efflorescences between the fingers, toes, in the neighbourhood of the wrist, of the elbow, on the anterior border of the arm-pit, on the tuber ischii, in the girdle region, and especially the presence of

[1] [This is produced by a distinct species, *vide* pp. 519-20.—F. V. T.]

disintegrated tracts over the penis (prepuce and glans), will allow of the diagnosis being made. Certain occupational eczemas (grocers, lime-workers, maltsters, bakers and others), also prurigo, must be borne in mind when diagnosing this disease.

The prognosis is always a favourable one. Even after such a long duration and after such severe symptoms the disease may completely clear up. There are, however, frequently left behind post-scabious inflammatous and pruriginous conditions which only yield after protracted treatment. Scabiophilia, which persists in certain patients for a long time after the scabies has been cured, must here be mentioned.

In the treatment of scabies four points must be kept in view. (1) The mites and the ova must be killed by the treatment; (2) the treatment must have regard to the intensity of the inflammatory symptoms; (3) the clothes (body-linen) of the patients must be disinfected; the bed-linen, the beds and the bedsteads must be cleansed; (4) when a person suffers from scabies his entourage must be examined, and all diseased conditions treated in the same way as under (3).

The treatment (1) should be preceded by a bath with thorough soap ablution, and when the inflammatory symptoms are not too severe, with green soap. After the bath the skin is dried and the scabies remedy proper applied in warmth. Sulphur preparations receive first consideration; among such Vlemingkz's mixture occupies a prominent position; this is rubbed in for half an hour by means of a strong camel-hair brush, to be followed by another bath and powder applications after drying. Repeat this method for three days one after the other, or for two days, and a third time eight days later. The latter method is worthy of recommendation as the ova, which perhaps resist the parasiticide action, have by this time developed into larvæ, and the latter can then be destroyed with certainty. The remaining sulphur preparations, which are specially employed in the form of ointments, are more complex, as the ointment should remain on the skin. Helmerisch's and Wilkinson's ointments are the kinds specially employed. Nagelschmidt[1] recommends thiopinol as a very suitable sulphur preparation in the form of baths or as a 10 or 5 per cent. ointment in the following way: Upon his reception the patient is given a thiopinol bath, in which he remains for thirty minutes. Immediately afterwards 30 to 40 grm. 10 per cent. thiopinol vaseline is carefully rubbed in. The rubbing is repeated daily, and the treatment is concluded on the second to fourth day with a second thiopinol bath. Thiopinol produces no more irritation than the ordinary sulphur ointments; it is, however, much more penetrative and more capable of absorption.

[1] Nagelschmidt, *Med. Klin.*, 1907, xxxv.

We frequently make use of Kaposi's naphthol ointment, as it renders the skin supple, causes proportionately little irritation, and has but little smell. Treatment with balsam of Peru is certainly expensive, but in the slighter attacks it is relatively the simplest. We give the patient a bath, have him thoroughly dried and rub in 30 to 40 to 50 grm. balsam of Peru carefully and evenly all over, wrap him in a covering of wool, and make him rest in bed for twelve to fifteen hours, to be followed by a bath with careful cleansing with soap; this treatment need rarely be repeated. The balsam of Peru can be applied undiluted for the rubbings or mixed with ung. glycerini, or resorbin or glycerine in equal parts. [Norman Walker uses balsam of Peru ½ oz. dissolved in rectified spirit; to be painted on with a brush.]—J. P. S. The manufacturers name the undiluted product of the active constituent of balsam of Peru, benzoic acid benzyl-ester, Peruscabin. For the treatment of scabies it is recommended by Sachs[1] that it should only be administered when mixed with ricinus oil, under the name of Peru oil, in applications repeated three times within thirty-six hours.

Sack[2] also considers Peru oil a non-irritant, effectual, pleasant, inodorous and non-staining drug. But he only allows the applications to be used every twelve hours for three to four consecutive days (altogether 200 to 300 grm. of Peru oil are requisite), and after the sixth or seventh rubbing a bath should be taken with the use of Dutch soap. Juliusberg[3] considers this treatment specially suited for private practice. Another modern drug is epicarin (β-oxy-naphthyl-ortho-oxy-meta-tolyol acid); this is applied in 10 to 20 per cent. ointments (Pfeiffenberger[4]), epicarin 7·0 grm., cretæ alb. 2·0 grm., vasel. flavi 30·0 grm., lanolin 15·0 grm., axungia poric. 45·0 grm. (Rille[5]); epicarin 15·0 grm., sapon. virid. 5·0 grm., axung. poric. 100·0 grm., cretæ alb. 10·0 grm. (Kraus[6]); for children, epicarin 5·0 grm., lanolin 90·0 grm., ol. olivar. 10·0 grm. (Kaposi[7]). Siebert[8] lays stress upon the odourlessness and colourlessness of epicarin ointment as a strong reason for its use, and points out that it is a harmless drug, the action of which is certain. Endermol (salicylic acid ointment) has a destructive action on the mites even in a 0·1 per cent. ointment (Wolters,[9] Demitsch[10]); it is, however, very expensive and not wholly free from danger; and the same applies to nicotiana soap (Taenzer,[11] Schumann[12]).

---

[1] Sachs, *Deutsch. med. Wochenschr.*, 1900.
[2] Sack, "Handb. d. Hautkrankh.," v. Mraček.
[3] Juliusberg, *Therap. Monatsh.*, 1901.
[4] Pfeiffenberger, *Klin. therap. Wochenschr.*, 1900.
[5] Rille, "Die Heilkunde," 1900.
[6] Kraus, *Allg. wien. med. Zeit.*, 1900.
[7] Kaposi, *Wien. med. Wochenschr.*, 1900.
[8] Siebert, *Münch. med. Wochenschr.*, 1900.
[9] Wolters, *Therap. Monatsh.*, 1898.
[10] Demitsch, *Wratsch*, 1905, iv.
[11] Taenzer, *Monatsh. f. prakt. Derm.*, xxi.
[12] Schumann, *Allg. med. Central-Zeitg.*, 1901.

To give an account in detail of the drugs and methods—old and new—used in the treatment of scabies would far outrun the limits of this work.

Demodex folliculorum.

It is not yet certain whether the *Demodex folliculorum* is capable of developing pathological conditions in man. Veiel[1] assumes that the hair follicle mite has no connection either with the formation of comedones or even with sebaceous gland disease. Kaposi[2] considers that they cause no disease in man and cannot be regarded as a cause of acne. Saalfeld[3] clearly adheres to the same standpoint, similarly so Jessner,[4] who, when discussing comedones, makes no mention of acne of hair follicle mites. Weyl[5] and Geber[6] adhere to the opinion that the presence of a Demodex in man in contradistinction to its presence in animals possesses absolutely no pathogenic influence. On the other hand de Amicis,[7] Majochi,[8] and Dubreuilh[9] report single cases of pronounced circumscribed clear brown pigmentations which they attribute to *Demodex folliculorum.* In all these cases, moreover, as regards localization the affection had a certain resemblance to pityriasis versicolor ; nevertheless, in the scales separated off with the scalpel no fungi were found, but on the other hand Demodices in moderate quantity. In his earlier cases Majochi has seen the Demodex in the secretion from meibomian glands and had claimed it to be the excitant of chalazion and, as Mibelli[10] did, considered it to be the cause of some diseases of the eyelids. Ivers[11] found the parasite in 69 per cent. of normal borders of the eyelids, and attributes a pathological signification to it. Hünsche[12] and Mulder[13] arrive at the same conclusions ; in the light of their investigations the Demodex is found as a constant accessory—certainly not in the meibomian glands, as it is limited only to the internal part of the hair follicle. Lewandowsky[14] considers that it can hardly be demonstrated at present that the same parasite which in individual specimens causes no symptoms is capable of producing pathological conditions when markedly increased in numbers.

Treatment is by the removal of the comedones, above all, by their mechanical removal by pressure with a watch-key and with the

---

[1] Veiel, v. Ziemssen's "Handb. d. spez. Path. u. Therap.," 1884, xiv.
[2] Kaposi, "Path. u. Therap. d. Hautkrankh.," 1899.
[3] Saalfeld, Lesser's "Encyclop. d. Haut- u. Geschlechtskrankh.," 1900.
[4] Jessner, "Kompend. d. Hautkrankh.," 1906, 3rd ed.
[5], [6] Weyl and Geber, v. Ziemssen's "Handb. d. spez. Path. u. Therap.," 1884, xiv.
[7] de Amicis, quoted by Lewandowsky. [8] Majochi, *Centralbl. f. Bakt.*, xxv.
[9] Dubreuilh, *La Prat. Derm.*, Paris, 1901.
[10] Mibelli, quoted by Lewandowsky. [11] Ivers, *ibid.*
[12] Hünsche, *Münch. med. Wochenschr.*, 1900, xlv.
[13] Mulder, *Weekbl. v. het Nederl. Tijdschr. v. Geneesk.*, 1889.
[14] Lewandowsky, *Deutsch. med. Wochenschr.*, 1907, xx.

various comedo-compressors, and by subsequent cleansing of the skin with ether, benzine or spirit. If the eyelids should be affected with blepharitis due to the presence of Demodex in large numbers, epilation and administration of a parasiticide is recommended.

Demodex folliculorum canis.

Transmission from dog to man is in any case very rare, and by many its occurrence is generally doubted. Nevertheless Gruby[1] and Remak[2] claim that it is transmissible—an opinion which has also been shared by Neumann[3] and Zürn.[4] The latter saw in the case of a married couple who had the care of mangy dogs the onset of diseased areas on their hands and feet, which were like those on the dogs and contained the same parasites.

A. Babes[5] also reports several observations which go to show that persons who, to some extent, have been shown to have been in contact with mange-stricken dogs have been attacked by a scabies-like eruption localized over the thorax, abdomen, back and extremities; large numbers of Demodices were found in the follicular pustules. Lewandowsky[6] reports one case—that of an Italian workman, who suffered from an outbreak on the face, like impetigo; there was crust formation and at the edge of the crusts the epidermis appeared like a narrow row or border of vesicles. A small portion of the covering of the row of vesicles was lifted off, and after slight warming examined in 40 per cent. liquor potassæ. In this a large number of animal parasites of the Demodex group were found, and without doubt *Demodex folliculorum canis* alone. Hünsche[7] assumes that *Demodex folliculorum* penetrates into the tissues and produces abscesses.

Treatment first consisted in dusting with zinc amyl powder, but after four days there was no change. After the regular use of xeroform as a powder application, the affection cleared up within fourteen days.

INSECTA.

Pediculus capitis (Pediculus capitis) (Head Louse).

We find *Pediculus capitis* in very young children and in others more grown up to be the incessant and frequent cause of impetiginous crust-forming eczemas. It is more frequent in girls than in

---

[1] Gruby, quoted by Lewandowsky. [2] Remak, *ibid.*
[3] Neumann, *ibid.* [4] Zürn, *ibid.*
[5] Babes, *ibid.*
[6] Lewandowsky, *Deutsch. med. Wochenschr.*, 1907, xx.
[7] Hünsche, *Münch. med. Wochenschr.*, 1900, xlv.

boys. In families it is endemic, in schools epidemic, but it also occurs in fair frequency in female adults (servant maids, waitresses) who may pay little attention to bodily cleanliness. The puncture of the parasites sets up a severe irritation, which leads to violent scratching. The consequences of this are the formation of nodules and pustules, crusts and "weeping" patches; the hairs become felted and the final clinical picture is that of plica polonica. The conditions of irritation which are produced by these parasites and then by the scratchings of the impetiginous, and frequently the very severe suppurative processes of the hair-bed, lead to swellings in the neck and sometimes even to glandular suppurations. The eczematous processes not infrequently extend over the face, the neck and the thorax. Blepharitis and conjunctivitis may be due to *Pediculus capitis.*

The means of infection are often very remarkable. Transmission from one individual to another certainly often occurs, but infection may take place in railway carriages and in other ways. A case under the observation of a colleague in Frankfort is a most remarkable one: he diagnosed pediculosis as the cause of a head eczema occurring among the children of one of the best families there. The infection took place through dolls adorned with human hair, in which the presence of nits could be demonstrated.

The diagnosis of *Pediculus capitis* is not difficult to make when the hairs and hairy scalp are carefully examined for nits and living parasites. In better families it is a good plan to point out the *corpora delicti* to their possessors and to make them aware of the possible sources of infection.

As regards treatment, lotions of sabadill vinegar are recommended; in slighter cases these are quite sufficient. In severe cases cure will not result unless dressings of petroleum, naphthol ointment (5 to 10 per cent.) and balsam of Peru be applied. In the case of plica polonica, the hair must be cut quite short (even in adults) so as to control matting of the hair. To get rid of nits from hair that is not matted, careful combing and washing with strongly alkaline fluids or with hot vinegar is suitable.

Pediculus vestimenti (Clothes Louse).

The clothes louse attacks adults by preference, and with especial frequency old and emaciated persons. It lives in the clothes, but derives its nourishment from the body. At the moment at which the clothes louse inserts its proboscis into the skin the person experiences a slight sting, which, however, at once ceases to hurt. If the body of the louse is sucked full of blood it falls off and the individual has rest from it for a time. A wheal develops around the hæmorrhagic area of the bitten spot and itches severely. The itching goes on until the eruption is scratched all over. This is followed by crust formation. When many parasites are present the itching reflexes become more severe, and the patients scratch themselves considerably and make long marks at those places where the Pediculi have been. The localization of the scratching effects is characteristic, corresponding with folds between portions of clothing (regions between the shoulder-blades, wrist and neck). If the condition lasts for a month, the scratching effects extend over the whole body, and secondary efflorescences become associated with it, such as pustules, ulcers and eczemas. Intermediate between this we find cicatrices and pigmentation, the latter under certain circumstances extending over the whole body. Sulla, Herod, Cardinal Dupet, Philip II, and others are said to have died from louse disease. That even at present many human beings are exposed to the danger of being devoured by lice is a fact that we have had the opportunity of observing on several occasions. Only to record one instance, a man, aged 65, was received into our clinic some time ago in an absolutely neglected condition (he had been staying for some weeks in a stable, lying on a wretched bed). The whole of the surface of his body was covered with countless furuncles, of greater and less size, which had partly become changed into undermined ulcers. Over the ulcers and beneath their undermined edges Pediculi were swarming.

Phthirius inguinalis (*Pediculus pubis*) (Crab Louse).

The transmission of these parasites generally takes place during coitus, and therefore they especially occur in the pubes. It is possible also that transmission is effected through dirty clothes and bed-linen and privy seats.[1] Starting from the pubes the animals crawl out over the other parts of the body provided with hairs to the abdominal wall and the thorax (so far as these parts are furnished with thick hair) to the arm-pits, the beard, the eyebrows; not, however, to the hair of the head, or rarely so; among our numerous cases we have never met with an example of the crab louse attacking the hair of the head.

The irritation produced by the crab louse is extraordinarily severe, especially during the night, as the warmth of the bed incites the lice to active sucking. In consequence of the violent scratching indulged

[1] [A case of infection through a dirty station privy in Switzerland came to my knowledge in 1899, and numbers of pediculi were found there.—F. V. T.]

in, eczemas are set up at the points attacked, and these often spread to the neighbouring parts not covered with hair.

Of special interest is the onset of maculæ cæruleæ (tâches bleues) in some persons affected with crab lice (people disposed to sweating seem to be peculiarly liable to these). They consist in pale blue patches of various size and shape, varying from that of a hemp-seed to that of a lentil, and again to that of a nail in size and form. These are found over the cutaneous surface of the abdomen, thorax and thigh, and are often only seen by a good lateral illumination. Duguet[1] considers that the condition is a toxic erythema, that it is set up, on the occasion of the bite of the parasite penetrating the skin, by the poisonous substance derived from it. Oppenheim[2] considers that it is a colouring substance that is formed in the salivary glands of the parasites, and which penetrates the skin when the insects bite, and thus forms the maculæ cæruleæ. We have on several occasions emulated the experiment of Duguet (trituration in a mortar of crab lice freshly taken from the human body and inoculating the mass thus obtained beneath the skin), and have similarly been enabled to produce the maculæ cæruleæ experimentally, but we have certainly been unable to determine which of the hypotheses is the correct one, the toxic erythema or the colouring substance inhibition theory.

The diagnosis of phthirasis is very easy, for either the sexually mature parasites or the nits are found on the hairs.

As regards treatment, grey ointment is regarded as a generally useful application ; it gives rise, however, to a slight eczema of the genitals, especially in males, when injudiciously used. Geber[3] recommends petroleum or balsam of Peru, Oppenheim[4] a 1 per cent. sublimate solution for lotions, or a mixture of equal parts of petroleum and benzine when the sublimate cannot be borne. The use of a 5 per cent. ointment with hydrarg. oxid. flavum is worth considering in treatment of pediculosis of the eyebrows and eyelashes. The simplest method of treatment, and one with a radical effect, is that by sulphuric ether recommended by Thomer.[5] It certainly produces a sharp burning sensation, but the living parasites and nits are destroyed in one sitting. We prefer ether lotions as a rule, and we thoroughly rub the affected parts with a pad of wadding well soaked with the ether. The dead parasites and the nits fall on to what lies

---

[1] Duguet, *Annal. de Derm.*, II Sér., i.

[2] Oppenheim, "Handb. d. Hautkrankh.," v. Mraček, 1907.

[3] Geber, *see* Seifert, Lesser's "Encyclop.," p. 387.

[4] Oppenheim, *loc. cit.*

[5] Thomer, *see* Seifert, Lesser's "Encyclop.," p. 387.

beneath when the rubbing is done thoroughly, and the burning sensation caused by the ether only lasts a few minutes.

Cimex (Acanthia) lectularia[1] (*Cimex lectularius*) (Bed Bug).

The puncture in the skin made by the bed bug gives rise to an extraordinary amount of severe itching and a burning sensation, and when the skin is sensitive wheals of remarkable size (*urticaria ex cimicibus*). These eruptions that cause such severe itching are scratched by those attacked, till very soon blood begins to flow, and this generally leads to the formation of a dried crust of blood at the point of eruption.

The diagnosis is not always easy, as urticaria arising in other ways frequently leads to similar vigorous scratching and formation of crusts of dried blood. Men who have some experience in this matter (for example, commercial travellers), when they are attacked by severe itching at night, are in the habit of striking a light and searching in their bed and body-linen for the bugs, in order to be able to hand over the *corpora delicti* to the landlord if need be. The assumption that the bugs in the East play an actual part in the propagation of tuberculosis and bubonic plague has been proved by investigations made by Nuttall[2] to be at least very exaggerated if not wholly without foundation. Further investigations may decide how far the bugs participate in the transmission of kala-azar, as is believed by Rogers to take place.

The bed bugs must be exterminated by spraying the chinks and joints in the boards with petroleum and benzine, pulling up the carpets and cleansing the bedsteads. For the treatment of the bite itself the methods recommended as an antidote against insects' stings in general are suitable: 2 per cent. carbol vaseline (Rosenbach[3]), thymol dissolved in spirit (1 in 50[4]), æthrol or deci-æthrol, form-æthrol (manufactured by Dr. Nordlinger, Flörsheim a. /M.), formol[5] (formol 15 parts, xylol 5 parts, acetone 44 parts, Canada balsam 1 part), with the aid of a pad of wadding placed over the part bitten, lavages with vinegar, citron juice and spirit of salmiac.

---

[1] *Vide* genus Cimex, p. 534.
[2] Nuttall, *see* Sack "Handb.," v. Mraček, p. 290.
[3] Rosenbach, *Therap. Monatsh.*, 1903.
[4] *Leipzig. med. Monatsh.*, 1907, vi.
[5] *Chemist and Druggist*, August 25, 1906.

Pulex irritans (Human Flea).

The bite of the flea produces a slight discharge of blood about the size of a pin's head, which rapidly becomes surrounded with a circular area similar to a patch of roseola. The redness fades away after a longer or shorter while (several hours), whilst the discharge of blood is to be seen for one or two days longer. In dirty people the whole body may be covered with such discharges of blood. Individuals with very delicate, sensitive skin, especially small children, show true wheal formation at the site of the bite. In certain cases there develops from one such single bite an urticaria that extends over a large part of the body. The manner by which an irritating substance is introduced into the skin upon biting by the bed bug and also by the flea is clear. The bite is followed by a feeling of itching, which is liable to rob nervous persons of their sleep. Sensitive individuals are upset even by the fleas moving over the surface of the skin during their rest at night.

Treatment consists in extreme cleanliness, capture of the parasites, sprinkling the body and bed-linen with insect powders. The fleas are difficult to remove from barracks, schools and hospitals.

Dermatophilus (Sarcopsylla) penetrans (Sand Flea).

The fertilized females penetrate into the skin with their heads, and here they swell, in consequence of the numerous and growing eggs and larvæ, to a white ball the size of a small pea, on which the head is recognizable only as a small brown point.

In this way a small brown tumour arises, over which, at the commencement, the skin is not reddened ; after some days, however, it becomes inflamed ; in the centre of it a small opening is seen. If the parasite is not extracted the skin that lies over it becomes destroyed by suppuration, and thus becomes removed. At the commencement the part affected itches, with increasing inflammation ; the symptoms of irritation become more severe and may amount to actual pain. If the small suppurative processes be neglected, inflammation and gangrenous and septic processes may arise. The region of the body sought out by preference by the sand flea is the sole of the foot, the toes, under the free ends of the nails and the digito-plantoid folds—more rarely the scrotum, thigh and other parts are attacked (Scheube[1]). The number of parasites found on one person may amount to several hundreds.

---

[1] Scheube, "Die Krankh. d. warmer Länder," 1896.

Treatment consists in the removal of the parasites from the skin with a needle or a small sharp knife and the application of a bandage. Rubbing the feet with copaiba or Peru balsam, sprinkling them with insect powder, or washing them with bay rum (Berger[1]) acts as a prophylactic or removes the irritation of the skin produced by the parasites.

Myiasis.

Under the name of myiasis we designate the complex symptoms which parasitic dipterous larvæ give rise to in man (Braun), and we conceive under the term myiasis externa (dermatosa s. cutanea) all lesions of the human integument caused by fly larvæ and of the cavities covered with mucosa therewith connected, such as the external auditory meatus, the oro-nasal cavity, the urethra and vagina. The occurrence of dipterous larvæ in the digestive tract is named myiasis intestinalia or interna.

Myiasis externa.

The larvæ of a species of fly belonging to the *Muscidæ*, *Lucilia macellaria*,[2] are found in relative frequency in the nose, especially in America and India.[3] Riley[4] has stated that the screw-worm of Central America and of the United States is nothing else than the larva of *Lucilia macellaria*, and also that the Brazilian fly named "berna" may be no other than *Lucilia macellaria*. Their offspring may set up inflammatory disturbances in the soft tissues of man. This fly has a wide distribution, from the Argentine Republic to Canada, also in the British portions of the East Indies, where the disease is named "peenash." This word is derived from the Sanskrit, and is said to be a collective name for all diseases of the nose. Lahory[5] states that within a period of nine years ninety-one cases of "peenash" occurred in Allyghar, two of these ending fatally. *Lucilia macellaria* is not at all timid but bold, like the house-flies and blue-bottles, its relatives. It not only lives at no great distance from human dwellings, and forces its way into villas and country houses, but even attacks its victims without awaking them from their sleep. Although this species shows a certain preference for nasal cavities affected with catarrh or pus (v. Frantzius[6]), and also the external auditory meatus,

[1] Berger, *Therap. Monatsh.*, April, 1907.

[2] [*Chrysomyia macellaria*, p. 587.—F. V. T.]

[3] [*C. macellaria*, Fabricius, the screw-worm fly, is found in tropical America and the West Indies. The genus is restricted to America. The species from India is a Pycnosoma.—F. V. T.]

[4] Riley, *American Naturalist*, 1883, xvii.

[5] Lahory, *Edin. Med. Journ.*, 1856.

[6] v. Frantzius, *Virchow's Archiv*, 1868, xliii.

as well as ulcerated or wounded parts of the body, and even badly ulcerated skin carcinoma (Lutz[1]), it is not a rare thing for it to penetrate into one of the above-mentioned cavities rapidly to deposit its eggs, without these parts having been previously affected. The report also of Conil,[2] in which these flies bear the name of *Calliphora anthropophaga*,[3] is an interesting one. Probably it was the same species of Muscid in the cases of myiasis nasi observed by von Tengemann, Delasiauve,[4] Weber,[5] Mankiewicz,[6] and Kirschmann.[7] In the case recorded by Prima,[8] and in that recorded by Britton,[9] the issue was a fatal one; in the latter the larvæ escaped through the pharynx and nose; the hyoid bone and the soft parts of the palate were destroyed, the speech and power of swallowing were hindered. At the *post-mortem* extensive destruction of the internal nose was found, so that the nasal bones could only be kept in their position by the aid of the external skin. Even during life 227 larvæ escaped. Similar destructive processes were found in the case communicated by Richardson.[10] In two cases reported by Schmidt[11] 300 and 350 larvæ were respectively removed from the nose, and the patients recovered. Wolinz[12] found his patient had lost consciousness, and that in the pus filling up the entrances to the nose numerous larvæ were moving; recovery followed. In the case communicated by Adler,[13] more than 150 larvæ escaped from the nose of an old man. Curran[14] states that people suffering from "peenash" frequently die from meningitis. The cases reported by Pierre[15] related to the forms of severe myiasis frequently to be observed in Guiana. In a patient who was suffering from typhus (? typhoid), Douglas[16] found the conjunctival sacs full of larvæ; in two other individuals the nasal cavities were attacked.

The case observed by Summa[17] was that of a man, aged 28, who suffered from nasal obstruction, fœtor, epistaxis and pain in the nose. Out of seven of the cases occurring at Fort Clark, U.S.A., and in its

---

[1] Lutz, *see* Joseph, *Deutsch. med. Zeitg.*, 1885.

[2] Conil, *Annal. de Science nat. zool.*, 1878.

[3] [This fly belongs to the genus Cordylobia, and is peculiar to Africa. *C. anthropophaga*, or the tumbri fly, is, when a larva, a subcutaneous parasite of man and animals.—F. V. T.]

[4] Delasiauve, Gerhardt's "Handb. d. Kinderkrankh.," 1878, iii.

[5] Weber, *Mexique Rec. d. Mém. de Méd. milit.*, 1867.

[6] Mankiewicz, *Virchow's Archiv*, 1868, xliv.

[7] Kirschmann, *Wien. med. Wochenschr.*, 1881.

[8] Prima, "Thèse de Paris," 1881.

[9] Britton, Cambridge, Massachusetts, 1883.

[10] Richardson, *Medical Monthly*, 1883.

[11] Schmidt, *Texas Med. Journ.*, 1887.

[12] Wolinz, *Wratsch*, 1884.

[13] Adler, *Med. Record*, 1885.

[14] Curran, *Med. Press and Circ.*, 1887.

[15] Pierre, "Thèse de Paris," 1888.

[16] Douglas, *Kansas City Med. Index*, 1890.

[17] Summa, St. Louis, 1889.

neighbourhood, six ended fatally; in all these cases Kimball[1] diagnosed ozæna; attracted by the strong odour the flies forced their way into the noses of the patients when asleep and there deposited their ova. In a case reported by Carrière[2] an abscess of the nasal septum was produced by the larvæ of flies; Chiodi[3] reports seven cases of myiasis due to *Lucilia macellaria;* among these was a case of rhinitis myiatica, in which a cerebral abscess leading to a fatal termination developed, being produced by the migration of a larva into the brain. Among the three cases of Lesbini[4] was that of a girl, aged 16, with 250 larvæ in the diseased nasal cavity. Quintano[5] observed larvæ beneath the eyelids in one case. It is possible that the cases of Cesare[6] and Calamida[7] were those of myiasis nasi due to *Lucilia macellaria.* The larvæ are also found in the nasal accessory sinuses, as is seen from the cases reported by De Saulle[8] (frontal sinus), Delasiauve[9] (frontal sinus), MacGregor[10] (antrum of Highmore), and Bordenave[11] (antrum of Highmore).

If a survey is made of the literature of the cases described of myiasis nasi produced by *Lucilia macellaria*[12] the following information is forthcoming: In Europe this form of the disease is of very rare occurrence, whilst in America and India[13] it is frequent. Persons suffering from ozæna are rendered the most liable to danger as the penetrating odour entices the flies in tropical countries with intense frequency, so much so that v. Frantzius does not consider this myiasis as an independent disease, but as a complication of ozæna of frequent occurrence in warm countries. The infection is so far of interest in its nature, in that it only takes place during the day. The fly is on the wing only by day when the sun is shining, and consequently only deposits its eggs at this time. Therefore persons suffering from ozæna are principally exposed to the danger of being pursued by the flies when they succumb to sleep during the mid-day hours in the open or in dwellings that are not closed up.

Headache is the symptom which most troubles the patients. It extends over the whole cranium and persists uninterruptedly, with

---

[1] Kimball, *New York Med. Journ.*, 1893.
[2] Carrière, *Gaz. hebd. de Méd. et de Chir.*, 1898, xciv.
[3] Chiodi, *La Argent. Med.*, March 1, 1905. [4] Lesbini, *ibid.*
[5] Quintano, "Cronic oftalm. de Cadiz," 1878.
[6] Cesare, *Arch. ital. di Otol.*, April, 1903.
[7] Calamida, *Giorn. d. R. Accad. de Med. di Torino*, September, 1903.
[8] De Saulle, *Gaz. des Hôp.*, Paris, 1857.
[9] Delasiauve, *Gaz. hebd. de Méd.*, Paris, 1885.
[10] MacGregor, *Arch. gén. de Med.*, No. 1,031.
[11] Bordenave, "Deuxième Mém. présenté à l'Acad. de Chir.," v, p. 387.
[12] [And the other species, of course, must be included here.—F. V. T.]
[13] [Concerning Europe and India, *macellaria* does not occur.—F. V. T.]

more or less severe periods. Violent headaches in the frontal and buccal regions are almost always present in this complaint; they are experienced either only on one side or on both simultaneously; sometimes the pain is extended to the lower jaw and region of the neck, following the whole extent of the trigeminal nerve. The inflammation of the nasal mucosa produced by the penetration into it of the larvæ extends right into the frontal sinus and antrum. Simultaneously the patients, at the height of their trouble, suffer from persistent sleeplessness and severe vertigo, so that they reel and cannot walk straight; excessive sneezing always sets in at the commencement. The larvæ immediately spread over the nasal mucosa to seek a place suitable to feed, and irritate the nasal mucous membrane by the tickling sensation they produce. Later the patients frequently sneeze when the maggots move to and fro.

One very characteristic symptom consists in the peculiar swelling of the face, which is extended either over the whole or only one half of it, and may alternate with attacks of erysipelas (Brokaw[1]).

The discharge from the nose is of special diagnostic value. It consists of a blood-stained serous matter or blood-stained fluid, which is perpetually trickling from one or both nostrils. The larvæ especially choose the anterior portions of the nasal cavity, where they can be seen lying in groups together at the base of the choanæ. The consequence of this is that the soft palate becomes intensely swollen, and this in turn makes swallowing very difficult; speech is impeded, and the voice acquires a nasal intonation. Symptoms of fever become more or less pronounced according to the number of larvæ present, and according to the nature and constitution of the individual. The appetite is in abeyance throughout the whole duration of the illness, and sometimes there is the onset of slight attacks of diarrhœa.

If the larvæ are not removed in good time there follows excessive destruction of the interior of the nose and of the turbinals; and the whole nasal framework undergoes disintegration, frequently, too, the velum palati, so that the larvæ come into sight in the oral cavity. Individuals thus severely attacked succumb through exhaustion, symptoms of meningitis (cerebral abscess) or septicæmia (Prima[2]). Twenty-one out of thirty-eight cases recorded (collected) by Maillard[3] died.

The method of prophylaxis is self-evident from what has been stated. On bright summer days neither the healthy nor those suffering

---

[1] Brokaw, *see* Seifert, in Heymann's "Handb.," p. 595.

[2] Prima, "Thèse de Paris," 1881.

[3] Maillard, "Thèse de Montpellier," 1870.

from diseases of the nose should sleep during the day-time in the open or in public habitations; sufferers from nasal diseases should pay special attention to this.

Treatment consists in the removal of the larvæ; this, however, is not always easy.

With regard to the methods which have proved to be effectual in the destruction of living larvæ and their expulsion from the nose, strongly smelling and easily diluted fluids come first, such as alcohol, eau-de-Cologne, and ether, which should kill the creatures when injected into the nostrils. The earlier physicians, such as Salzmann,[1] Honold,[2] and Henkel,[3] have seen good results from the use of these methods, whilst Mankiewicz[4] and Goldstein[5] obtained no results whatever. Kimball's[6] careful investigations have shown that a decoction of bitter herbs recommended by Behrends[7] (tansy, wormwood) have just as little effect as the tobacco decoction employed by Boerhave[8] and Kilgour.[9] The sternutatories employed by the older physicians are entirely neglected. Delasiauve[10] experienced good results from the inhalation of the smoke of paper cigarettes, which were soaked with a solution of 2·0 pot. arsenic in 30·0 distilled water. Whilst, according to Kimball, balsam of Peru had no effect on the larvæ, Mankiewicz succeeded in removing the larvæ from the nose with the help of that drug. Turpentine steam or mixtures of turpentine employed by Indian physicians have not been very effectual according to Moore,[11] Kimball and Goldstein. Success has been attained in some cases by the use of insufflations of calomel (Roura,[12] Cerna,[13] Schmidt[14]) or of iodoform (Pascal[15]). Joseph[16] recommends concentrated alum solution being sniffed up into the nose as very effectual. Sublimate and carbol solutions do not appear to be very successful (Kimball, Moore, Goldstein), whilst benzine inhalations (Pierre[17]) have shown better results. Scheppegrell[18] strongly recommends injections of oil which kill the larvæ, while it is perfectly harmless to the nasal mucosa. Cesare[19] employed nasal lavages with solutions of salicylate of soda with good results, and Calamida[20] lavages with physiological saline solution. Bresgen[21] recommends the nose being

[1] Salzmann, *see* Tiedemann, Mannheim, 1844.
[2] Honold, *ibid.*
[3] Henkel, *ibid.*
[4] Mankiewicz, *Virchow's Archiv*, 1868, xliv.
[5] Goldstein, *New York Med. Journ.*, 1892.
[6] Kimball, *ibid.*, 1893.
[7] Behrends, *see* Tiedemann.
[8] Boerhave, *ibid.*
[9] Kilgour, *ibid.*
[10] Delasiauve, *loc. cit.*
[11] Moore, *Chicago Med. Times*, 1893.
[12] Roura, *Gaz. di San. milit.*, 1884.
[13] Cerna, *New York Med. Journ.*, 1893.
[14] Schmidt, *Texas Courier*, 1884.
[15] Pascal, *Arch. d. Méd. milit.*, 1895.
[16] Joseph, *Deutsch. med. Zeitg.*, 1885.
[17] Pierre, "Thèse de Paris," 1888.
[18] Scheppegrell, *New York Med. Journ.*, 1898.
[19] Cesare, *loc. cit.*
[20] Calamida, *loc. cit.*
[21] Bresgen, Eulenburg's "Real. Encyclopädie," third edition.

cocainized and the larvæ being removed with a pincette. Roorda-Smit[1] cocainized the nose, then insufflated calomel and plugged the nose with a gauze tampon dusted with calomel. After two hours fifty-six larvæ crawled out along the plug. Continuation of the treatment resulted in a complete cure.

Injections of chloroform water (Jourdran[2]) or chloroform inhalations, or injections of pure chloroform into the nose, have proved the most effectual (Goldstein,[3] Osborn,[4] Jourdran, Durham,[5] Jennings,[6] Kimball,[7] Mackenzie,[8] Oatmann,[9] Zarniko,[10] Antony,[11] Folkes[12]). Camphorated carbolic solutions are very well spoken of: Grayson[13] states that these kill the larvæ immediately. Some authors have removed the larvæ with forceps (Goldstein[14]), others with pincettes; thus Brokaw extracted 200 fragments with the forceps, Pascal eighty fragments with the pincettes, and Wolinz[15] also appears to have removed the larvæ with forceps.

Greater operative measures than these do not appear to have been undertaken in latter days; yet Morgagni[16] states that the army surgeon, Cæsar Mogatus, at Bologna, first trephined the frontal sinus and then extracted a "worm" from it.

Larvæ of other *Muscidæ* have come under observation much more rarely (Cheval[17] [larvæ of *Galleria mellonella*[18]], Bond,[19] Dumesnil[20] [larvæ of *Piophila casei*]). Species of the genus Scolopendra (*Myriapoda*), which all shun the light and seek their food during the night—which consists of animal and vegetable substances—frequently make their way into the nasal cavities of people when asleep. They are found not only in the nose, but in the accessory cavities. In the chapter on the "Parasites of the Nose"[21] we have collected striking

---

[1] Roorda-Smit, *Deutsch. med. Wochenschr.*, 1906.
[2] Jourdran, *Arch. de Méd. nav.*, 1895.
[3] Goldstein, *New York Med. Journ.*, 1892.
[4] Osborn, *Daniel's Med. Journ.*, 1891.
[5] Durham, *Chicago Med. Times*, 1893.
[6] Jennings, *Kansas City Med. Index*, 1890.
[7] Kimball, *New York Med. Journ.*, 1893.
[8] Mackenzie, "Diseases of the Nose and Throat."
[9] Oatmann, *Med. Mirror*, February, 1894.
[10] Zarniko, "Lehrb. d. Krankh. d. Nase."
[11] Antony, *Bull. Soc. méd. des Hôp. de Paris*, 1903.
[12] Folkes, *New York Med. Record*, 1907.
[13] Grayson, *St. Louis Med. and Surg. Journ.*, 1891.
[14] Goldstein, *New York Med. Journ.*, 1892.
[15] Wolinz, *Wratsch*, 1884. [16] Morgagni, *see* Tiedemann.
[17] Cheval, *Journ. de Méd. et de Chir.*, 1893.
[18] [This is the larva of a moth.—F. V. T.]
[19] Bond, *Int. Zentralbl. f. Laryng.*, 1896.
[20] Dumesnil, *see* Friedreich, "Die Krankh. d. Nase," 1858.
[21] Seifert, *see* Heymann's "Handb."

instances, but we have omitted to mention the observation made by Bertrand[1] (Scolopendra in sinus maxillaris) and that made by Bergmann[2] (Scolopendra in sinus frontalis). In the same chapter some remarks are made as to the occurrence in the nose of earwigs, caterpillars, scorpions and termites, as well as of animals which have not been identified.

The larvæ that develop in the auditory meatus penetrate the membrana tympani, destroy the middle ear and may produce meningitis and intracranial suppurations. In one case Vesescu[3] extracted seven living larvæ from the ear with the aid of a thin pair of pincettes. Köhler[4] recommends the infusion of drops of ol. terebinth. to destroy the larvæ, Quintano[5] the insufflation of the following powder: Oxid. hydrarg. rubr., sulfur., āā 1·0 grm., pulv. gi. arab. 8·0 grm.; Lesbini[6] recommends tincture of iodine. In the case reported by Henneberg[7] the larvæ were those of *Lucilia cæsar*.

Eye affections due to *Lucilia macellaria* are very uncommon; the literature relating to the lesions of the eye produced by the larvæ of flies has been collected in Kayser's[8] work. In the cases under the observation of Schultz-Zeyden[9] both the eyes of a female tramp were destroyed, and quantities of larvæ were also found in the nasal fossæ and in the ears.

The Lucilia is found relatively seldom on the cutaneous surface. Henneberg's[10] case was that of a neglected girl, aged 20, in whom countless larvæ (*L. cæsar*) were found in a plica polonica; after the plica polonica had been removed the scalp was found to be covered with a large quantity of ulcers which swarmed with larvæ, large and small. The skin of the trunk was also much macerated and covered with larvæ. Death resulted from sepsis; Westenhöffer[11] remarks on this case that a lesion of the head from which the patient had suffered previously and the perpetual state of intoxication in which she was had probably given rise to the lodgment of the fly larvæ. Whether the communications made by Munk[12] of maggots in the mouth relate to Lucilia I do not know. Vesescu,[13] in one case with extensive

---

[1] Bertrand, *Soc. méd. de Bologne*, 1839.
[2] Bergmann, *Korrespondenzbl. d. deutsch. Ges. f. Psych.*, Neuwied, 1859.
[3] Vesescu, *Riv. stiintelor med.*, February, 1906.
[4] Köhler, *Monatsschr. f. Ohrenheilk.*, 1885.
[5] Quintano, *see* Seifert, *loc. cit.*
[6] Lesbini, *La Argent. Med.*, 1905.
[7] Henneberg, *Berl. med. Ges.*, February 18, 1903.
[8] Kayser, *Klin. Monatsbl. f. Augenheilk.*, 1905.
[9] Schultz-Zeyden, *Berl. klin. Wochenschr.*, 1906.
[10] Henneberg, *Berl. med. Ges.*, February 18, 1903.
[11] Westenhöffer, *Verein f. innere Med.*, Berlin, May 7, 1906.
[12] Munk, *Wien. med. Presse*, xxi.
[13] Vesescu, *loc. cit.*

ulceration and deep fistulæ in the skin, removed 176 larvæ with the pincette. In Roorda-Smit's[1] case there were two ulcers in the neck of a girl, aged 17, and larvæ appeared at their base. After dusting with calomel and the application of a bandage the next day fifty-two dead or half-dead larvæ came to light. Recovery took place. Lesbini,[2] in the case of an old lady, saw numerous larvæ in an ulcer of the leg she was suffering from. Hector's[3] case appears to have been one of myiasis cutanea provoked by Lucilia.

The first exact observations of myiasis cutanea from *Sarcophaga magnifica* are due to Wohlfahrt,[4] in whose honour Portschinsky[5] named this species of fly *S. wohlfahrti.* Portschinsky ascertained that *S. wohlfahrti* was not confined to man as its sole host, but that several of our domestic animals, such as cattle, horses, pigs, dogs and geese, were visited. In these animals small wounds serve to entice the flies and to supply them with a suitable site for the deposition of their eggs. The oral armature of the young larvæ renders it easy for them to penetrate not only the mucosa and cutaneous surface but also intact places in the submucous connective tissue. In many localities more than half the herds have proved to be infected by the flies. The fly only frequents open spaces and never enters human dwellings, and is so timid that it approaches man only during sleep ; infection, therefore, takes place only out of doors, in summer, in clear, warm weather, and only in such individuals as sleep in the open air. Individuals are most exposed to risk who suffer from catarrhs or inflammations, combined with purulent secretions of the nasal cavity (ozæna), or otorrhœa, or ulcers in any parts of the body accessible to the female fly.

The frequency and intensity of the infection will be in inverse proportion to the advance in civilization of the inhabitants, their idea of cleanliness, their having timely medical aid and the chances of their being rapidly attended to. On that account the majority of cases of myiasis (Sarcophaga) are reported from Russia. The literature of this kind of myiasis nasalis is not very extensive ; in addition to Wohlfahrt, Portschinsky and Joseph,[6] there is a communication by Gerstäcker,[7] who found fifteen adult larvæ of *S. wohlfahrti* in the nasal cavity of one man. The larvæ transmitted from Ordruf by Dr. Thomas to Löw,[8] in Vienna, which were discharged from the nose of a woman,

---

[1] Roorda-Smit, *Deutsch. med. Wochenschr.*, 1906.
[2] Lesbini, *loc. cit.*
[3] Hector, *Lancet*, 1902.
[4] Wohlfahrt, "De vermibus per nares excretis," Norimbergae, 1770.
[5] Portschinsky, "Norae Soc. entomolog. Rossicae," 1875.
[6] Joseph, *Deutsch. med. Zeitg.*, 1885.
[7] Gerstäcker, "Sitzungsberichte d. Ges. f. naturf. Freunde in Berlin," 1875.
[8] Löw, *Wien. med. Wochenschr.*, 1883, xxxi.

aged 71, suffering from ozæna, were recognized by the well-known dipterologist Braun as belonging to *S. wohlfahrti*. Among the cases reported by Joseph, one only affected the nose; it was that of a peasant girl, aged 11, who had suffered from ozæna; she had travelled on the open road and had there gone to sleep. Severe symptoms set in and death followed under delirium. In making the *post-mortem* it was found that the interior of the nose was extensively destroyed by larvæ of *S. wohlfahrti*. Powell found Sarcophaga larvæ in two persons who had slept in the open air; the larvæ were killed by injections of chloroform and sublimate. Destruction of the eyes by *S. wohlfahrti* has only been observed in a few cases; it is reported by Cloquet[1] that, in the case of a ragman who had lain some time in the fields, both eyes were pierced by larvæ. On the outer skin the larvæ of *S. wohlfahrti* have been found more than once in inflammatory or festering areas. Freund[2] demonstrated that from a five year old child, which had suffered for some time from an impetiginous eczema of the skin of the head, from two suppurating abscess cavities which extended to the periosteum, which was already affected, twenty-one living larvæ were taken; rapid healing took place under antiseptic bandaging.

The small treatise by Balzer and Schimpff[3] contains two new observations on myiasis externa; in the one case an ulcer on a man's foot was full of larvæ, in the other case the head of a woman showed numerous larvæ without the skin of the head being destroyed. Brandt's[4] observation is interesting, for he found such larvæ in the gums of a sick person.

The impression which one obtains of the active movement of larvæ on wounds is a strange and at the same time uncanny one. One finds that the larvæ to obtain protection against the drying of the surface of the abscess almost incessantly burrow with their heads, first contracting and then expanding the body, which rises and falls, and keeping the tail upwards. Owing to these movements producing irritation, increase of inflammation may ultimately arise, causing erysipelas and cellulitis.

The treatment of myiasis nasalis caused by Sarcophaga is the same as in myiasis caused by Lucilia, and in the other places where found it is merely a question of the removal of the larvæ and the subsequent proper treatment of the surface of the abscess. In Northern Nigeria

---

[1] Cloquet, *see* Schultz-Zehden, *loc. cit.*

[2] Freund, *Ges. f. innere Med. in Wien*, December 5, 1901; and *Wien. med. Wochenschr.*, 1910, li.

[3] Balzer and Schimpff, *Annal. de Derm. et de Syph.*, 1902.

[4] Brandt, *Wratsch*, 1888.

Lelean[1] found *Auchmeromyia depressa* to be the cause of myiasis externa.[2]

The occurrence of Oestrid larvæ in a human being is very rare, at least up till now myiasis oestrosa has been very seldom observed in man in Europe. Whilst the hosts of the *Muscidæ* comprise a considerable number of warm-blooded animals, on which the larvæ develop, each species of the *Oestridæ* appears, on the other hand, to have a definite host or some definite hosts of the class Mammalia. No species of Oestrid is peculiar to man. Although in America, as well as in Europe, *Oestrus hominis* was spoken of up to the middle of the last century, no such species exists.

But in both hemispheres, in America much more often than in Europe, Oestrid larvæ have been found in man. In Florida, Mexico, New Granada, Argentina, Brazil, Costa Rica and other districts, and especially where large herds of cattle are kept, myiasis oestrosa has been observed in shepherds, huntsmen and amongst the rural population. The larvæ of *Hypoderma bovis*, according to the observations of Goudot,[3] occur as a parasite in man. Poilroux[4] found larvæ of cavicolous *Oestridæ* in the nose of a man, aged 55. Amongst the species of warble flies, whose larvæ are parasites in domestic animals and game in Europe, reliable observers have found larvæ of two kinds, *Hypoderma bovis* and *Hypoderma diana*, also in man.[5]

The larvæ of *H. bovis* have very seldom been observed in the nose. The case quoted by Kirschmann,[6] which was that of a peasant woman, aged 50, who was suffering from ozæna, and in which violent attacks of sneezing, epistaxis, pain in the forehead, and swelling of the face were observed, is, according to Löw[7] and Joseph,[8] not an Oestrid; Muscid larvæ were evidently the cause. By the injection of diluted iron chloride solution seventy-nine larvæ were removed from the nose. In the case reported by Razoux[9] the species of larva is not definitely known—at least, v. Frantzius[10] did not consider them Oestrid larvæ. Joseph does not definitely say that Oestrid larvæ were the cause of a case which he quotes. He was sent a number of uninjured larvæ of *Oestrus ovis* ready to pupate, which

---

[1] Lelean, *Brit. Med. Journ.*, 1904.

[2] [Numerous instances of attacks by Auchmeromyia are known and referred to under that genus, pp. 593-4. The species referred to here is not *depressa*, Walker.—F. V. T.]

[3] Goudot, *Annal. d. Sci. nat.*, 1845.

[4] Poilroux, *Journ de Méd.*, *Chir.*, etc., 1809.

[5] [*Hypoderma linearis* is frequently confused with *H. bovis*.—F. V. T.]

[6] Kirschmann, *Wien. med. Wochenschr.*, 1881.

[7] Löw, *Wien. med. Wochenschr.*, 1882.

[8] Joseph, *Deutsch. med. Zeitg.*, 1885.

[9] Razoux, *Journ. de Méd*, *Chir.*, etc., 1758.

[10] v. Frantzius, *Virchow's Archiv*, 1868, xliii.

were said to have been expelled, during violent sneezing, from the nose of a peasant woman who had suffered for six months from continuous frontal headache and chronic nasal catarrh.

The Oestrides prefer to use the surfaces of wounds on the skin of man to lay their eggs, which develop into larvæ ; but they often use their ovipositors[1] to make a fresh wound. In this case there arise in the skin, and particularly in the subcutaneous connective tissue of the neck, in the region of the shoulder, as well as in other parts of the body painful, furuncle-like inflammations which are known under the name of gad-fly boils. These boils may become the size of pigeons' eggs ; if several are together, they appear to form a connected tumour. Each tumour is elastic and somewhat movable, and has an orifice through which the larva breathes and discharges its excreta. At times these turn to festers and gangrenous disintegrations, which may even cause the loss of a limb. Wilms[2] had the opportunity a few years ago of observing a case of myiasis dermatosa oestrosa in Leipzig. The fistula which led to the larva was slit open and the larva extracted. As a notable characteristic of myiasis oestrosa Joseph states that the larvæ grow very slowly. The flight time of the *Oestridæ* is the hot summer months.

Adams[3] observed on the Isthmus of Panama a number of cases of a skin disease which is caused by the larvæ of *Dermatobia noxialis* (*Gusano-peludo-Muche*). The larvæ penetrate not only the skin but also the mucous membrane of the pharynx and larynx, and from there proceed through the tissue to the subcutaneous cellular tissue. The infection seems to result from bathing.

The study of " thimni," a human myiasis caused by *Oestrus ovis*, by Ed. and Et. Sergent,[4] deals more with the zoology and with the geographical distribution of this insect in North Africa than with the clinical appearances of myiasis. [This paper deals with matters of great interest, with important facts.—F. V. T.]

The treatment consists in the removal of the larvæ (from the nose) ; in Brazil it is the custom to drop tobacco juice into the boil in order to kill the larvæ (Strauch[5]).

One is only justified in speaking of myiasis intestinalis when there is no doubt that living fly maggots or flies themselves can be proved to have been found in the fresh contents of the stomach or intestine

---

[1] [The Oestrides appear to lay their ova on the hair of animals. They do not puncture the skin.—F. V. T.]

[2] Wilms, *Deutsch. med. Wochenschr.*, 1897.

[3] Adams, *Journ. Amer. Med. Assoc.*, 1904.

[4] Ed. and Et. Sergent, *Annal. de l'Inst. Pasteur*, 1907.

[5] Strauch, *Journ. of Cut. Dis.*, 1906.

(Schlesinger and Weichselbaum[1]). In the discussion of myiasis intestinalis we give the evidence of Schlesinger and Weichselbaum, as well as that of Wirsing,[2] to which must be added a number of other investigations.

In a great number of acute cases apparently only the stomach was affected, there being no signs in the intestine. In these cases sudden illness is noticed, colic, sometimes unbearable pains in the region of the stomach, pyrosis, vomiting or continuous intense inclination to vomit, occasionally even with the mixture of blood. Frequently a general feeling of malaise, twinges of pain in the muscles, and attacks of giddiness were notified, very rarely fever. Generally all the symptoms disappeared in a short time when the larvæ had been removed by an act of vomiting or by washing out the stomach.

It is well to note that in the history of many cases the pains preceding the expulsion of the larvæ are stated to be extremely violent.

Acute myiasis of the intestinal canal frequently runs a course without special symptoms and is only an accidental condition; one has, however, in such cases to guard against errors. The fæces may be deposited in vessels or places where fly larvæ are in great numbers, or a subsequent infection of the fæces with the eggs or larvæ of flies may have taken place. Only when the inspection of the excrement immediately following defæcation proves the presence of living larvæ, and when there were certainly no fly larvæ in the vessel previously, can one speak of the passing of fly larvæ from the intestine. More frequent than the cases showing no special symptoms are those with pronounced disturbances in the intestinal passage, obstruction or diarrhœa (also constipation and diarrhœa alternately), violent and sometimes agonizing abdominal pains (Pottiez[3]), which preceded the evacuation of the larvæ and subsided after their removal. General symptoms, like weakness, languor, transitory vague pains, loss of appetite, sickness, rarely fever, giddiness, attacks of faintness, epileptic attacks (Krause[4]) are observed. In a few cases blood and pus have been noticed in the evacuation of the bowels.

In the cases of chronic myiasis of the intestine the aspect of the disease is dominated by the complex symptom of colitis mucosa.

The following features are noticeable, namely, the intermittent passing of blood, the influence over the expulsion of the larvæ of mechanical procedure (massaging of the abdomen), the duration of the process for several years, the sometimes enormous number of

---

[1] Schlesinger and Weichselbaum, *Wien. klin. Wochenschr.*, 1902, i.
[2] Wirsing, *Zeitschr. f. klin. Med.*, 1906, lx.
[3] Pottiez, *Bull. de l'Acad. royale de Méd. de Belgique*, xv.
[4] Krause, *Deutsch. med. Wochenschr.*, 1886, xvii.

insects contained in the dejecta. Another clinically important factor is the passing of the larvæ in batches. While for some time no larvæ may appear in the stools, they may suddenly be ejected in great numbers, either because the conditions of feeding are not suitable, or because medicaments remove them from the intestine. The hæmorrhage is ascribed by Schlesinger and Weichselbaum directly to lesions of the mucous membrane caused by the larvæ; in the case reported by these writers there were found shreds of tissue as well as pus in the stool. The pains occurring spontaneously in the abdomen are at times influenced by position and attitude of the body, often they were more violent after rest and after evacuation of the bowels; often they were continuous, but in that case less intense; pressure on the abdomen is generally little felt. The condition of the blood was in two cases (Pasquale[1] and Schlesinger and Weichselbaum) a marked chlorotic one. The state of nutrition seems almost always to suffer with prolongation of the disease, but in Peiper's[2] cases this was not so. The condition of the appetite was in some instances good, in others very bad. A frequent symptom is headache of a migraine-like character and neuralgic pains in different parts.

Schlesinger and Weichselbaum's case shows that there are forms of myiasis intestinalis which, after prolonged sickness, lead to death, and that in consequence of the formation of intestinal abscesses stricture of the intestine may arise from the subsequent formation of a scar.

The question of the mode of infection is interesting; in this mouth, nose and anus must be considered. The most frequent way is certainly by means of food on which flies have laid their eggs, or which is permeated with young maggots. This may be raw (especially grated) meat, cheese, fruit, salad, milk, cabbage, cold farinaceous foods, raspberries. When the stomach is affected, when the gastric juice has lost acidity and power of digestion, the larvæ will be able to stay and develop more easily. According to Csokor,[3] if the eggs get into the gastro-intestinal canal of man with the food, the delicate stages of the young larvæ would certainly not survive the action of the gastric juice. Salzmann[4] assumed that the invasion occasionally occurred through the rectum, the larvæ creeping into the anus while the person is asleep. Wirsing accepts this method of infection for two of his cases, where it was a question of the infection of an infant. Salzmann[4] reports a case where the maggots of *Anthomyia*[5] *scalaris*

---

[1] Pasquale, *Centralbl. f. Bakt.*, 1891.

[2] Peiper, "Fliegenlarv. als gelegentl. Parasiten d. Menschen," Berlin, 1900.

[3] Csokor, *Wien. klin. Wochenschr.*, 1901, p. 129.

[4] Salzmann, *Württemberg. med. Korrespondenzbl.* 1883, liii.

[5] [This is presumably *Homalomyia* (*Fannia*) *scalaris*.—F. V. T.]

were passed in great numbers from the urethra of an old man. The patient had been catheterized on account of urethral stricture and was probably infected with eggs or larvæ at the same time.

The diagnosis of the affection is easy and sure, if living larvæ are found in the contents of the stomach or in the stools, and if contamination is out of the question.

The number of different species of flies whose larvæ are found in myiasis intestinalis is considerable. The larvæ of species of Anthomyia (*A. canicularis*,[1] *A. scalaris*, *etc.*), of *Sarcophaga carnaria* and *S. magnifica* and of *Musca vomitoria*[2] are especially observed.

The prognosis is certainly generally favourable, but must be made with some reserve in chronic cases, in view of the observations of Schlesinger and Weichselbaum (intestinal stenosis).

The treatment must aim at removing the larvæ as soon as possible from the digestive canal.

In cases of myiasis of the stomach, a thorough washing out of the stomach (Joseph,[3] Staniek[4]) is to be preferred to emetics used with success in individual instances; perhaps it would be advisable to add menthol or thymol to the mixture.

In myiasis of the intestine internal remedies and local treatment of the intestine must be considered.

So far santonin seems to have proved to be the best remedy. In some cases extract. filicis maris, calomel, semina cucurbitæ, naphthalene 0·1 to 0·5 (Peiper[5]), infus. of Persian insect powder (5 in 200), mineral waters, Carlsbad water, seem to have had good results.

For irrigation of the rectum, weak solutions of argentum nitricum, tannin, thymol, gelatine, ol. ricini, naphthalene may be used. Wirsing administered an aperient (Rurellà compound liquorice powder) and a soap enema after the passing of the first larvæ.

The principal thing is the prophylaxis, which must include the careful protection of articles of food, on which flies may lay their eggs (protection by glass dishes, tulle or fine wire nets). Fruit should not be eaten before being washed or rubbed with a cloth.

---

[1] [This fly, common in houses, is known as *Homalomyia canicularis*, and the next belongs to the same genus.—F. V. T.]

[2] [This fly belongs to the genus *Calliphora*, not *Musca*.—F. V. T.]

[3] Joseph, *Deutsch. med. Zeitg.*, 1885 and 1887.

[4] Staniek, *see* Schlesinger and Weichselbaum, p. 47.

[5] Peiper, "Fliegenlarv. als gelegentl. Parasiten d. Menschen," Berlin, 1900.

Gastricolous Oestridæ (Creeping Disease).

Syn. : *Creeping eruption; Larva migrans; Hautmaulwurf; Dermatomyiasis linearis migrans oestrosa; Hyponomoderma; Dermatitis linearis migrans; Linea migrans; Epidermiditis linearis migrans Wolossatik; Kriechkrankheit; Hautkratzschorf; Myiase hypodermique.*

Under the name "creeping disease," R. J. Lee[1] has recorded a peculiar affection of the skin in a three year old girl, which appeared first in the form of pale red, thread-like irregular protuberances, which seemed partly to become entwined on the right malleolus and had spread without causing special disturbances to the abdomen. Dickinson, Fox and Duckworth[2] reported, in connection with this, that they observed a growth of this red line of about 1 in. per diem. Since then a number of similar cases have been reported which, without doubt, were cases of larvæ creeping under the skin. Crocker[3] saw such a case in a two year old girl, the progress of the red line varying in one night between 4 and $7\frac{1}{2}$ in. In Europe the first case was observed in Vienna, by v. Neumann and Rille,[4] also in a two year old girl.

v. Samson-Himmelstjerna,[5] Sokoloff,[6] Rawnitzky[7] found larvæ at the end of the tract, which had been recorded as larvæ of Gastrophilus by Cholodowsky.[8] According to Blanchard (*Arch. f. Par.*, 1901) the larvæ were those of *Hypoderma bovis*.

How these larvæ get into the skin has not yet been definitely ascertained; v. Samson is of the opinion that they usually obtain access to man as larvæ, Stelwagon[9] believes that the infection generally occurs in a seaside watering place; a patient of Ehrmann's[10] fell ill when he returned from the manœuvres, where he had lain for some time on the ground. Here and there it is reported that the eruption was preceded for a longer or shorter time by lesions of the skin (incised wounds, furuncles, slight excoriations, v. Harlingen[11]).

Twice it has been suggested that perhaps the parasites might come from vineyard snails (Crocker, Lenglet and Delaunay[12]), and it is

---

1 R. J. Lee, *Journ. Clin. Soc. Lond.*, November 27, 1874.

2 Dickinson, Fox and Duckworth, *ibid.*, 1875.

3 Crocker, "Diseases of the Skin," 1893; "Atlas of the Diseases of the Skin."

4 v. Neumann and Rille, *Wien. klin. Wochenschr.*, 1895; *Dermatologenkongr.*, Graz, 1895.

5 v. Samson-Himmelstjerna, *Wratsch*, 1895; *Arch. f. Derm. u. Syph.*, 1897.

6 Sokolöff, *Wratsch*, 1896.

7 Rawnitzky, *Derm. Zeitschr.*, v, p. 704.

8 Cholodowsky, *Wratsch*, 1896.

9 Stelwagon, *Journ. Cut. Dis.*, xxii, 8.

10 Ehrmann, *Wien. derm. Ges.*, November 17, 1897.

11 v. Harlingen, *Amer. Journ. of Med. Sci.*, 1902.

12 Lenglet and Delaunay, *Annal. de Derm. et de Syph.*, 1904.

pointed out by v. Samson that in Russia the infection of peasants who work in the fields was specially frequent. It is noticeable how frequently the affection begins on uncovered parts of the body (face, hands, arms); but that fact, on the whole, is not in conflict with the statement (Kengsep[1]) that the disease makes its first appearance over the nates, because children often sit on the ground and play with that part of their body uncovered. A case observed by us was that of an elderly lady who did not do this and was properly clothed, yet showed the typical lines of creeping disease on the nates, and asserted again and again that she had the feeling as if a worm were creeping under her skin.

The disease occurs in children as well as adults, so that age, sex and calling offer no determining point etiologically.

The clinical symptoms of the disease consist in the sudden appearance of itching and burning; if the cause is looked for one perceives a red line, raised but little above the surface of the skin, with irregular curves, never branched, but often entwined, broadening more or less rapidly at one end (1 to 15 cm. in twenty-four hours). The larva can be seen sometimes with a lens under pressure of the skin as a dark spot; formations of pus, such as other larvæ produce, are not noticed; now and again there is a formation of little vesicles (Hamburger,[2] v. Harlingen,[3] Bruno,[4] Ehrmann,[5] Brodier and Fouquet,[6] Rawnitzky[7]). It may happen that the parasite burrows through a small region of the skin with many close curves for some time; on the other hand, observations exist where it covered large tracts in a short time. The itching and smarting cease in the place left by the larva, so that the patients even in the shortest tract can point out at which end the larva is, even if they have not watched the lengthening of the tract. Very rarely the larva invades the mucous membrane of the mouth, the nose, and the conjunctiva, proceeding from thence to the external cutaneous area.

The localization of the affection is very varied; the primary seat has been observed on the glutei muscles (Lee, Kengsep, Morris,[8] Rille, Seifert) and their surroundings (Stelwagon, Hamburger, Bruno), on the lower extremities (Stelwagon, Lenglet and Delaunay, Hutchins, Moorhead, Lee, Crocker, Schmid,[9] v. Harlingen), on the

---

[1] Kengsep, *Derm. Centralbl.*, 1906, vii.
[2] Hamburger, *Journ. of Cut. Dis.*, 1904.
[3] v. Harlingen, *loc. cit.*
[4] Bruno, v. Rille and Riecke, "Handb. d. Hautkrankh. v. Mraček."
[5] Ehrmann, *loc. cit.*
[6] Brodier and Fouquet, *Bull. de la Soc. franç. d. Derm.*, 1904.
[7] Rawnitzky, *loc. cit.*
[8] Morris, *Brit. Journ. Derm.*, 1896.
[9] Schmid, *Verein der Aerzte in Steiermark*, February 12, 1900.

upper extremities (Samson, Meade and Freeman, Hutchins, Sokoloff, v. Harlingen, Brodier and Fouquet, Shelmire,[1] Stelwagon), on the face (Sokoloff, Moorhead, Kumberg,[2] Rawnitzky, Crocker, Boas[3]), on the neck (Sokoloff), and on the body (Ehrmann, Brodier and Fouquet, Kaposi,[4] Topsent[5]).

The duration of the affection varies very much; it varies between a few hours and some years[6]; several times a spontaneous recovery has been reported.

The diagnosis of the disease is not at all difficult owing to its peculiar appearance.

The treatment can only consist in the removal or killing of the larvæ, since one cannot rely on spontaneous recovery, even if it has occurred in some cases. If one should succeed in locating the larva as a black spot at the end of the tract, its removal by means of a needle is the simplest method (Quortrup and Boas[7]). In some instances a cure has been successfully accomplished by excision of the active end of the tract (v. Neumann and Rille, Schmid). In opposition to this method, which not all patients will allow, the method practised by Arab women (Rille and Riecke[8]) of killing the worm with red hot needles is quite rational. Shelmire[9] used the electrolytic needle for the destruction of the maggots, Stelwagon[10] made use of cataphoresis, by means of which he applied a sublimate solution, afterwards cauterizing with a drop of nitric acid, as excision was refused. Crocker[11] and v. Harlingen[12] injected small quantities of carbolic acid; Moorhead[13] by a single freezing of the skin with ethyl chloride, attained a definite cessation of the attack at the active end. Hutchins[14] in one case made use of hypodermic injection of a few drops of solution of cocaine and afterwards of 1 to 2 drops of chloroform; in a second case of repeated applications of tincture of iodide, as Lenglet and Delaunay[15] did.

---

[1] Shelmire, *Journ. Cut. Dis.*, 1905.

[2] Kumberg, *St. Petersb. med. Wochenschr.*, 1898.

[3] Boas, *Monatsh. f. prakt. Derm.*, 1907, xliv.

[4] Kaposi, *Wien. klin. Wochenschr.*, 1898.

[5] Topsent, *Arch. de Par.*, 1901.

[6] [This is extremely unlikely, as the bots of Hypoderma only live for nine or ten months at the most!—F. V. T.]

[7] Quortrup and Boas, *Hospitalstid.*, 1907.

[8] Rille and Riecke, "Handb. d. Hautkrankh.," v. Mraček, 1907, iv.

[9] Shelmire, *loc. cit.*

[10] Stelwagon, *loc. cit.*

[11] Crocker, *loc. cit.*

[12] v. Harlingen, *loc. cit.*

[13] Moorhead, *Texas Med. News*, 1906.

[14] Hutchins, *Journ. Cut. Dis.*, 1906.

[15] Lenglet and Delaunay, *loc. cit.*

v. Harlingen[1] allayed the affection in his first case by rubbing in sapo viridis and tar, in Kensep's[2] case the cure seems to have been accomplished by an ointment containing resorcin, in Meade and Freeman's[3] case by a 20 per cent. ichthyol paste. In our case we made exclusive use of Lassar's paste; within four weeks a cure resulted, probably spontaneously, since one cannot ascribe any essential effect to this paste.

---

[1] v. Harlingen, *loc. cit.* [2] Kensep, *loc. cit.*
[3] Meade and Freeman, *Brit. Journ. Derm.*, October, 1906.

APPENDIX ON PROTOZOOLOGY,

Comprising Notes on Recent Researches, Formulæ of some Culture Media, and Brief Notes on General Protozoological Technique.

BY

H. B. FANTHAM, M.A., D.Sc.

I.—NOTES ON RECENT RESEARCHES.

Since the foregoing section on Protozoology was sent to press, certain interesting observations and results have been published. Brief notes on such, and some references thereto, are now added.

It is necessary, however, to remark that sometimes it is impossible to give a precise or rigid definition to a genus of Protozoa, owing to differences of opinion, to differences regarding nomenclature or to incompleteness of knowledge. Such a lack of definition, while inconvenient for the time being, is not unhopeful, as it directs attention to the necessity for further work, which is inevitable in such a relatively new and wide subject as protozoology. Thus, it may be noted in illustration that Minchin, in 1912, in his text-book regarding the genus *Entamœba* writes : " The entozoic amœbæ are commonly placed in a distinct genus, *Entamœba*, distinguished from the free-living forms by little, however, except their habitat and the general (but not invariable) absence of a contractile vacuole."

Differences between Entamœba histolytica and E. coli.—In continuation of the remarks on pp. 34 and 40, it may be added that Lugol's solution (iodine in aqueous potassium iodide solution) in fresh specimens shows by brownish staining the presence of glycogen in the vacuoles of *Entamœba coli*. Such a reaction is rarely or never given by *E. histolytica*.

Phagedænic Amœbæ.—Carini and others record cases in which the skin around an operation wound in connection with liver abscess became gangrenous. Amœbæ, possibly *Entamœba histolytica*, were found therein and may have been responsible for the gangreno-phagedænic action.

Endamœba gingivalis (*see* pp. 43, 44).—Smith and Barrett,[1] after

---

[1] *Journ. of Parasitol.*, i, p. 159.

analysing the early literature, state (June, 1915) that *Endamœba gingivalis*, Gros, 1849, is the correct name for the following organisms: *E. buccalis*, Prowazek, 1904 (see p. 43); *Amœba gingivalis*, Gros, 1849; *Amœba buccalis*, Steinberg, 1862, and *Amœba dentalis*, Grassi, 1879. They conclude that *E. gingivalis* is the causal agent of pyorrhœa alveolaris, and that this disease responds to treatment with emetine.

Entamœba kartulisi (see p. 44), synonym *E. maxillaris*, Kartulis, is considered to be *E. gingivalis*.

Smith and Barrett adopt the generic name *Endamœba*, Leidy, 1879 (*see* footnote on p. 31, also p. 34). Leidy worked on *Endamœba blattæ*.

Craigia and Craigiasis (*see* p. 45).—Barlow[1] (May, 1915) found *Craigia* (*Paramœba*) *hominis* in cases of chronic diarrhœa and mild dysentery in Honduras. He also described a new species of *Craigia* under the name of *C. migrans*. Fifty-six cases were studied, five of which were due to *Craigia hominis*, the remainder to *C. migrans*. In *C. migrans*, each flagellate, on attaining full development, becomes an amœba without dividing. Each amœba encysts and produces a number of flagellates which are somewhat like cercomonads. On the other hand, in *C. hominis* the flagellate form produces, by longitudinal fission, several generations of flagellates before entering upon the amœbic stage. The cysts of *C. migrans* contain fewer "swarmers" (flagellulæ) than those of *C. hominis*, but the "swarmers" are somewhat larger, namely, 5 μ instead of 3 μ in diameter. Further, there is no accessory nuclear body in *C. migrans*, but its flagellum stains more deeply than that of *C. hominis* and has a peculiar banded appearance.

Human Trichomoniasis (*see* pp. 52-56).—Lynch[2] (April and May, 1915), working in Charleston, seems to favour the view that the trichomonads found in the vagina, urethra, mouth, lungs and alimentary tract are one and the same organism, and that these flagellates may further excite already existing inflammatory conditions. He gives detailed histories of cases of (*a*) infection of the vagina and gums, and (*b*) intestinal infection manifested as intermittent attacks of diarrhœa. The flagellates were found in catarrhal vaginal discharge, in blood-stained scrapings from the gums (together with *Endamœba buccalis*), and in stools after a purge of magnesium sulphate. The parasites were tetratrichomonads (*see* footnote, p. 53), that is, each possessed four flagella anteriorly as well as an undulating membrane. Lynch successfully infected rabbits from the cases and from cultures of the parasite. Encysted trichomonads were seen in a

---

[1] *Amer. Journ. Trop. Dis. and Prevent. Med.*, ii, p. 680.

[2] *Ibid.*, p. 627; *New York Med. Journ.*, May 1, 1915, ci, p. 886.

patient's stools, in rabbits infected therefrom and in cultures. The culture medium used was bouillon acidified with about 0·05 per cent. acetic acid and the cultures were maintained at 30° C.

Trichomonads occur in the digestive tracts, for example, the cæca of rats and mice (fig. 422). In man allied flagellates can occur in similar situations, as well as in other parts of the intestine.

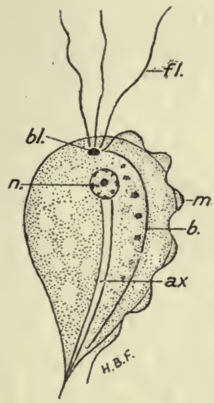


FIG. 422.—*Trichomonas* from cæcum and gut of rat: *n*, nucleus; *bl*, blepharoplast; *fl*, flagella; *ax*, axostyle; *m*, undulating membrane; *b*, line of attachment of undulating membrane to the body. × 2,000 approx. (Original.)

Other trichomonad-like organisms have been recently described from the fæces of man, more particularly from cases of chronic dysentery in the tropics. Derrieu and Raynaud[1] (July, 1914), working in Algeria, found a flagellate possessing five free flagella anteriorly and an undulating membrane apparently lateral. They named the parasite *Hexamastix ardin-delteili*, but the generic name *Hexamastix* is pre-occupied. Chatterjee[2] (January, 1915), working in India, found probably the same flagellate and called it *Pentatrichomonas bengalensis*.

Chilomastix (Tetramitus) mesnili (*see* p. 57).—Alexeieff[3] (1914) now places the parasite originally called *Macrostoma mesnili*, by Wenyon (1910), in the genus *Chilomastix*, Alexeieff. The differential characters of the genera *Tetramitus* and *Chilomastix* are not especially well marked. According to Alexeieff, *Tetramitus* is characterized by four unequal flagella (which he figures anteriorly), a ventral cytostome in the form of a linear cleft and a pulsatile vacuole in front of the anterior nucleus. *Chilomastix*, according to the same author, has

---

[1] *Bull. Soc. Path. Exot.*, vii, p. 571.
[2] *Ind. Med. Gaz.*, l, p. 5.
[3] *Zool. Anzeiger*, xliv, pp. 203, 206; and *ibid.*, xxxix, p. 678.

three forwardly directed flagella and a fourth backwardly directed one in the cytostome, which is well developed (fig. 423). Some authors consider that the fourth flagellum forms the edge of an undulating membrane in the cytostome.

Diagrams of *Chilomastix mesnili* are given in fig. 423.

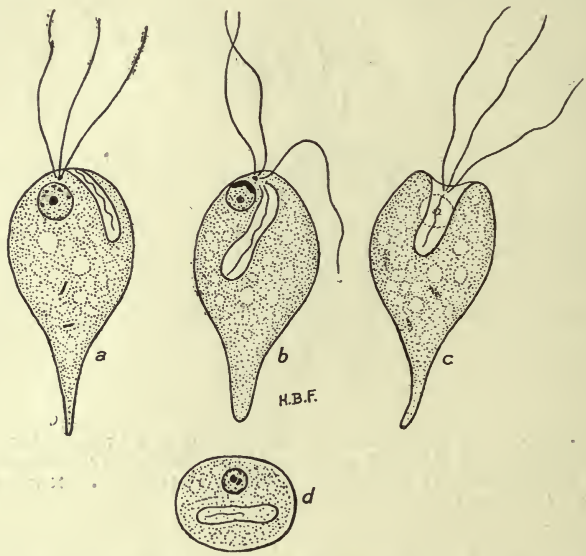


FIG. 423.— *Chilomastix* (*Tetramitus*) *mesnili*. *a, b, c*, flagellate forms; *d*, rounded or encysted form. × 2,500. (Original.)

Giardia (Lamblia) intestinalis (*see* p. 57).—Alexeieff[1] (1914) considers that *Lamblia intestinalis*, Lambl, should be placed in the genus *Giardia*, Kunstler, 1882. Bipartition occurs in the encysted state. The axostyles persist in the quadrinucleate cyst.

Cercomonas hominis (*see* p. 61).—This parasite is considered by some authors to be of a doubtful nature, as it is thought to have been mistaken for deformed or incompletely observed *Trichomonas* or *Chilomastix* or even *Lamblia*.

Wenyon[2] (1910) described *Cercomonas longicauda* from cultures of human fæces. It is considered that the genus is very confused, and the author points out that the tail flagellum has been overlooked. He considers that the genus *Cercomonas* should include flagellates with an anterior blunt end from which arises a single long flagellum, and a posterior tapering end also with a flagellum, which can be traced

---

[1] *Zool. Anzeiger*, xliv, p. 210.

[2] *Quart. Journ. Micros. Sci.*, lv, p. 241.

over the surface of the body towards the insertion of the anterior flagellum.

Another species, *Cercomonas parva*, has been found in cultures of human fæces by Hartmann and Chagas[1] (1910). It has a somewhat different structure.

Furthur researches are necessary on the organisms variously referred to the genus *Cercomonas*.

Transmissive Phase of Trypanosomes in Vertebrates.—In addition to the general remarks on the morphology of trypanosomes set forth on pp. 70 to 72, it may be noted that Woodcock[2] (November, 1914) states that, in certain cases, there is a definite transmissive phase of a trypanosome in its vertebrate host. He quotes the work of Minchin and himself on *T. noctuæ* of the little owl, in which the transmissive form is spindle-shaped and occurs in the bird's peripheral blood during the early summer months (*see* p. 69). A similar phase occurs in *T. fringillarum*, and Robertson[3] has found that the short, stumpy form of *T. gambiense* is its transmissive phase in vertebrates.

Trypanosoma lewisi (*see* p. 88).—Brown (1914-15) has published some interesting results on the potential pathogenicity of *T. lewisi*.

Blepharoplastless Trypanosomes (*see* p. 101).—Laveran[4] (April, 1915) suggested a practical use of strains of blepharoplastless trypanosomes produced by the action of drugs. He finds that tryposafrol will also produce such strains, and remarks on blepharoplastless strains of *T. evansi* and *T. brucei*, which in the former case can undergo 450 passages without reversion, and in the latter 273 passages. He states that if it is desired to inoculate surra or nagana to Capridæ or Bovidæ in order to produce immunity, use should be made of the blepharoplastless races of the respective trypanosomes, which races are a little less virulent than the corresponding normal ones. Also, the immunity which follows from an infection due to blepharoplastless *T. evansi* or *T. brucei* is only a little less complete than that following infections from either of the respective normal strains.

The Experimental Introduction of certain Insect Flagellates into various Vertebrates, and its bearing on the Evolution of Leishmaniasis.—In continuation of the remarks on pp. 103, 104, and 112, further researches have been conducted on the introduction into vertebrates of flagellates normally parasitic in insects. The vertebrates became infected by inoculation with the flagellates or by

---

[1] *Mem. Inst. Oswaldo Cruz*, ii, p. 67.
[2] *Arch. f. Protistenk.*, xxxv, p. 197.
[3] *Proc. Roy. Soc.*, B, lxxxv, p. 527.
[4] *C. R. Acad. Sci.*, clx, p. 543.

being fed on insects containing the protozoa. Fantham and Porter[1] (June, 1915) published the following results. Flagellates from sanguivorous and non-sanguivorous insects were used, and cold-blooded as well as warm-blooded vertebrates as hosts. The introduced protozoa were pathogenic to the mammals, but not markedly so to the cold-blooded vertebrates. *Herpetomonas jaculum*, *H. stratiomyiæ*, *H. pediculi*, and *Crithidia gerridis* (parasitic in certain water-bugs) proved pathogenic to mice. A puppy was infected by way of the digestive tract with *H. ctenocephali*. Frogs became infected with *H. jaculum* and with *C. gerridis*, toads and grass snakes with *H. jaculum*, lizards with *C. gerridis*, and sticklebacks with *H. jaculum*. Second and third passages of some of the parasites were obtained. The protozoa, whether *Herpetomonas* or *Crithidia*, were present in the vertebrate hosts in either the non-flagellate or the flagellate form, or usually both. They were more abundant in the internal organs of the hosts, more particularly in the liver, spleen and bone-marrow. In all experiments in which *C. gerridis* was used the parasite invariably retained the crithidial facies in the vertebrate host. No transition to a trypanosome was ever seen. Infections in adult animals were not so heavy as in the young ones, and the parasites were more virulent in young hosts, as is the case with Mediterranean kala-azar in children.

The mode of infection of the vertebrate in Nature seems to be contaminative, either by its food or through an already existing abrasion or puncture on the surface of its body. Cases in which the flagellate-infected insects have been allowed to suck the blood of vertebrates have proved negative up to the present. In areas where leishmaniases are endemic, an examination should be made of all insects and other invertebrates likely to come into contact with men or dogs, or rats and mice (see below), in order to ascertain if these invertebrates harbour herpetomonads. Preventive measures should be directed against such invertebrates, especially arthropods. Further, it is likely that certain vertebrates, such as reptiles and amphibia (especially those that are insectivorous), may serve as reservoirs of leishmaniases, or, as they should preferably be termed, herpetomoniases. From such reservoirs the herpetomonads may reach man by the agency of ectoparasites or flies, especially such as are sanguivorous.

That vertebrates in Nature can harbour herpetomonads in their blood has been shown by the work of Dutton and Todd (1903) on the herpetomonads of Gambian mice, while the recently published

[1] *Proc. Camb. Philosoph. Soc.*, xviii, p. 137; and *Annals Trop. Med. and Parasitol.*, ix, p. 335.

investigations of Fantham and Porter[1] (June, 1915) on natural herpetomonads in the blood of mice in England have shown that these rodents may be a natural reservoir of herpetomoniasis. The origin of the infection of mice is to be sought in a flagellate of an ectoparasite of the mouse, very probably *Herpetomonas pattoni* parasitic in various fleas, which protozoön can adapt itself to life in the blood of mice. Herpetomonads were also found naturally in the blood of birds by Sergent (1907). Recently, Fantham and Porter have successfully infected birds with herpetomonads experimentally.

The significance of insect flagellates in relation to the evolution of disease has recently been set forth by Fantham[2] (June, 1915). The deductions to be made from the occurrence of a herpetomonad stage in *Leishmania*, especially in *L. tropica*, in man himself, and of flagellate stages of the so-called *Histoplasma capsulatum* in man are fully discussed and correlated. It is pointed out that flagellosis of plants (see p. 104) may possibly be connected with leishmaniasis. The evolution of *Leishmania* from flagellates of invertebrates is thus traced and the way again indicated for preventive measures against leishmaniasis, as first set forth by Dodds Price and Rogers.

Franchini and Mantovani (March, 1915) have successfully infected rats and mice by inoculation or by feeding with *Herpetomonas muscæ domesticæ* obtained from flies and from cultures.

It is of great interest to note that the recent observations of Ed. and Et. Sergent, Lemaire and Senevet[3] (1914) have demonstrated the presence of a herpetomonad flagellate in cultures of the blood and organs of geckos obtained from areas in Algeria in which Oriental sore, due to *L. tropica*, is prevalent. *Phlebotomus* flies, which may harbour a natural herpetomonad, feed on the geckos and on men. Hence animals like geckos may possibly act as reservoirs of leishmaniasis. Lindsay[4] (1914) writes that the parasite of dermomucosal leishmaniasis in Paraguay is believed by native sufferers to be conserved in rattlesnakes, and spread by ticks or flies (*Simulium*) feeding on the reptiles and transferring the parasite to man.

The Transmission of Spirochæta duttoni (*see* p. 116).—It is probable that *Ornithodorus savignyi* acts as the transmitting agent of *S. duttoni* in places like Somaliland (Drake-Brockman, 1915).[5]

Spirochæta bronchialis (*see* p. 122).—The morphology and life-history of *S. bronchialis* have been investigated by Fantham[6] (July, 1915). From researches conducted in the Anglo-Egyptian Sudan, he

---

[1] *Parasitology*, viii, p, 128.
[2] *Annals Trop. Med. and Parasitol.*, ix, p. 335.
[3] *Bull. Soc. Path. Exot.*, vii, p. 577.
[4] *Trans. Soc. Trop. Med. and Hyg.*, vii, p. 259.
[5] *Ibid.*, viii, p. 201.
[6] *Annals Trop. Med. and Parasitol.*, ix, p. 391.

found that *S. bronchialis* is an organism presenting marked polymorphism, a feature that has only been determined by the examination of numerous preparations from the deeper bronchial regions of various patients.

S. bronchialis varies in length from $5\,\mu$ to $27\,\mu$, and its breadth is about $0{\cdot}2\,\mu$ to $0{\cdot}6\,\mu$. These variations are due to the processes of growth and division. Many of the parasites measure either $14\,\mu$ to $16\,\mu$ long, or $7\,\mu$ to $9\,\mu$, the latter resulting from transverse division of the former. The ends show much variation in form, but approach the acuminate type on the whole. The discrepancies in dimensions given by the very few previous workers on the subject are probably the result of the measurement of a limited number of parasites. All such sizes can be found on some occasion during the progress of the disease, when a larger number of spirochætes is examined.

The movements of *S. bronchialis* are active, but of relatively short duration, when it is removed from the body. The number of coils of the spirochæte is rather an index of its rapidity of motion than a fixed characteristic of the species.

The motile phase of *S. bronchialis* is succeeded by one of granule formation, the granules or coccoid bodies serving as a resting stage from which new spirochætes are produced. The formation of coccoid bodies and reproduction of spirochætes from them can be observed in life.

S. bronchialis is a species distinct from the spirochætes occurring in the mouth. It differs from them in morphology, pathogenicity and in staining reactions. It is not a developmental form of any bacterium, and is an entity in itself.

The passage from man to man is effected most probably by means of spirochætes, and especially coccoid bodies, that leave the body in the spray with expired air and by way of the nasal secretions. Owing to the fragility and short life of *S. bronchialis* extracorporeally, the resistant coccoid bodies in air, in dried sputum and dust, and possibly also on the bodies of flies and other insects, are probably instrumental in inducing attacks of bronchial spirochætosis in human beings, especially those having a lowered bodily resistance, such as occurs after a chill. Lurie (December, 1915), has described a case from Serbia.

The Spirochætes of the Human Mouth (*see* p. 122).—Two species of spirochætes were recorded as occurring in the human mouth about forty or fifty years ago. These are *Spirochæta buccalis*, Steinberg (often ascribed to Cohn, 1875), and *S. dentium*, Miller (often attributed to Koch, 1877).

The most recent work on *S. dentium* and *S. buccalis* is that of Fantham[1] (July, 1915), who observed the parasites ascribed to Cohn

---

[1] *Annals Trop. Med. and Parasitol.*, ix, p. 402.

and to Koch, these being the two common spirochætes seen in the mouths of natives of the Sudan and of Europeans in England, as well as the forms described and cultivated by recent investigators. Some of the mouth spirochætes are not very active, but there is marked corkscrew and boring movement, and they are flexible. Tangles or tomenta of these mouth spirochætes are common. Internal structure is seen with some difficulty, but in some specimens it can be determined, and chromatin granules are then seen. Mühlens (1907) figured stained specimens of *S. buccalis* and *S. dentium*, in which chromatin-coloured granules were distributed along the bodies of the organisms.

S. dentium has tapering ends, and varies in length from 4 μ to 10 μ. *S. dentium* is rather like *Treponema pallidum*, and has been placed by some workers—for example, Dobell—in the genus *Treponema*. It has already been mentioned, on p. 128, that Noguchi cultivated three species of *Treponema* from the human mouth—namely, *T. macrodentium*, *T. microdentium*, and *T. mucosum*, but they cannot be easily distinguished morphologically, and so may appear to be biological varieties of *S. dentium*.

S. buccalis has somewhat rounded or bluntly acuminate ends and varies in length from 9 μ to 22 μ. A slight membrane or crest may sometimes be observed. *S. buccalis* was found to be the predominant spirochæte in the mouths of eight natives examined by Fantham in the Anglo-Egyptian Sudan.

S. buccalis and *S. dentium* take up stains well and with relative ease. Intracellular stages of the parasites are uncommon. Multiplication by binary fission has also been observed. Coccoid bodies or granule stages of the mouth spirochætes are formed, but appear to be relatively few in number.

J. G. and D. Thomson[1] (1914) have written an interesting paper on various spirochætes occurring in the alimentary tract of man and of some of the lower animals. They have also given a useful list of references, and the work of some of the earlier authors is discussed in the paper.

With regard to the general morphology of spirochætes, it may be noted that the so-called axial fibre of Zuelzer is acknowledged to be homologous with the membrane or crista of molluscan spirochætes.

Coccidia in Cattle.—Regarding the remarks on coccidiosis or "red dysentery" in cattle on p. 147, it may be added that Schultz[2] (July, 1915) has found the malady among cattle in the Philippine Islands. He states that some irregular or atypical cases of apparent rinderpest are really due to coccidia. As has been pointed out by

[1] *Proc. Roy. Soc. Med.*, vii, pt. 1, p. 47. [2] *Journ. Infect. Dis.*, xvii, p. 95.

Montgomery, rinderpest can be transmitted by blood inoculation, while coccidiosis cannot be so transmitted, but may be diagnosed by the microscope. These differences should be remembered as the two diseases are often found to be associated and are difficult to separate clinically. Coccidia have also been found in Australian cattle.

The Hæmosporidia.—It is likely that this order (*see* p. 151) may be soon abolished. Mesnil[1] (April, 1915) considers that the grouping of the three families, Plasmodiidæ (or Hæmamœbidæ), Hæmogregarinidæ and Piroplasmidæ in the order Hæmosporidia is no longer possible, because of the coccidian nature of the Hæmogregarines (*see* p. 154). The Coccidia are divisible into the Adeleidea and the Eimeridea (*see* p. 141). The Hæmogregarinidæ are allied to the former, and the Plasmodiidæ to the latter. The Piroplasmidæ, until more is known of their life-cycle in the invertebrate host, cannot be more definitely placed.

The Leucocytozoa of Birds.—Regarding the statement, on p. 153, that Laveran and França consider that avian leucocytozoa may inhabit red blood cells, it may be added that França[2] (April, 1915) remarks that the action of the parasites on the red cells is very rapid and very intense. The host cells become so altered that it is difficult to recognize their true nature. He used very young birds in his researches. Two shapes of host cell are considered, namely, those with fusiform prolongations, and those which are rounded and without such prolongations (*see* p. 153). The movements and form of the Leucocytozoa determine the shape of the host cell, as was pointed out by Fantham[3] in 1910.

Schizogony of these parasites has been seen by França (1915) and by Coles (1914), in addition to Fantham (1910), and to Moldovan (1913), mentioned on p. 153. Schizogony may also take place in the lungs of the host. The genus *Leucocytozoön*, established by Ziemann in 1898, belongs to the family Hæmamœbidæ.

II.—FORMULÆ OF SOME CULTURE MEDIA.

(1) **Culture Media for growing Amœbæ.**—There has been much discussion as to whether the true parasitic *Entamœbæ* or *Endamœbæ* can be grown on culture media (*see* p. 42). Undoubtedly certain free-living amœbæ can be so grown, and it is considered that some of the earlier researches on the so-called artificial growth of the dysenteric amœbæ were really due to contaminations with free-living forms. The following media are worthy of note :—

---

[1] *Bull. Soc. Path. Exot.*, viii, p. 241.
[2] *Ibid.*, p. 229.
[3] *Proc. Zool. Soc. Lond.*, 1910, p. 694

Musgrave and Clegg in 1904 devised a culture medium for amœbæ. The organisms grown by them were probably not dysenteric amœbæ, as was thought, but free-living forms. Phillips[1] (1915) gives a slightly modified formula of Musgrave and Clegg's medium, thus:—

Agar-agar	2·5 grm.
Sodium chloride	0·05 ,,
Liebig's beef extract	0·05 ,,
Normal sodium hydroxide	2·0 c.c.
Distilled water	100·0 ,,

Without clarifying, sterilize at 7 kilograms pressure per square centimetre for about three-quarters of an hour. It should be neutral to phenolphthalein.

Anna W. Williams[2] (1911) described a medium consisting of fresh tissue spread on agar plates for the culture of amœbæ. There are three stages in the procedure: (1) obtaining living amœbæ free from other living organisms; (2) obtaining sterile tissue; and (3) making successive transplants of amœbæ and tissue, and showing that every transplant is free from other living organisms. Each step requires many controls. The essentials of the method may now be given. Remove aseptically and rapidly the tissue required, such as brain, liver, kidney, or spleen, from a freshly killed animal (guinea-pig, rabbit, or dog). Put each tissue on a separate agar plate. Cut the selected tissue into tiny pieces, and spread them over freshly made agar plates. Place these plates in a thermostat at 36° C. for twenty-four hours to insure sterility. Add the broken up tissue to the amœbæ, free from bacteria, and maintain the cultures in thermostats, some at 36° C., and some at 20° C. to 24° C. Emulsions of liver and brain in sterile neutral glycerine may also be used. The freshly removed tissue serves as food for the amœbæ.

The cultural amœbæ mentioned on p. 42 were grown on such media or modifications thereof. One modified medium actually used was brain tissue, to which blood was added from day to day, and an easily assimilable bacterium (one of the influenza group of bacilli) was present, which did not overgrow the medium at a temperature of 38° C. Different conditions of food and of temperature produced morphological variations in the cultural amœbæ.

Couret and J. Walker[3] (1913) state that they have cultivated five varieties of intestinal amœbæ, the associated bacteria having been previously separated. They used a medium consisting of agar to

---

[1] "Amœbiasis and the Dysenteries," p. 8.

[2] *Journ. Med. Research*, xxv, p. 263; and *Proc. Soc. Exper. Biol. and Med.*, viii, p. 56.

[3] *Journ. Exper. Med.*, xviii, p. 252.

which sterile autolysed tissue had been added. The sterile tissue, such as brain or liver, was kept in a sterile thermostat at a temperature of 40° C. for ten to twenty days. The surface of the agar should be broken up before use, and the medium must not be too acid (not over 1·5 per cent.). They consider that autolysed tissue is necessary for the growth of Entamœbæ, and that naturally associated bacteria aid growth by autolysing the tissues.

(2) **Culture Media for the growth of Protozoa parasitic in the Blood.**—MacNeal and Novy,[1] in 1903, used a mixture of blood and agar for the cultivation of trypanosomes such as *T. lewisi* and *T. brucei.* They employed varying proportions of the blood and agar, a medium consisting of two parts of defibrinated rabbit's blood mixed with one part of agar being useful. The trypanosomes grew in the water of condensation. Some of the authors' earlier formulæ contained different proportions of blood and agar with a little peptone, while one of these media contained meat extract, agar, peptone, salt and sodium carbonate. The temperature, like the proportion of blood and agar, varied with the trypanosome investigated, but the optimum was 25° C.

Mathis[2] (1906) somewhat simplified the technique of Novy and MacNeal. He collected the blood of a suitable animal, such as rabbit, cow or dog, strict asepsis not being essential. The blood was defibrinated in the ordinary way. One part of blood was added to two parts of agar at 50° C. The mixture was sterilized several times by heating to 75° C. or 100° C. Slopes were made and the water of condensation was inoculated with a little blood containing the trypanosomes. Blood may be obtained from a superficial vein or from the heart.

Novy-MacNeal-Nicolle or N. N. N. Medium.—In 1908 C. Nicolle[3] brought forward a modification of the Novy-MacNeal (N.N.) medium. The formula is as follows:—

Agar	14 grm.
Sea salt	6 ,,
Water	900 ,,

Apparently pure sodium chloride can be substituted equally well for sea salt. The mixture is placed in tubes and sterilized in an autoclave. To each tube one-third of its volume of rabbit blood, taken by aseptic puncture of the heart, is added. The salt agar is kept liquid at 45° C. to 50° C. and the blood is added to the mixture. The culture medium so prepared is maintained for five days at 37° C., and then for a few days at room temperature.

[1] *See Sleeping Sickness Bulletin* (1909), i, No. 8, p. 287.

[2] *C. R. Soc. Biol.*, lxi, p. 550.

[3] *C. R. Acad. Sci.*, cxlvi, p. 842.

This medium was devised for the cultivation of *Leishmania* (*see* p. 106), but trypanosomes may also be grown thereon. Subsequently, Nicolle recommended the use of citrated rat's blood heated to 45° C. for half an hour, instead of defibrinated rabbit's blood. On such a medium, J. G. Thomson and Sinton[1] (1912) succeeded in growing *Trypanosoma gambiense* and *T. rhodesiense* (*see* pp. 76, 83).

Noguchi's media for the cultivation of Spirochætes and Treponemata are described on pp. 123, 125. Hata's modification is discussed on p. 126.

Bass's glucose-blood medium for the cultivation of malarial parasites is described on pp. 170-172. It has also been used successfully for the cultivation of *Piroplasma* or *Babesia* (*see* p. 172).

III.—BRIEF NOTES ON GENERAL PROTOZOOLOGICAL TECHNIQUE.

The object of this book is to give accounts of the structure and life-histories of the numerous parasitic organisms that affect man more particularly. It is, therefore, inappropriate to devote much space to a consideration of technique, regarding which many volumes have already been written. Methods of procedure are largely matters of opinion, and the technique that gives brilliant results when used by one investigator may be a complete failure in the hands of another. In the present appendix, brief notes regarding certain relatively simple methods only can be given, because the number of fixatives in use is very great; there are also large numbers of stains as well as many modifications of them, while the methods of applying both fixatives and stains are, perhaps, still more numerous. There are so many, in fact, that confusion frequently arises from the multiplicity of choice presented to the worker. Those desiring more information on the subject of technique are advised to consult the treatises of Bolles Lee[2] and of Langeron.[3]

Fresh Material.

(*a*) *Simple Examination.*

Fluid Substances, such as Blood and Sputum.—A small quantity of the substance to be examined is taken on a sterile platinum loop and transferred to a perfectly clean glass slide. A clean cover-slip is gently lowered on to the drop, air bubbles being avoided. The preparation

[1] *Annals Trop. Med. and Parasitol.*, vi, p. 331.

[2] "The Microtomist's Vade Mecum" (7th edition, 1913). London: J. and A. Churchill.

[3] "Précis de Microscopie" (1913). Paris: Masson et Cie.

is luted with vaseline or paraffin and examined first with a low power and then with a high power objective. The light is cut down by partly closing the diaphragm of the substage of the microscope.

Skin Ulcers and Similar Sores.—Scrapings are made from the edge of the sore, mixed with sterile physiological salt solution, and prepared and examined as above.

Fæces.—A small portion of fæces, or flakes of mucus (which may be blood-stained) from the same, is removed on a sterile platinum loop, spread out thinly after dilution, if necessary, with physiological salt solution on a slide, covered and examined as before.

Alternatively, hanging drop preparations of blood, ulcerative tissue, or fæces, appropriately diluted if necessary with sodium citrate or physiological salt solution, may be made on a cover-slip, which is inverted over a slide with a well in it. The cover-slip is then luted and examined.

For the elucidation of the developmental processes of such organisms as trypanosomes, spirochætes and piroplasms, fresh preparations may be often kept under observation longer by the use of a thermostat, maintained at or near blood heat, in which the microscope is inserted.

(*b*) *Intra vitam Staining of fresh Preparations.*

Intra vitam staining is of service on some occasions, more particularly for the study of the nucleus and other chromatoid substances of the living organism. Two methods are in common use. In the first case, the stain, employed usually in very dilute solution, is mixed with the medium containing the organism. The latter takes up some of the stain, the amount of coloration depending on the organism concerned and on the stain employed.

The commoner *intra vitam* stains are pure, medicinal (zinc-free) methylene blue and neutral red, used in aqueous solutions. A solution of methylene blue of 1 per 1,000 of water may be tried, while neutral red in the proportion of 1 per 3,000 parts of water has proved of service.

The second method of vital colouring consists in placing a drop of 1 per cent. solution of methylene blue on a slide or cover-slip, slightly spreading it, and allowing it to dry. The living organism is then placed in a drop of saline on the prepared slide or cover-slip, which is then mounted and examined under the microscope. Progressive staining of the organism occurs and its internal structure can be seen. A similar procedure may be followed for neutral red. *Intra vitam* staining is useful for relatively large and easily deformed protozoa such as ciliates, as well as for amœbæ and flagellata of the gut.

When examining very actively motile organisms, it is sometimes useful to endeavour to restrict their movements by adding a little gum or gelatine to the medium.

(c) *Examination by aid of the Paraboloid Condenser.*

The use of one of the dark-ground illuminators (so-called ultra-microscopes) is of service for the detection of minute living organisms or of organisms present in small numbers only. The forms of paraboloid condenser manufactured by the firms of Zeiss and Leitz can be recommended. For details of their methods of employment, reference should be made to the leaflets of the firms supplying the said instruments. By the use of the paraboloid condenser, the finer details of certain stages of life-cycles, such as the formation of granules in spirochætes and treponemata, can be observed more readily than by using the ordinary substage of the microscope. The use of the paraboloid condenser for the detection of small numbers of living organisms renders it of value for rapid diagnostic purposes.

Stained Material.

Fuller accounts of the technique of fixed and stained material will be found in Bolles Lee and in Langeron, already mentioned.

Thin Films.—For the examination of blood-inhabiting Protozoa, it is necessary to make first thin films or smears of blood. There are many ways of doing this, and opinions differ as to their respective merits. A simple method is to take a straight surgical needle about 2 in. long, the eye of which has been removed, and a clean glass slide. The patient's skin is pricked, and when the bead of blood reaches the size of a small pin's head, the slide is applied to the surface of the blood, about $\frac{1}{3}$ in. from the far (left-hand) end of the slide. The shaft of the needle is laid across the drop of blood, which spreads between the slide and the needle. The latter is drawn evenly along the slide towards the right. The film is dried by waving it in the air. The film should possess a straight edge parallel with that of the slide and should be as uniform and thin as possible. Another glass slide may be used as a spreader, or a cover-slip or thin glass rod may be employed.

Thick Films.—These are of service in detecting malarial parasites or trypanosomes, especially when the parasites are few. The method of Ross, or a modification thereof, has been much used. A small drop of fresh blood is spread evenly and quickly with a needle-point over a square area somewhat less than that of an ordinary square cover-glass. The blood is allowed to dry. The film is then carefully dehæmoglobinized in water in which there is a trace of acetic acid. The dehæmoglobinizing fluid is then carefully drained off and the film again dried. It is fixed in absolute alcohol and stained with Romanowsky's solution. A cubic millimetre of blood divided into quarters may be thus dehæmoglobinized and stained. The parasites in such a cubic millimetre of blood may be counted. Such a procedure was followed by R. Ross and D. Thomson,[1] in determining the periodic variation of the numbers of trypanosomes in the blood of a patient, as mentioned and figured on pp. 78 and 79.

For cytologica details of various Protozoa, thin film preparations on cover-slips or slides are often useful. Cover-slip preparations are preferable, unless the organisms under investigation are extremely scanty. The medium containing the organisms, such as blood, lymph, intestinal contents, sputum, scrapings of ulcers, and urine, is spread thinly, either alone or diluted with a little physiological salt solution, on the cover-slip. Fixation while still *wet* is necessary. Various methods are employed.

Fixatives.—A useful procedure is to fix the wet film by exposure to 4 per cent. osmic acid vapour for ten to thirty seconds, then place in absolute alcohol for five minutes to harden. Grade down from absolute alcohol through 90 per cent., 70 per cent., 50 per cent., and 30 per cent. alcohols to water. Stain wet with a suitable stain such as hæmatoxylin, and gradually dehydrate by grading through the necessary strengths of alcohol, clear in xylol or other oily clearing medium and mount in Canada balsam.

Other fixatives may be employed, such as are also useful for fixing pieces of tissue for sectioning. Films or smears on cover-slips while *still wet* are floated on the surface of the fixative in a watch glass. Some good fixatives of wide application are:—

Schaudinn's Fluid.—This consists of a mixture of

Saturated aqueous solution of corrosive sublimate	2 volumes
Absolute alcohol	1 volume

Two modifications of Schaudinn's formula may be found useful. A saturated solution of corrosive sublimate in physiological salt solution may be substituted for the aqueous one, and the addition of a few drops of glacial acetic acid to either of the preceding mixtures may be made.

Some workers prefer to use hot fixatives, raised to a temperature of about 50° C.

Fixation by corrosive sublimate solutions must be followed by thorough removal of the mercury salt by washing repeatedly in 30 per cent. alcohol or with iodine-alcohol.

---

[1] *Proc. Roy. Soc.*, B, lxxxii, p. 411.

Bouin's Fluid, or modifications thereof, is also very useful for wet fixation. Bouin's picro-formol solution consists of :—

Saturated aqueous solution of picric acid	...	30 volumes
Formalin, 40 per cent.	...	10 ,,
Acetic acid, glacial	...	2 ,,

The best-known modification is one due to Duboscq and Brasil, and often known as *Bouin-Duboscq Fluid*. Its formula is as follows :—

Alcohol, 80 per cent.	...	150 c.c.
Formalin, 40 per cent.	...	60 ,,
Acetic acid, glacial	...	15 ,,
Picric acid	...	1 grm.

Thorough washing of the smear or cover-slip preparation with 70 per cent. alcohol until the yellow colour disappears is necessary to remove excess of fixative.

Other fixatives, which may be of use, more especially for fixing small pieces of tissue for sectioning, are the solutions of Flemming (chromo-aceto-osmic acids) and of Zenker (sublimate-bichromate-acetic, with sodium sulphate).

Regarding the time of fixation, there is much difference of opinion. Usually, exposure to or contact with the fixative for five minutes is sufficient in the case of films or smears. Material for sections should be cut into small cubic pieces, of a thickness of about 5 mm. ($\frac{1}{5}$ in.). One or two hours should be sufficient time for the fixation of such pieces of tissue, though some, as Langeron, prefer a longer time of fixation. On the other hand, Gustav Mann[1] recommends a short fixation period. The excess of fixative should be thoroughly washed out of the tissue in the manner appropriate to the particular fixative used. If it is desired to keep the tissue for some time before sectioning and staining, it should be transferred to 70 per cent. alcohol.

When fluid fixatives are employed, large quantities of the fixing media are necessary. The volume of the fixative should be at least ten to twenty times that of the object, and the latter should be suspended in the middle of the fixative. The tissue should be fixed as soon as possible after the death of the host.

For sectioning tissue parasitized by Protozoa, embedding in paraffin is generally recommended. Microtome sections should not, if possible, exceed 5 μ in thickness. Details of special procedures must be sought in larger works.

Staining.—Here, as with fixatives, much choice is presented. The various modifications of the Romanowsky stain have aided greatly in

---

[1] "Physiological Histology," 1902, Clarendon Press, Oxford.

the detection of various Protozoa parasitic in the blood. Such stains, however, leave something to be desired in the revealing of finer cytological details. Other stains, more especially the hæmatoxylins, must be employed for cytological purposes.

Formulæ of some of the principal Romanowsky and hæmatoxylin stains may now be given.

The underlying principle of the *Romanowsky Stain* is the reaction between alkaline methylene blue and eosin, forming the so-called eosinate of methylene blue which stains chromatin purplish-red. A solution of medicinal methylene blue after having been subjected to the action of an alkali, such as sodium carbonate, becomes partly converted into certain derivatives, the chief of which are methylene azure and methylene violet. These substances are also present in matured polychrome methylene blue.

The formula of a *slightly modified Romanowsky Stain* which gives excellent results is given below :—

Two stock solutions are required—

Solution A.—	Methylene blue, pure medicinal	1·0 grm.
	Sodium carbonate	0·5 ,,
	Water	100·0 c.c.

Keep in a warm incubator for two or three days, until the solution is distinctly purple in colour. It improves with age.

Solution B.—	Eosin, water soluble, extra B.A.	1·0 grm.
	Water	1,000·0 c.c.

This solution must be kept in the dark, in dark-tinted (amber-coloured) bottles, as unfortunately it is decolorized by light.

Before use each stock solution must be diluted. Thus, make up 5 c.c. of each stock solution to 100 c.c. by adding distilled water. For staining, 1 volume of solution A is added to 2 or 3 volumes of solution B. Mix thoroughly by shaking, pour the mixture over the film, previously fixed in absolute alcohol, and stain for ten to fifteen minutes. Wash carefully in running water, then dry. The cytoplasm of a protozoan parasite will be stained blue, the chromatin purplish-red and vacuoles or very tenuous protoplasm will remain colourless.

The exact proportions of solutions A and B, which must be mixed together, should be determined by experiment. Freshly mixed stain must be used on each occasion.

Leishman's Stain is the precipitate resulting from the interaction of alkaline methylene blue and eosin. The washed and dried precipitate is collected and dissolved in pure methyl alcohol, which acts as a fixative ; 0·015 grm. of Leishman powder may be dissolved in 10 c.c. of methyl alcohol for staining films. The film is covered with the solution for one minute, twice the volume of water is then added and mixed with the stain on the slide. The staining is then continued for five to ten minutes, and the film is finally washed with water.

Giemsa's Stain.—This should be procured ready made. Azure II is a mixture of methylene azure and methylene blue. (Methylene azure is sometimes known as Giemsa's Azure I.) The formula given by Giemsa himself in 1912 is :—

Azure II-eosin	3·0 grm.
Azure II	0·8 ,,
Glycerine, pure	125·0 ,,
Methyl alcohol, pure	375·0 ,,

The film is first fixed in absolute alcohol. The proportion of stain usually used is one drop of stain to 1 c.c. of water. Stain for about ten minutes and then wash in water.

The details of the application of the Giemsa stain to films fixed wet and to sections must be sought in larger works on technique. These works should also be consulted for information regarding the use of Pappenheim's Panchrome mixture.

There are numerous formulæ of stains containing ripened *Hæmatoxylin* or its essential principle, *Hæmatein.* A mordant is necessary, one of the alums being usually employed. The mordant may be included as an ingredient in the staining mixture, or it may be used separately as in the case of the so-called iron-hæmatoxylins, wherein ferric ammonium alum is used separately and is followed by staining with hæmatoxylin or hæmatein. A few of these stains of general application may now be mentioned.

Delafield's (or Grenacher's) Hæmatoxylin.

Hæmatoxylin crystals	4 grm.
Absolute alcohol	25 c.c.
Saturated aqueous solution of ammonia-alum ...	400 ,,

Mix these ingredients, and leave exposed to light and air for three to four days. Filter and add—

Glycerine	100 c.c.
Methyl alcohol	100 ,,

Allow the mixture to stand until the colour is sufficiently deep, then filter and place in a stoppered bottle. The solution should be allowed to ripen for at least two months before use. Dilute aqueous solutions of the stain are of service for films and for sections. A trace of acetic acid may be added at the moment of use, for sharp differentiation.

Ehrlich's acid hæmatoxylin, Mayer's hæmalum, and Mayer's glychæmalum are also useful. Their formulæ will be found in larger works.

The chief *Iron-Hæmatoxylin Stain* is that devised by Heidenhain. Unfortunately the procedure involved is a long one, and various modifications have been made to obviate this disadvantage. Hæmatein may be used instead of ripened hæmatoxylin.

One efficacious modification of Heidenhain's stain is that of *Rosenbusch.* The smear or tissue, after fixation, must be graded downwards through the alcohols to water. Mordant for one and a half hours in a 3½ per cent. aqueous solution of ferric ammonium sulphate. Stain for about three minutes in 1 per cent. solution of ripe hæmatoxylin or hæmatein in absolute or 96 per cent. alcohol, to which a drop of saturated aqueous solution of lithium carbonate, sufficient to produce a wine-red colour, has been added. Differentiate under the microscope with a very dilute solution of the ferric ammonium sulphate. Wash, gradually dehydrate, clear and mount in balsam. It must be remarked that iron-hæmatoxylin is a regressive stain, hence great care must be exercised in differentiating with the iron alum.

Gentian Violet.—A 1 per cent. alcoholic solution of gentian violet, or of methyl violet, or of crystal violet, will be found useful for staining spirochætes.

Methyl Green.—This substance is considered to be a chromatin stain, for either fresh or perhaps recently fixed tissues. A concentrated aqueous solution contains about 1 per cent. of the stain. This should be added to a 1 per cent. solution of acetic acid. It may be used for demonstrating the nuclei of ciliates.

In conclusion it is essential to remember that the actual magnification of figures of Protozoa should be given, and not merely the combination of objective and ocular that has been used, for unless the tube-length and distance of the drawing board from the ocular be also given, it is not possible to compute the magnification from such information. Drawings should always be made with the aid of a camera lucida, drawing prism or other form of projection apparatus.

APPENDIX ON TREMATODA AND NEMATODA.

BY

J. W. W. STEPHENS, M.D., B.C., D.P.H.

TREMATODA.

Artyfechinostomum sufrartyfex, Clayton Lane, 1915.—Leiper thinks this may be the same as *Echinostoma malayanum*, Leiper, 1911, which species Odhner assigns to the genus Euparyphium.

Metagonimus (*Yokogawa*) **yokogawai** occurs in dogs in Shanghai. Encysted cercariæ probably in the perch.

Opisthorchis sp.—Skin covered with spines. Gut forks almost reach end of body. Œsophagus two to three times length of pharynx. Ovary multilobed. Ovary and testes in posterior fourth of body. Vitellaria end opposite the ovary. Distinguished from *O. felineus* by presence of spines and lobed ovary; from *O. pseudo-felineus* and *O. noverca* by the lobed ovary, and by the fact that the yolk glands do not extend as far as the anterior testis. It agrees with Poirier's description of *O. viverrini* in the Indian civet cat, but whether this species has spines on the cuticle is not known.

Habitat.—Man in Chiengmai (Malay States). Fifteen per cent. of prisoners in the jail showed the ova of this species in their fæces.

Schistosome cercariæ.

Schistosome cercariæ belong to the furcocercous division of the *Distomata* cercariæ.

Distomata cercariæ.

Body without a floating membrane. Tail absent, or if present not cleft to the base. Mouth anterior, gut forked. Oral sucker present. Ventral sucker near middle of body. Eyes generally absent.

Group **Fercocercous cercariæ.**

Cercariæ single (not in colonies). Tail forked at its end.

Family. **Schistosomidæ.**

Pharynx absent.

Cercaria bilharzia, Leiper, 1915.

Pigment spots (eyes) anterior to ventral sucker absent, cuticular keel on forks of tail absent.

In *Bullinus* sp. and *Planorbis boissyi* in Egypt, (?) in *Physopsis africana*, South Africa. Adult form, *Schistosoma hæmatobium.*

Cercaria bilharziella, Leiper, 1915.

Cuticular keel on tail forks present. Pigment spots (eyes) in front of ventral sucker present.

In *Planorbis boissyi* and *P. mareoticus*, and in *Melania* sp. Adult form (?).

For characters of numerous other cercariæ which occur in fresh water molluscs *see* "Die Susswasserfauna Deutschlands," Max Lühe, H. 17 (Gustav Fischer, Jena, 1909).

The characters of *Cercaria japonica* of *S. japonicum* in the mollusc *Katayama nosophora* and of *C. mansoni* have still to be defined.

Schistosoma mansoni, Sambon, 1907.

The evidence appears to be strong that terminal-spined eggs are not found in the West Indies, and that therefore the lateral-spined eggs found in fæces there belong probably to *S. mansoni.* If this be true, then the egg described by Stephens and Christophers in man in India probably also belongs to another species of Schistosome.

NEMATODA.

Ancylostomiasis. — Treatment : (1) *Oleum chenopodii* (U.S.P.), dose ♏ x to ♏ xv on a lump of sugar, three doses at two-hourly intervals, preceded and followed by a purge. It is cheap, not unpleasant to take, and non-toxic. Effective also against *Ascaris lumbricoides.*

(2) Milk of the higueron *Ficus laurifolia.* A spoonful in milk, three times daily for three days followed by a purge. Described as a harmless but very sucessfu form of treatment.

Ground-itch.—Completely cured in a few days by a 3 per cent. solution of salicylic acid in ethyl alcohol. Apply for five minutes twice daily.

Ascaris lumbricoides can be kept alive for twelve days in Kronecker's solution ; NaHO 0·069 grammes, normal saline 1,000 c.c.

Eggs are laid and develop in about a fortnight at ordinary room temperature. At 70° C. they are readily killed.

Filariasis.— Dutcher and Whitmarsh have cultivated from the blood and from the exudation fluids of cases of filariasis (elephantiasis, lymphangitis, etc.), in about sixteen cases, a bacillus resembling *B. subtilis.* Controls were negative. They propose the name *Bacillus lymphangiticus* for this organism, and they believe it to be the cause of the diseases grouped under the designation "filariasis."

Oncocerca volvulus.—*Unsheathed* embryos (indistinguishable from those taken from the uterus of this worm) have been found in lymphatic glands and in the blood (if considerable pressure is used so as to squeeze out lymph at the time of taking the finger blood, otherwise none occurs in the specimens). The measurements in dried films are: Nerve ring 23·7 per cent. of length; G1 cell 69·6 per cent.; end of last tail cell 96·3 per cent; total length 274·3 μ.

Strongyloides stercoralis.—Pathology: They occur in the wall of the intestine and may be associated with ulceration. They also occur in lymphatics and blood-vessels.

BIBLIOGRAPHY.

[In the following pages the letters C. f. B., P. u. Inf. are used to indicate the *Centralblatt für Bakteriologie, Pathologie und Infektions-Krankheiten.*]

(A) PROTOZOA (pp. 25 to 210, 617 to 637, and 733 to 742).

[*This list applies to the earlier literature only. More recent references are given as footnotes in the text.*]

(*a*) General.

BÜTSCHLI, O. Protozoa in Bronn's Klass. u. Ordn. d. Tierreichs, Leipz., 1880-1889.

CALKINS, G. N. The Protozoa, Columbia Univ. Biol. Ser., vi, New York, 1901.

DELAGE, Y., and E. HÉROUARD. Traité de Zool. Concr., i, La cellule et les protozoaires, Paris, 1896.

FARMER, J. B., J. J. LISTER, E. A. MINCHIN and S. J. HICKSON. Protozoa, in A Treatise on Zoology, edited by E. Ray Lankester, London, 1903, i, 2.

LANG, A. Lehrb. d. vergl. Anatomie d. wirbellos. Tiere, 2. Aufl., 2. Lief, Protozoa, Jena, 1901.

(*b*) Pathogenic Protozoa in General.

DOFLEIN, F. Die Protozoen als Parasiten u. Krankheitserreger, Jena, 1901; Lehrbuch der Protozoenkunde, 1912.

DOFLEIN, F., and S. v. PROWAZEK. Die pathog. Protoz. mit Ausnahme d. Hämospor., in Handb. d. path. Mikroorganism.; issued by W. Kolle and A. Wassermann, 11. and 12. Lief, Jena, 1903.

KÄSTNER, P. Die tierpathogenen Protozoen, Berlin, 1906.

KISSKALT, K., and M. HARTMANN. Praktikum der Bakteriologie und Protozoologie, Jena, 1907.

LÜHE, M. Die im Blute schmarotzenden Protozoen und ihre nächsten Verwandten, in Handb. d. Tropenkrankh., issued by C. Mense, Leipz., 1906, iii.

PFEIFFER, L. Die Protozoen als Krankheitserreger, 2. Aufl., Jena, 1891; Supplement, Jena, 1895.

ROOS, E. Die im menschl. Darm vork. Protozoen u. ihre Bedeutg., Med. Klinik, 1905, i, p. 1328.

SCHNEIDEMÜHL, G. Die Protozoen als Krankheitserreger der Menschen und der Haustiere, Leipz., 1898.

SIEVERS, R. Zur Kenntn. d. Verbreitg. d. Darmparas. d. Mensch, Helsingfors, 1905, Festschrift f. Palmèn.

WARD, H. B. Protozoa, Wood's Ref. Handbook of the Med Sci., 1904, viii.

Class I.—Sarcodina (pp. 29 to 50).

Order. *Amœbina* (p. 29).

Entamœba coli; Entamœba histolytica (pp. 32 to 41, 618 to 620, and 733).

BLANCHARD, R. Traité de Zool. médic., 1885, i, Paris, p. 15.

— Maladies paras., 1895, p. 658.

BOWMANN, M. H. Dysentery in the Philippines, Journ. Trop. Med., 1901, iv, p. 420.

BUNTING, C. H. Hæmatogenous Amœbic Abscess of the Lung, Arch. f. Schiffs- u. Tropenhyg., 1906, x, p. 73.

CALANDRUCCIO. Anim. par. dell' uomo in Sicilia, Atti Accad. Gioen., iv, 1890, ii, p. 95.

CASAGRANDI, O., and P. BARBAGALLO. Sull' amœba coli, Boll. Accad. Gioen. sci. nat., Catania, 1895.

— — *Entamœba hominis* s. *Amœba coli* Lösch, Annal. d'Igiene sperim., 1897, vii, 1.

CELLI, A., and R. FIOCCA. Beitr. z. Amoebenforsch., ii, C. f. B. u. Par., 1894, xvi, p. 329; Ric. int. alla biol. d. Amœbe, Bull. Accad. med. Roma, 1894-95, xxi, p. 285; abstracted in C. f. B., P. u. Inf., 1897, i, xxi, p. 290.

COUNCILMAN, W. P., and H. A. LAFLEUR. Amœbic Dysentery, Johns Hopkins Hosp. Rep., 1891, ii, p. 395.

CRAIG, C. F. Etiology and Pathology of Amœbic Infection of the Intestines and Liver, Intern. Clin., Philad., 1905 (14), iv, p. 242.

CUNNINGHAM, D. Seventh Ann. Rep. San. Comm. of India, Calcutta, 1871.

— Unters. üb. d. Verh. mikrosk. Organ. z. Cholera in Indien, Zeitschr. f. Biol., 1872, viii, p. 251; Quart. Journ. Micros. Sci., 1881 (2), xxi, p. 234.

GRASSI, B. Dei protozoi par. e spec. di quelli che sono nell' uomo, Gazz. med. ital.-lomb., 1879 (8), i, p. 445; Int. ad alc. prot. endop., Atti soc. ital. sci. nat., 1882, xxiv, p. 1; Morf. e sist. di alc. prot. par., Atti Acc. Lincei. Rendic. (4), iv, 1, p. 5; Signif. patol. d. prot. par. dell' uomo, *ibid.*, p. 83.

GROSS, A. Beobacht. üb. Amoebenenteritis, Arch. f. klin. Med., 1903, lxxvi, p. 429.

HARRIS, H. F. Amœbic Dysentery, Amer. Journ. of Med. Sci., April, 1898.

— Experimentell bei Hunden erzeugte Dysent., Arch. f. path. Anat., 1901, clxvi, p. 66; On the Alterations Produced in the Large Intestine of Dogs by the *Amœba coli*, Philadelphia, 1901.

HOPPE-SEYLER, G. Üb. Erkrankung des Wurmfortsatzes bei chron. Amoeben-enteritis, Münch. med. Wochenschr., 1904, No. 15.

JAEGER, H. Die in Ostpreuss. heim. Ruhr eine Amoebendysent., C. f. B., P. u. Inf., 1902, i Abt. Orig., xxxi, p. 551.

— Erwiderg. a. d. Bemerk. Shigas, *ibid.*, 1902, xxxii, p. 865.

JANOWSKI, W. Zur Ätiol. d. Dys., C. f. B., P. u. Inf., 1897, i, xxi, pp. 88, 151, 194, 234.

JÜRGENS. Zur Kenntn. d. Darm-Amoeb. u. d. Amoeben-Enteritis, Veröff. a. d. Geb. d. Milit.-Sanitätswes., Berl., 1902, Heft 20, p. 111.

KARTULIS. Über Riesenamoeben (?) bei chron. Darmentdg. d. Ägypt, Virch. Arch. f. Path., 1885, xcix, p. 145; Zur Ätiol. d. Dysent. in Ägypt, C. f. B. u. Par., 1887, v, p. 745; Üb. trop. Leberabsc. u. ihr Verh. z. Dysent., Virch. Arch. f. Path., 1889, cxviii, p. 97; Einiges üb. d. Path. d. Dysenterie-Amœb., C. f. B. u. Par., 1891, ix, p. 365; Article: Dysenterie in Spec. Path. u. Ther. v. H. Nothnagel, Wien, 1896, v, 3.

— Gehirnabscesse nach dysent. Leberabsc., C. f. B., P. u. Inf., 1904, i Orig., xxxvii, p. 527.

KOCH, R., and G. GAFFKY. Bericht üb. d. Tätigkeit d. z. Erforschg. d. Cholera ents. Kommiss., Arb. a. d. kais. Gesundheitsamt, 1887, iii.

KOVACS, F. Beob. u. Vers. üb. d. sog. Amoeben-Dys., Zeitschr. f. Heilkde., 1892, xiii, p. 509.

KRUSE, W., and PASQUALE. Eine Exped. nach Ägypt, Deutsch. med. Wochenschr., 1893, No. 15, p. 354; No. 16, p. 368.

— — Untersuch. üb. Dys. u. Leberabsc., Zeitschr. f. Hyg., 1894, xvi, p. 1.

LAMBL. Aus d. Franz-Joseph-Kinderspit. in Prag, 1860, i, p. 362.

LESAGE, A. Culture de l'amibe de la dysenterie des pays chauds, Ann. Inst. Pasteur, 1905, xviii, p. 9; 1905, xix, p. 8.

LEWIS. Sixth Ann. Rep. San. Comm. of India, Calcutta, 1870.

LÖSCH, F. Massenh. Entw. v. Amoeben im Dickd., Virch. Arch. f. Path., 1875, lxv, p. 196.

MARCHOUX. Note sur la dysentérie d. pays chauds, C. R. Soc. Biol., Paris, 1899 (11), i, p. 870.

MUSGRAVE, W. E., and M. T. CLEGG. Amœbæ, their Cultivation and Etiological Significance. "Treatment of Intestinal Amœbiasis," in the Trop. Manila, 1904, Bur. of Govern. Lab., Biol. Lab., No. 18.

NORMAND. Note sur deux cas de colite parasit., Arch. méd. nav., 1879, xxxii, p. 211.

QUINCKE and ROOS. Über Amoebenenteritis, Berl. klin. Wochenschr., 1893, xxx, No. 45, p. 1089.

ROOS, E. Zur Kenntn. d. Amoebenenteritis, Arch. f. exper. Path. u. Pharm., 1894, xxxiii, p. 389.

RUGE, A. Amoebenruhr., Handb. d. Tropenkrankh., issued by C. Mense, 1906, iii, p. 1.

SCHAUDINN, FR. Unters. üb. d. Fortpflanz. einig. Rhizopod, Arb. a. d. kais. Gesundheitsamt, 1903, xix, 3, p. 547.

SCHUBERG, A. Die paras. Amoeb. d. menschl. Darms, C. f. B. u. Par., 1893, xiii, pp. 598, 654, 701.

SHIGA, K. Bemerk. zu Jaegers Die in Ostpreuss. einh. Ruhr eine Amoebendys., C. f. B., P. u. Inf., 1902, i Abt. Orig., xxxii, p. 352.

STRONG, R. P., and W. E. MUSGRAVE. Report on the Etiology of the Dysentery of Manila, Rept. Surg.-Gen. of the Army to the Secretary of War, Washington, 1900, p. 251.

VERDUN. Sur quelq. caract. spécif. de l'amibe de la dysenterie et des abscès trop. du foie, C. R. Soc. Biol., 1904, lvi, p. 183.

WOOLLEY, P. G., and W. E. MUSGRAVE. The Pathology of Intestinal Amœbiasis, Dept. of the Int. Bureau of Government Lab., No. 32, Manila, 1905, Journ. Amer. Med. Assoc., Chicago, 1905, xlv, p. 1371.

Entamœba buccalis (pp. 43 and 620).

LEYDEN, E. V., and W. LOEWENTHAL. *Entam. bucc.* Prow. bei einem Fall von Carcinom d. Mundbod, Charité-Ann., Berl., 1905, xxix; Berl. klin. Wochenschr., 1905, xlii, No. 7, p. 187.

PROWAZEK, S. *Entamœba buccalis* n. sp., Arb. a. d. kais. Gesundheitsamt, Berl., 1904, xxi, 1, p. 42.

TIETZE, AL. Ein Protozoenbef. i. ein. erkrankt. Parotis., Mitt. Grenzgeb. Med. u. Chirurg., 1905, xiv, p. 302.

Entamœba undulans (p. 43).

CASTELLANI, A. Dysentery in Ceylon, Journ. of the Ceylon Branch of the Brit. Med. Assoc., 1904.

— Observations on some Protozoa found in Human Fæces, C. f. B., P. u. Inf., 1905, i Abt. Orig., xxxviii, p. 67.

Entamœba kartulisi (pp. 44 and 734).

DOFLEIN, F. Die Protoz. als Paras. u. Krankheitserreg., Jena, 1901, p. 30.

FLEXNER. Amœbæ in an Abscess of the Jaw, Johns Hopkins Hosp. Bull., 1892, No. xxv; abstracted in C. f. B., P. u. Inf., 1893, xiv, p. 288.

KARTULIS. Üb. pathog. Protoz. b. Mensch., Zeitschr. f. Hyg., 1893, xiii, p. 9.

— Über Amoebenosteomyelitis d. Unterkief, C. f. B., P. u. Inf., 1903, i Abt., Ref. xxxiii, p. 471.

Amœba gingivalis, *A. buccalis* and *A. dentalis* (pp. 44 and 733).

GRASSI, B. Gazz. med. ital.-lomb., 1879 (8), i, No. 45, p. 445.

GROS, G. Fragm. d'helm. et de phys. micros., Bull. soc. Imp. d. natur. de Moscou, 1849, i, 2, p. 555.

STEINBERG. In Zeitschr. f. neuere Med. (Russ.), issued by Walter in Kiew, 1862, Nos. 21-24.

Craigia (*Paramœba*) *hominis* (pp. 45 and 734).

CRAIG, CH. F. A new Intestinal Parasite of Man: *Paramœba hominis*, Amer. Journ. Med. Sci., 1906, N.S. cxxxii, Philad. and New York, p. 214.

SCHAUDINN, FR. Über den Zeugungskreis von *Paramœba eilhardi* n. g. n. sp., Sitzgsber. Kgl. Pr. Akad. d. Wiss., Berlin, Phys.-math. Cl., 1896, No. 2.

Entamœba pulmonalis (p. 45).

ARTAULT, ST. Flore et faune d. cav. pulm., Arch. de paras., 1898, i, p. 275.

BLANC, L. Sur une Amibe viv. accid. dans le poumon du mouton, Ann. Soc. Linn. Lyon, 1899 (2), xlv, p. 529.

Amœba urogenitalis (pp. 45, 46).

BAELZ, E. Üb. einige neue Paras. d. Mensch., Berl. klin. Wochenschr., 1883, p. 237.

JEFFRIES. Present. of a Specimen of Urine containing Amœbæ. Med. Rec., New York, 1904, xlvi, p. 356.

JÜRGENS. In Deutsche med. Wochenschr., 1892, p. 454.

KARTULIS. Pathog. Prot. b. Mensch, Zeitschr. f. Hyg., 1893, xiii, p. 2, Anm. 2.

POSNER, C. Üb. Amoeben im Harn, Berl. klin. Wochenschr., 1893, xxx, No. 28, p. 674.

WIJNHOFF, J. A. Over amoeburie, Nederl. Tijdschr. v. Geneeskde., 1895, p. 107.

Amœba miurai (p. 46).

IJIMA, J. On a New Rhizopod Parasite of Man, Ann. zool. japon., 1898, ii, 3, p. 85; abstracted in C. f. B., P. u. Inf., 1899 (i), xxv, p. 885.

MIURA, K. Amoebenfund i. d. Punktionsflüss. bei Tumoren d. Peritonealh., Mitt. med. Facult. d. kais. Jap. Univ., Tokyo, 1901, v, p. 1.

Chlamydophrys and *Leydenia* (pp. 47 to 50).

CIENKOWSKI, L. Üb. einige Rhizop. u. verwandte Organismen, Arch. f. mikr. Anat., 1876, xii, p. 39.

LAUENSTEIN, C. Üb. ein. Fund von *Leyd. gemmip.*, Deutsche med. Wochenschr., 1897, xxiii, p. 733.

LEYDEN, E. v., and F. SCHAUDINN. *Leyd. gemmip.*, ein neuer i. d. Ascites-Flüssigk. d. leb. Mensch. gefund. amoebenähnl. Rhizop., Sitzgsb. kgl. Preuss. Akad. d. Wiss., Berlin, 1896, xxxix, p. 951.

LEYDEN, E. V. Zur Ätiol. d. Carcin., Zeitschr. f. klin. Med., 1901, xliii, p. 4.
SCHAUDINN, FR. Untersuch. üb. d. Fortpflanz. einig. Rhizopod., Arb. a. d. kais. Gesundheitsamt, 1903, xix, 3, p. 560.
SCHNEIDER, A. Beitr. z. Naturgesch. d. Infus., Müllers Arch. f. Anat., Phys. u. wiss. Med., Jahrg. 1854, p. 191.

Class II.—Mastigophora (pp. 50 to 128, 620 to 633, and 734 to 741).

BILAND, J. Beitr. z. Frage d. Pathog. d. Flagellat., Deutsch. Arch. f. klin. Med., 1905, lxxxvi, p. 274.
BLOCHMANN, F. Mikrosk. Tierw. d. Süsswassers, 2. Aufl., 1895.
KENT, W. S. Manual of the Infusoria, London, 1880-81.
PROWAZEK, S. Flagellatenstudien, Arch. f. Protistenkde., 1903, ii, p. 195.
SENN, G. Flagellata in Engler und Prantl, Die natürlich. Pflanzenfam., Lief 202, 203, Leipzig, 1900.
STEIN, F. V. Der Organismus der Infus., iii, Der Org. d. Flagellaten, Leipzig, 1878.

Trichomonas vaginalis (pp. 52, 53, and 734).

BAATZ, P. *Trich. vag.* in der weibl. Harnblase, Monatsber. f. Urol., 1902, vii, 8.
BLOCHMANN, F. Bemerk. über einige Flagell., Z. f. wiss. Zool., 1884, xl, p. 42.
DOCK, G. Flagellate Protozoa in the freshly passed Urine of a Man, Med. News, 1894, lxv, p. 640.
— *Trichomonas* as a Parasite of Man, Amer. Journ. Med. Sci., 1896, p. 1.
DONNÉ, A. Rech. sur la nature du mucus, Paris, 1837.
HAUSMANN. Die Paras. der weibl. Geschlechtsorg., Berlin, 1870.
KUNSTLER, J. *Trichom. vag.* D., Journ. de Micrographie, 1884, viii, p. 317.
LAVERAN, A., and F. MESNIL. Sur la morph. et la syst. d. Flag. à membr. ondul., C. R. Acad. Sci., Paris, 1904, cxxxiii, p. 131.
MARCHAND, F. Über das Vorkomm. v. *Trichom.* im Harne eines Mannes, C. f. B. u. Par., 1894, xv, p. 709.
— Remarks [in the paper by K. Miura], *ibid.*, 1894, xvi, p. 74.
MIURA, K. *Trichom. vag.* im frischgelass. Urin eines Mannes, *ibid.*, 1894, xvi, p. 67.
SCANZONI, F. W. Beitr. z. Geburtskde., 2, Würzb., 1855, p. 131.
SCANZONI, F. W., and A. KOELLIKER. Quelq. rem. sur le *Trichom. vag.*, C. R. Acad. Sci., Paris, 1868, xl, p. 1076.

Trichomonas intestinalis (pp. 54 to 56, 623, and 734).

BOAS. In Deutsch. med. Wochenschr., 1896, p. 214.
COHNHEIM, P. Über Infus. im Magen und im Darmkanal des Menschen, Deutsch. med. Wochenschr., 1903, xxix, Nos. 12-14.
— Zur klinisch-mikrosk. Diagnose der nicht-pylor. Magencarcinome, Festschr. f. Jul. Lazarus, Berlin, 1899, p. 65.
DAVAINE, C. Sur les anim. infus. trouv. dans les selles d. malad. atteints du choléra et d'autr. malad., C. R. Soc. Biol., 1854 (2), i, p. 129.
EMDEN, J. E. G. VAN. Flagell. en hunne beteeknis voor de pathol., Handel 8, Nederl. Natuur- en Geneesk. Cong., Rotterdam, 11-14 April, 1901, p. 186.
EPSTEIN, A. Beob. üb. *Monocercomonas hominis* und *Amœba coli*, Prag. med. Wochenschr., 1893, Nos. 38-40.
GALLI-VALERIO, B. Note de parasitol., C. f. B., P. u. Inf., i Abt., 1900, xxvi, p. 305.

GRASSI, B. Int. ad alc. prot. entopar., Atti soc. ital. sci. nat. Milano, 1882, xxiv, p. 135.
— Sur quelq. protoz. endop., Arch. ital. de biol., 1882, ii, p. 402; 1883, iii, p. 23.
— Signific. pathol. dei protoz. paras. dell' uomo, Atti R. accad. d. Lincei. Rendic., 1888, iv, p. 83.
HENSEN, H. In Deutsch. Arch. f. klin. Med., 1897, lix, p. 450.
JANOWSKI, W. Flagellat. i. d. mensch. Faeces, Zeitschr. f. klin. Med., 1897, xxxi, p. 442.
KUNSTLER, J. Observ. sur le *Trichom. intest.*, Bull. scientif. de la France et de la Belg., 1898, xxxi.
LEUCKART, R. Die Paras. d. Mensch., Leipzig, 1879-86, 2. Aufl., i, 1, p. 131.
MARCHAND. Ein Fall von Infus. im Typhusstuhl, Virch. Arch. f. path. Anat., 1875, lxiv, p. 293.
PROWAZEK, S. Notiz über *Trichom. hominis*, Arch. f. Protistenkde., 1902, i, p. 166.
— Unters. über einige paras. Flagell., Arbeit. aus dem kais. Gesundheitsamt, 1904, xxi, 1, p. 1.
RAPPIN, G. Contrib. à l'étude des bact. de la bouche, Thèse Paris, 1881.
ROOS, E. Über Infusorien-Diarrhöe, Deutsch. Arch. f. klin. Med., 1893, li, p. 505.
ROSENFELD, A. Die Bedeutung der Flagellaten im Magen und Darm des Menschen, Deutsch. med. Wochenschr., 1904, No. 47.
ROSS, R. Cercomonads in Ulcers, Indian Med. Gaz., 1902, xxxvii, 4, p. 157.
SCHAUDINN, FR. Unters. Fortpfl. einig. Rhizop., Arbeit. kais. Gesundheitsamt, xix, 3, p. 547.
SCHUBERG, A. Die paras. Amoeb. d. menschl. Darms, C. f. B. u. Par., 1893, xiii, p. 598.
SCHÜRMAYER, B. Über das Vorkommen der Flagell. im Darmkanal des Menschen, C. f. B. u. Par., 1895 (1), xviii, p. 324.
STRUBE, G. *Trichom. hominis* im Mageninh. bei Carcin. cardiae, Berl. klin. Wochenschr., 1898, p. 708.
ZABEL, E. Flagellaten im Magen, Wien. klin. Wochenschr., 1904, xvii, No. 38.
ZUNCKER. Über das Vorkommen des *Cercom. intest.* im Digestionskanal des Menschen, Deutsch. Zeitschr. f. prakt. Med., 1878, p. 1.

Lamblia intestinalis (pp. 57 to 60, 625, and 736).

BLANCHARD, R. Traité de Zool. méd., 1885, i, Paris, p. 91.
— Rem. sur le *Megast. ent.*, Bull. Soc. Zool. France, 1888, xiii, p. 18.
BÜTSCHLI, O. Protozoa in Bronn's Kl. u. Ord. d. Tierr., 1884, p. 843.
COHNHEIM, P. Über Infus. im Magen- und Darmkanal des Menschen und ihre klin. Bedeutung, Deutsch. med. Wochenschr., 1903, xxix, Nos. 12-14.
FRSHEZJESSKI. Über die Rolle des *Megast. ent.* bei chron. Darmkatarrh, Russk. Arch. Patol., klin. Med. i. Bakt., 1867, ii.
GRASSI, B. Des protoz. par. e spec. di quelli che sono nell' uomo, Gazz. med. ital.-lomb., Milano, 1879, No. 45.
— Di un nuova paras. dell' uomo (*Megastoma entericum*), Gazz. degli ospit., 1881, ii, Nos. 13-15.
— Intorno ad alc. prot. endop., Atti soc. ital. sci. nat., 1882, xxiv, and Arch. ital. de biol., 1882, ii, p. 421.
GRASSI, B., and W. SCHEWIAKOFF. Beitr. zur Kenntnis des *Megastoma entericum*, Zeitschr. f. wiss. Zool., 1888, xlvi, p. 143.

JAKSCH, V. Über das Vorkommen von tier. Paras. in den Faeces der Kinder, Wiener klin. Wochenschr., 1888, No. 25, p. 511.

KRUSE, W., and A. PASQUALE. Unters. über Dysent. und Leberabsc., Zeitschr. f. Hyg., 1894, xvi, p. 19.

LAMBL. Unters. der Darmexkrete, Vierteljahrsschr. f. prakt. Heilkunde, 1859, lxi, Prag, p. 51.

— Aus dem Franz-Josef-Kinderspit. in Prag, 1860, i, Prag, p. 360.

METZNER, R. Unters. an *Megast. ent.* aus dem Kaninchendarm, Zeitschr. f. w. Zool., 1901, lxx, p. 299.

MORITZ, E., and HÖLZL. Über Häufigk. und Bedeutung des Vorkommens des *Megastoma entericum* im Darmkanal des Menschen, Münch. med. Wochenschr., 1892, xxxix, No. 47; Sitzungsb. ärztl. Ver. in München, 1893, ii, p. 89.

MÜLLER, E. Cercom. intest. i. jejunum fran männ, Nord. med. ark., 1889, xxi, No. 21; Förhdlg. biol. Föreng. Stockh., 1890, ii, p. 42; abstracted in C. f. B. u. Par., 1890, viii, p. 592.

PERRONCITO, E. Über die Einkaps. des *Megast. intest.*, C. f. B. u. Par., 1887, ii, p. 738, and Giorn. R. Accad. med., Torino, 1887.

— Une maladie mort. du lapin prod. par la *Lamblia intest.* de l'homme et du rat, Bull. Soc. Zool. France, 1902, xxvii, p. 151.

— La *Lamblia intest.* di R. Blanchard nell' uomo e nei topi causa di moria dei conigli, Ann. R. Accad. d. Agric., Torino, 1902, xlv.

PICCARDI. Alc. prot. delle feci dell' uomo, Giorn. R. Accad. med., Torino, 1895, lviii, 1; Progr. méd., 1895, No. 23, p. 377.

QUINCKE, H. Über Protozoen-Enteritis, Berl. klin. Wochenschr., 1899, Nos. 46, 47.

ROOS. Über Infusorien-Diarrhöe, Deutsch. Arch. f. klin. Med., 1893, li, p. 505.

SALOMON, H. Über einen Fall von Infus.-Diarrhöe, Berl. klin. Wochenschr., 1899, No. 46.

SCHMIDT, R. Infus. im Mageninhalt bei Ulcus ventriculi, Wiener klin. Wochen schr., 1904, xvii, 48, p. 1304.

SCHUBERG, A. Abstract of the work of Moritz and Hölzl, C. f. B. u. Par., 1893, xiv, p. 85.

SIEVERS. *Balantidium coli, Megastoma entericum* und *Bothriocephalus latus* bei derselben Person, Zeitschr. f. klin. Med., 1896, xxxiii, p. 25.

STILES, C. W. First American Case of Infection with *Lamblia duodenalis*, Washington Med. Ann., 1902, i, No. 1, p. 64.

UCKE, A. Beobacht. über Flagell. in den Faeces des Menschen, C. f. B., P. u. Inf., 1904, xxxiv, p. 772.

ZABEL, E. *Megastoma intestinale* und andere Paras. in den Zotten eines Magenkrebses, Arch. f. Verdauungskrankh., 1901, vii, 6, p. 509.

— Flagellaten im Magen, Wiener klin. Wochenschr., 1904, xvii, 38, p. 1007.

Cercomonas hominis (pp. 61, 62, and 736).

ARTAULT, ST. Flore et faune d. cav. plum., Arch. de Paras., 1898, i, p. 278.

CAHEN. Über Protoz. im kindlichen Stuhl, Deutsch. med. Wochenschr., 1891, No. 27, p. 853.

DAVAINE, C. Sur des animalcules inf. trouv. dans les selles d. mal. att. du choléra et d'autres mal., C. R. Soc. Biol., Paris, 1854 (2), i, p. 129.

EKECRANTZ. Bidr. t. känned. om de i mennisk. tarmkan. förek. infus., Nord. med. ark., 1869, i, No. 20; Virchow-Hirschs Jahresber., 1869, i, p. 202.

FENOGLIO. Entérocolite par *Amœba coli*, Arch. ital. de méd., 1890, xiv, p. 62.

JANOWSKI, W. Flagellaten in den menschlichen Faeces, Zeitschr. f. klin. Med., 1897, xxxi, p. 442.
KANNENBERG. Über Infus. im Sputum, Virch. Arch. f. path. Anat., 1879, lxxv, p. 471; Zeitschr. f. kl. Med., 1880, i, p. 228.
KRUSE, W., and PASQUALE. Unters. über Dysent., Zeitschr. f. Hyg., 1894, xvi, p. 1.
LAMBL. *Cercomonas* et *Echinococcus* in hepate hominis, Med. Wjestnik, 1875, No. 33.
LEUCKART, R. Die thier. Paras. des Menschen, 2. Aufl., i, p. 308.
LITTEN. Über Hydropneumothorax, Verh. Congr. f. inn. Med., 1886, p. 417.
MASSIUTIN. Amöben als Paras. des Dickdarms, Wratsch, 1889, No. 25; C. f. B. u. Par., 1889, vi, p. 451.
PERRONCITO, E. Über die Art der Verbreitung der *Cercom. intest.,* C. f. B. u. Par., 1888, iv, p. 220; Arch. ital. de biol., 1888, x, p. 257; Ann. R. Acc. d'agric. Torino, 1889, xxxii.
PICCARDI. Alc. prot. d. feci dell' uomo, Giorn. R. Accad. d. med. Torino, 1895, lviii, 1; Progr. méd., 1895, p. 377.
QUINCKE and ROOS. Amöb.-Enteritis, Berl. klin. Wochenschr., 1893, p. 1089.
ROOS, E. Über Infus.-Diarrhöe, Deutsch. Arch. f. klin. Med., 1893, li, p. 505.
STRENG, W. Infusor. im Sputum bei Lungengangrän, Fortschr. d. Med., 1892, x, p. 757.
THAM, P. V. S. Tvänne fall of *Cercom.,* Upsala läkarefören. förhdlg., 1870, v, p. 691; Virchow-Hirschs Jahresber., 1870, i, p. 314.
ZUNKER. Über die Verbr. v. *Cerc. int.* im Dig. des Menschen, Deutsch. Zeitschr. f. prakt. Med., 1878, p. 1.

Monas pyophila (p. 62).

BLANCHARD, R. Maladies parasit., etc., Paris, 1895, p. 690.
GRIMM, F. Über einen Leber- und Lungenabsc. mit Protoz., Arch. f. Chir., 1894, xlviii, p. 478.

Prowazekia urinaria (pp. 63 to 65).

BARROIS, TH. Quelq obs. au sujet du *Bodo urinarius*, Rev. biol. nord France, 1894-95, vii, p. 165.
BLANCHARD, R. Traité Zool. méd., i, Paris, 1885, p. 78.
— Malad. paras., etc., Paris, 1895, p. 691.
BRAUN, M. Die thier. Paras. d. Menschen, 2. Aufl., 1895, p. 108.
COHNHEIM, P. Über Infus. im Magen, Deutsch. med. Wochenschr., 1903, xxix, Nos. 12-14.
HASSALL, A. H. On the Development and Significance of *Vibrio lineola, Bodo urinarius,* in Alkaline and Albuminous Urine, Lancet, 1859, ii, p. 503.
KUNSTLER. Analys. micr. des urines d'un mal. atteint de pyélite chron. conséc. à une opér. de taille, Bull. Soc. d'Anat. et de Phys. norm. et path., Bordeaux, 1883, iv, p. 215.
SALISBURY. On the Parasitic Forms developed in Epithelial Cells of the Urinary and Genital Organs, Amer. Journ. Med. Sci., 1868.

Trypanosomes (pp. 67 to 102, 620 to 623, and 737).

BOUFFARD, M., and G. SCHNEIDER. Etude exp. de la dourine du cheval, Bull. Acad. Méd., 1900, 3e sér., xliv, p. 154; Rev. vétér., 1900, xxv, p. 589; C. f. B., P. u. Inf., 1900, i Abt., xxvii, p. 882.
BRODEN, A. Rapport sur les travaux du labor. méd. de Léopoldville de 1900-1905, Bruxelles, 1906, ii.

BRODEN, A. Trypanosomiasis et maladies du sommeil, Bruxelles, 1904, Publ. Soc. d'étud. colon. de Belg.

— La Trypanosomiase chez l'Européen, Bruxelles, 1905, *ibid.*

BRUCE, D. Preliminary Report on the Tsetse-fly Disease or Nagana in Zululand, Durban, 1895, C. f. B., P. u. Inf., 1896, i Abt., xix, p. 955.

— Note on the Discovery of a new Trypanosome (*T. theileri*), Lancet, 1902, i, p. 664.

BRUCE, D., and D. NABARRO. Progress Report on Sleeping Sickness in Uganda, Royal Society Report of the Sleeping Sickness Commission, No. 1, London, 1903, p. 11; No. 4, p. 1.

BRUCE, D., D. NABARRO and E. D. W. GREIG. Further Report on Sleeping Sickness in Uganda, Roy. Soc. Lond., Report of the Sleeping Sickness Commission, No. 4, 1903.

BRUMPT, E. Maladie du sommeil expér. chez le singe, C. R. Soc. Biol., Paris, 1903, lv, p. 1494.

— Les trypanos. chez les vertébrés, Arch. Méd. exp. et d'Anat. path., 1905, xvii, p. 743.

— Maladie du sommeil, Arch. de Paras., 1905, ix, 2, p. 205.

CASTELLANI, A. On the Discovery of a Species of *Trypanosoma* in the Cerebrospinal Fluid of Cases of Sleeping Sickness, Proc. Roy. Soc., London, 1903, lxxi, p. 501.

— Die Ätiologie der Schlafkrankh. der Neger, C. f. B., P. u. Inf., 1903, i Abt. Orig., xxxv, p. 62; Arch. f. Schiffs- u. Tropen-Hyg., 1902, vii, p. 382.

— Researches on the Etiology of Sleeping Sickness, Journ. Trop. Med., 1903.

CHALACHNIKOW. Rech. sur les paras. du sang chez les animaux à sang froid et à sang chaud, Charkow, 1888.

CHAUSSAT, J. B. Rech. micr. appl. à la pathol. d. hématozoaires, Thèse de Paris, 1850.

CHRISTY, C. The Distribution of Sleeping Sickness in the Victoria Nyanza, Brit. Med. Journ., 1903, ii, p. 648.

DANILEWSKY, B. Zur Parasitol. des Blutes, Biol. Ctrbl., 1885, v, p. 529.

— Matér. pour servir à la parasit. du sang, Arch. slav. de biol., 1886, i, pp. 85, 364; 1887, iii, pp. 33, 157, 257, 370.

— Rech. sur la parasit. comp. du sang; Zooparas. du sang des oiseaux; Charkow, 1888 et 1889.

— Nouv. rech. sur les paras. du sang des oiseaux, Charkow, 1889.

DURME, P. VAN. Contrib. à l'étude des Trypanosomoses, repartition des tryp. dans les organes, Arch. de Paras., 1906, x, 2, p. 160.

DUTTON, J. E. Preliminary Note upon a Trypanosome occurring in the Blood of Man, Thompson Yates Laboratory Report, Liverpool, 1902, iv, 2, p. 453; Brit. Med. Journ., 1902, ii, No. 2,177, p. 881; Journ. Trop. Med., 1902, v, p. 363.

DUTTON, J. E., and J. L. TODD, in Brit. Med. Journ., 1903, i, ii; First Report of the Trypanosome Expedition to Senegambia, Liverpool School of Trop. Med., Memoir XI, 1903; Memoir XVI, 1905.

ELMASSIAN, M. Mal de caderas, Annales Soc. rur. Argent., 1901, xxxvi, p. 195; Berl. tierärztl. Wochenschr., 1901, p. 606; Rec. Méd. vét., 1901, 8e sér., viii, p. 786.

— Sur le mal de caderas ou flagellose parésiante des équidés sud-amér., Annal. Inst. Pasteur, 1903, xvii, p. 241.

EVANS, GRIFFITH. Report on Surra Disease in the Dera Ismail Khan District Military Depôt, 1880; Report by Punjab Govt. Military Dept., No. 439, 1880.

— On a Horse Disease in India known as Surra, probably due to a Hæmatozoon, Vet. Journ., 1881, xiii, pp. 1, 83, 180, 326; 1882, xiv, pp. 97, 181.

FORDE, R. M. Some Clinical Notes on a European Patient, in whose Blood a Trypanosoma was observed, Journ. Trop. Med., 1902, v, p. 261.

GLUGE. Über ein eig. Entozoon im Blute des Frosches, Müllers Arch. f. Anat., Phys. u. wiss. Med., 1842, p. 148.

GRASSI, B. Sur quelq. protistes endopar., Arch. ital. de biol., 1882-83.

GROS. Observ. et induct. microsc. sur quelq. paras., Bull. Soc. imp. d. Natural, Moscow, 1845, xviii, 1, p. 380.

GRUBY, D. Rech. et obs. s. une nouv. esp. d'hématozoaires, C. R. Acad. Sci., Paris, 1843, xvii, 2, p. 1134; Ann. sci. nat. (Zool.), 1844, 3e sér., i, p. 104.

KEYSSELITZ, G. Über flagell. Blutparas. b. Süsswasserfisch, Sitzungsber. Ges. nat. Frde., Berl., 1904, p. 285.

— Über *Trypanophis grobbeni*, Arch. f. Protistenkde., 1904, iii, 3, p. 367.

KOCH, R. Über die Trypanosomenkrankh., Dtsche. med. Wochenschr., 1904, xxx, p. 1706.

— Über die Unterscheidg. d. Trypanosomen, Sitzungsber. kgl. preuss. Akad. d. Wiss., 1905, No. 46.

KRUEGER. Bericht über die Schlafkrankh. in Togo, Arch. f. Schiffs- u. Tropen-Hyg., 1904, viii, p. 479.

KRZYSTALOWITZ, FR., and M. SIEDLECKI. Contribut. à l'étude de la struct. et du cycle évol. de *Spirochaeta pallida* Schaud., Bull. Acad. sci. de Cracow, Cl. d. sci. math. et natur., 1905, p. 713.

LAVERAN, A. Des trypanosomes parasites du sang, Arch. Méd. exp. et d'Anat. path., 1e sér., 1892, i, p. 257.

— Sur un nouv. tryp. des bovidés (*Tr. theileri*), C. R. Acad. Sci., Paris, 1912, cxxxiv, p. 512.

LAVERAN and R. BLANCHARD. Les hématozoaires de l'homme et des animaux, Paris, 1895, Part I, p. 129.

LAVERAN, A., and F. MESNIL. Sur les Flag. à membr. ondul. des poiss., C. R. Acad. Sci., Paris, 1901, cxxxiii, p. 670.

— — Des trypan. des poissons, Arch. f. Protistenkde., 1902, i, p. 475.

— — Rech. morph. et expér. sur le Tryp. des rats, Annal. Inst. Pasteur, 1901, xv, p. 673.

— — Rech. morph. et exp. sur le Tryp. du Nagana, *ibid.*, 1902, xvi, p. 1.

— — Trypanosomes et Trypanosomiasis, Paris, 1904.

LEBAILLY, CH. Rech. sur les hématozoaires paras. des téléostéens marins, Arch. de Paras., 1906, x, 3, p. 348.

LÉGER, L. *Tryp. varium* n. sp., paras. du sang. de *Cobitis barbatula* L., C. R. Soc. Biol., Paris, 1904, lvii, p. 345.

LEWIS, F. R. Flagellate Organisms in the Blood of Healthy Rats, Fourteenth Ann. Rept. San. Comm., Govt. India (1878), Appendix; Quart. Journ. Micros. Sci., 1879, N.S. xix, p. 109.

LÜHE, M. Die im Blute schmarotzenden Protozoen und ihre nächsten Verwandten, Handb. d. Tropenkrankh., issued by Mense, 1906, iii.

LUHS, F. *Trypanosoma theileri* in Transkaukasien, Arch. de Paras., 1906, x, 2, p. 170.

MANSON, P. Trypanosoma occurring in the Blood of Man, Lancet, 1902, clxiii, 2, p. 1391.

MANSON, P., and C. W. DANIELS. Remarks on Case of Trypanosomiasis, Brit. Med. Journ., 1903, i, p. 1249.

MARTINI. Trypanosomenkrankheiten (Schlafkrankheit) und Kala-azar, Jena, 1907.

MAYER, A. F. J. C. Specileg. obs. anat. de org. electr. in Rajis anelectr. et de haematozois, Bonn, 1843.

MITROPHANOW, P. Beitr. z. Kenntn. d. Haematoz., Biol. Ctrbl., 1883-84, iii, p. 35.

MUSGRAVE, W. E., and M. T. CLEGG. Trypanosoma and Trypanosomiasis with special reference to Surra in the Philippine Islands, Dept. of the Int. Bur. of Govt. Lab., Biol. lab., No. 5, Manila, 1903.

NEPVEU, G. Sur un trypanosome dans le sang de l'homme, C. R. Soc. Biol., Paris, 1898, 10e sér., v, p. 1172.

NOCHT, B., and M. MEYER. Trypanosomen als Krankheitserreger, Ergänzungsbd. zu Kolle u. Wassermann, Handb. d. pathog. Mikroorg., Jena, 1906.

NOVY, F. G., and W. J. MCNEAL. On the Cultivation of *Trypanosoma lewisi.* Contribution to med. res. dedicated to V. Cl. Vaughan, Ann Arbor, Mich., 1903, p. 549.

— — The Cultivation of *Tr. brucei,* Journ. Amer. Med. Assoc., 1903, xli, p. 1266, and 1904, xlii; Journ. of Inf. Dis., 1904, i, p. 1.

POCHE, FR. Über zwei neue in Siphonoph. vork. Flagell., Arb. a. d. zool. Inst., Wien, 1903, xiv, 3, p. 307.

RABINOWITSCH, L., and W. KEMPNER. Die Trypanos. in der Menschen- u. Tierpathol., C. f. B., P. u. Inf., 1903, i Abt., xxxiv.

— — Beitr. z. Kenntn. d. Blutpar., speziell der Rattentrypanos., Zschr. f. Hyg., 1899, xxx, p. 251.

Reports of the Sleeping Sickness Commission, Roy. Soc. Lond., 1903-1905, Nos. 1-6.

ROUGET, J. Contrib. à l'étude du Tryp. des mammif., Annal. Inst. Pasteur, 1896, x, p. 716.

SALMON, D. E., and CH. W. STILES. Emergency Report on Surra, with a Bibliography of Surra and Allied Trypanosomatic Diseases, by A. Hassall, U.S. Dept. of Agric., Bureau of Animal Industry, Bull. No. 42, Wash., 1902.

SAMBON, L. W. Sleeping Sickness in the Light of Recent Knowledge, Journ. Trop. Med., London, 1903.

SCHAUDINN, FR. Generations- und Wirtswechsel bei *Trypanosoma* und *Spirochaete*, Arb. a. d. kais. Gesundheitsamt, 1904, xx, p. 387.

SCHILLING, A. Über die Tsetsekrankh. oder Nagana, Arb. Reichsges.-Amt, 1904, xxi, p. 476.

STEEL, J. H. An Investigation into an Obscure and Fatal Disease among Transport Mules in British Burma, 1885.

— On Relapsing Fever of Equines, Vet. Journ., 1886, xxii, pp. 166, 248.

— Le surra, malad. contag. des anim. dom. dans l'Inde, Rec. Méd. vétér., 1886, 7 sér., v, p. 298.

THIROUX. Rech. morph. et exp. sur *Trypanosoma duttoni* Thir., Annal. Inst. Pasteur, 1905, xix, p. 504.

VALENTIN. Über ein Entozoon im Blut von *Salmo fario,* Müllers Arch. f. Anat., Phys. u. wiss. Med., 1841, p. 435.

WASILIEWSKI, V., and G. SENN. Beitr. z. Kenntn. d. Flagell. d. Rattenbl., Zeitschr. f. Hyg., 1900, xxxiii, p. 444.

WEDL, C. Beitr. z. Lehre v. d. Haematozoen, Denkschr. k. k. Akad. d. Wiss., Wien, 1850.

WITTICH. Spirillen im Blut von Hamstern, Centralbl. f. d. med. Wiss., 1881, xix, p. 65.

ZIEMANN, H. Eine Methode der Doppelfärbung bei Flagell., C. f. B., P. u. Inf., 1898, i Abt., xxiv, p. 945.

Leishmania (pp. 104 to 112 and 626 to 629).

BLANCHARD, R. Note critique sur les corpuscles de Leishman, Rev. de Méd. et d'Hyg. trop., 1904, i, p. 37.

CUNNINGHAM, D. A Peculiar Parasitic Organism in the Delhi Boil, Scient. Mem. of Med. Off. of the Army of India, Calcutta, 1885, i.

DONOVAN, C. Human Piroplasmosis, Lancet, 1904, ii, p. 744; Brit. Med. Journ., 1904, ii, p. 651.

FIRTH, R. H. Note on the Appearance of Certain Sporozoon Bodies in the Protoplasma of the Oriental Sore, Brit. Med. Journ., 1891.

LAVERAN, A., and F. MESNIL. Sur un protozoaire nouveau (*Piroplasma donovani*), paras. d'une fièvre de l'Inde, C. R. Acad. Sci., Paris, 1903, cxxxvii, p. 957; 1904, cxxxviii, p. 187.

LEISHMAN, W. B. On the Possibility of the Occurrence of Trypanosomiasis in India, Brit. Med. Journ., 1903, i, p. 1253.

— The Nature of the Leishman-Donovan Body, *ibid.*, 1904, ii, pp. 29, 642.

LEISHMAN, W. B., and J. C. B. STATHAM. The Development of the Leishman Body in Cultivation, Journ. Roy. Army Med. Corps, March, 1905.

MANSON, P., and G. C. LOW. The Leishman-Donovan Body and Tropical Splenomegaly, Brit. Med. Journ., 1904, i, p. 183.

MARCHAND, F., and J. C. G. LEDINGHAM. Über die Infektion mit Leishmanschen Körperchen (Kala-Azar?) und ihr Verhältnis zur Trypanosomenkrankheit, Zeitschr. f. Hyg. u. Infkrankh., 1904, xlvii, i, p. 1.

MARZINOWSKI, J. E., and S. L. BOGROW. Zur Ätiologie der Orientbeule, Arch. f. path. Anat., 1904, clxxviii, 1, p. 112

RIEHL, G. Zur Anatomie und Ätiologie der Orientbeule, Vierteljahrsschr. f. Dermat. u. Syph., 1886, p. 805.

ROGERS, L. On the Development of Flagellated Organisms from the Spleen; Protozoic Parasites of Cachexial Fevers and Kala-Azar, Quart. Journ. Micros. Sci., 1904, xlviii, p. 367.

— Further Work on the Development of the Hepatomonas [Herpetomonas] of Kala-azar and Cachexial Fever from Leishman-Donovan Bodies, Proc. Roy. Soc., London, 1906, lxxvii, B, p. 284.

WRIGHT, J. H. Protozoa in a Case of Tropical Ulcer, Journ. Med. Research, 1903, x, 3, p. 472.

Spirochætes (pp. 114 to 128, 629 to 633, and 739 to 741).

SCHAUDINN, FR., and E. HOFFMANN. Vorl. Ber. über das Vork. von Spirochaeten in syph. Krankheitsprod. und bei Papillomen, Arb. a. d. kais. Gesundheitsamt, 1905, xxii, p. 527.

Class III.—Sporozoa (pp. 128 to 197).

BALBIANI, G. Leçons sur les Sporozoaires, Paris, 1884.

HAGENMÜLLER, P. Bibliographie générale et spéciale des travaux concernant les Sporozoaires parus antérieurement au 1er janvier, 1899, Ann. Mus. d.'Hist. nat., Marseille, 2 sér., 1899, i.

LABBÉ, A. Sporozoa, Berlin, 1899, Das Tierreich, 5. Lief.

LÜHE, M. Ergebnisse der neueren Sporozoenforschung, Jena, 1900. Reprinted from C. f. B., P. u. Inf., 1900, xxvii and xxviii.

WASILJEWSKI, TH. V. Sporozoenkunde, Jena, 1896.

TELOSPORIDIA.

ORDER. *Gregarinida* (pp. 129 to 135).

BENEDEN, E. VAN. Sur une nouvelle espèce de Grégarine désignée sous le nom de *Gregarina gigantea*, Bull. Acad. roy., Belg., 2e sér., 1869, xxviii, p. 444.

— Recherches sur l'évolution des Grégarines, *ibid.*, 1871, xxxi, p. 325.

BERNDT, A. Beitrag zur Kenntnis der im Darme der Larve von *Tenebrio molitor* lebenden Gregarinen, Arch. f. Protistenkde., 1902, i, p. 375.

BRASIL, L. Recherches sur la reproduction des Grégarines monocystidies, Arch. Zool. exp., 4e sér., 1905, iii, p. 17; 1905, iv, p. 69.

BÜTSCHLI, O. Kleine Beiträge zur Kenntnis der Gregarinen, Zeitschr. f. wiss. Zool., 1881, xxxv, p. 384.

— Bemerkungen über einen dem Glycogen verwandten Körper in den Gregarinen, Zeitschr. f. Biol., 1885, xxi, p. 603.

CAULLERY, M., and MESNIL, F. Sur une Grégarine coelomique présentant dans son cycle évolutif une phase de multiplication asporulée, C. R. Soc. Biol., Paris, 10e sér., 1908, v, p. 65; C. R. Acad. Sci., Paris, 1898, cxxvi, p. 262.

— — Le parasitisme intracellulaire et la multiplication asexué des grégarines, C. R. Soc. Biol., Paris, 1901, liii, p. 84.

CAVOLINI, F. Memoria sulla generazione dei pesci e dei granchi, Napoli, 1787, p. 169. Translation into the German by E. A. W. v. Zimmermann, Berlin, 1792, p. 169.

CRAWLEY, H. The Progressive Movement of Gregarines, Proc. Acad. Nat. Sci., Philadelphia, 1902, p. 4.

CUÉNOT, L. Recherches sur l'évolution et la conjugaison des grégarines, Arch. de Biol., 1901, xvii, p. 581.

DRZEWECKI, W. Über vegetative Vorgänge im Kern und Plasma der Gregarinen des Regenwurmhodens, Arch. f. Protistenkde., 1904, iii, p. 107.

DUFOUR, L. Note sur la Grégarine, nouveau genre de ver qui vit en troupeau dans les intestins de divers insects, Ann. Sci. nat., 1e sér., 1828, xiii, p. 366.

DUJARDIN, F. Recherches sur les organismes inférieures, II, Sur les Infusoires appelées Protées, Ann. Sci. nat., 2e sér., Zool., 1835, iv, p. 352.

GIARD, A. Contributions à l'histoire naturelle des Synascidies, IV, Sur une Grégarine parasite d'un *Amaraecium*, Arch. Zool. expér., 1873, ii, p. 495.

GREEFF, R. Über die pelagische Fauna an den Küsten der Guinea-Inseln, Zeitschr. f. wiss. Zool., 1885, xlii, p. 452.

HENLE, J. Über die Gattung *Gregarina*, Müllers Arch. f. Anat. u. Phys., 1845, p. 369.

KÖLLIKER, A. Beiträge zur Kenntnis niederer Tiere, I, Über die Gattung *Gregarina*, Zeitschr. f. wiss. Zool., 1848, i, p. 1.

LÉGER, L. Recherches sur les Grégarines, Tabl. zool., 1892, iii, p. 1.

— Nouvelles recherches sur les Polycystidées parasites des Arthropodes terrestres, Ann. Fac. Sci., Marseille, 1896, vi, p. 3.

— Sur un nouveau Sporozoaire des larves de Diptères, C. R. Acad. Sci., Paris, 1900, cxxxi, p. 722.

— La réproduction sexuée chez les *Stylorhynchus*, Arch. f. Protistenkde., 1904, iii, p. 303.

LÉGER, L. Etude sur *Taeniocystis mira*, Grégarine métamérique, Arch. f. Protistenkde., 1906, vii, p. 307.

LÉGER, L., and O. DUBOSCQ. Les Grégarines et l'épithélium intestinal chez les Trachéates, Arch. de Parasitologie, 1902, vi, p. 377.

— — Nouvelles recherches sur les Grégarines et l'épithélium intestinal chez les Trachéates, Arch. f. Protistenkde., 1904, iv, p. 335.

— — La reproduction sexuée chez *Pterocephalus*, Arch. Zool. exper., 4e sér., 1903, i; Notes et revue p. cxli.

LIEBERKÜHN, N. Evolution des Grégarines, Mém. Cour. et Mém. d. Sav. étrang., Acad. Belg., 1855, xxvi.

LÜHE, M. Bau und Entwicklung der Gregarinen, I, Arch. f. Protistenkde., 1904, iv, p. 88.

MAUPAS, E. Sur les granules amylacés du cytosome des Grégarines, C. R. Acad. Sci., Paris, 1886, cii, p. 120.

NUSBAUM, J. Über die geschlechtliche heterogame Fortpflanzung einer im Darmkanale von *Henlea leptodora* schmarotzenden Gregarine (*Schaudinella henleae*), Zeitschr. f. wiss. Zool., 1903, lxxv, p. 280.

PAEHLER, FR. Über die Morphologie, Fortpflanzung und Entwickelung von *Gregarina ovata*, Arch. f. Protistenkde., 1904, iv, p. 64.

PROWAZEK, S. Zur Entwickelung der Gregarinen, Arch. f. Protistenkunde, 1902, i, p. 297.

REDI, FR. De animalculis vivis, quae in corporibus animalium viventium reperiuntur, Amstelod., 1708, p. 270. [An earlier account was published in 1684.]

SCHEWIAKOFF, W. Über die Ursache der fortschreitenden Bewegung der Gregarinen, Zeitschr. f. wiss. Zool., 1894, lviii, p. 340.

SCHNEIDER, AI. Sur quelques points de l'histoire du genre *Gregarina*, Arch. Zool. exper., 1873, ii, p. 515.

— Contributions à l'histoire des Grégarines des Invertébrés de Paris et de Roscoff, *ibid.*, 1875, iv, p. 493; also Thèse de Paris, 1876.

— Second contribution à l'étude des Grégarines, *ibid.*, 1882, x, p. 432.

— Sur le développement du *Stylorhynchus longicollis*, *ibid.*, 2e sér., 1884, ii, p. 1.

— Etudes sur le développement des Grégarines, Tabl. zool., 1885, i, pp. 10, 81.

— Grégarines nouvelles ou peu connues, *ibid.*, pp. 25, 90; 1887, ii, p. 67.

SCHNITZLER, H. Über die Fortpflanzung von *Clepsidrina ovata*, Arch. f. Protistenkunde, 1905, vi, p. 309.

SIEBOLD, TH. V. Beiträge zur Naturgeschichte der wirbellosen Tiere, Über die zur Gattung *Gregarina* gehörenden Helminthen, Neueste Schrift d. naturforsch. Ges., Danzig, 1839, iii, p. 56.

SIEDLECKI, M. Über die geschlechtliche Vermehrung der *Monocystis ascidiae*, R. Lank., Anz. Akad. d. Wiss., Cracow, 1899, p. 515.

— Contributions à l'étude des changements cellulaires provoqués par les Grégarines, Arch. d'anat. micros., 1901, iv, p. 87.

STEIN, FR. Über die Natur der Gregarinen, Müllers Arch. f. Anat. u. Phys., 1848, p. 182.

— Neue Beiträge zur Kenntnis der Entwickelungsgeschichte und des feineren Baues der Infusionstiere: I, Die Entwickelungsgeschichte der *Vorticella microstoma* Ehrb., nebst vergleichenden Bemerkungen über die Entwickelungsweise der Gregarinen, Zeitschr. f. wiss. Zool., 1852, iii, p. 474.

WOLTERS, M. Die Conjugation u. Sporenbildung bei Gregarinen, Arch f. mikr. Anat., 1891, xxxvii, p. 99.

Schizogregarinea (p. 135).

LÉGER, L. La reproduction sexuée chez les *Ophryocystis*, C. R. Soc. Biol., Paris, 1900, lii, p. 927.

— Les Schizogrégarines des Trachéates : I, Le genre *Ophryocystis*, Arch. f. Protistenkunde, 1907, viii, p. 160.

LÉGER, L., and HAGENMÜLLER. Morphologie et évolution de *l'Ophryocystis schneideri*, Arch. Zool. exp., 3e sér., 1900, viii; Notes et revue p. xl.

SCHNEIDER, AI. *Ophryocystis bütschlii*, sporozoaire d'un nouveau type, Arch. Zool. expér., 2e sér., 1884, ii, p. 111.

— *Ophryocystis francisci*, Tabl. zool., 1885, i, p. 1.

ORDER. *Coccidiidea* (pp. 135 to 150, 741 and 742).

BALBIANI, G. Leçons sur les Sporozoaires, Paris, 1884, p. 104.

BLANCHARD, R. Les coccidies et leur rôle path., Causeries scientif. Soc. Zool. France, No. 5, Paris, 1900.

EIMER, TH. Über die ei- und kugelförmigen Psorospermien der Wirbelthiere, Würzburg, 1870.

HAKE, A. A Treatise on Varicose Capillaries as constituting the Structure of Carcinoma of the Hepatic Ducts, with an account of a New Form of the Pus Globule, London, 1839.

KAUFFMANN, W. Anal. ad tubercul. et entoz. cognitionem, Diss. inaug., Berol, 1847.

KLOSS, H. Über die Parasiten der Niere von *Helix*, Abh. Senckenb. nat. Ges. Frankf. a. M., 1855, i, p. 189.

LABBÉ, A. Recherches zoologiques, cytol. et biol. sur les Coccidies, Arch. Zool. exp. 1896 (3), iv, p. 516.

LAVERAN, A., and F. MESNIL. Sur la coccidie trouvée dans le rein de la *Rana esculenta* et sur l'infection générale qu'elle produit, C. R. Acad. Sci., Paris, 1902, cxxxv, p. 82.

LÉGER, L. Le cycle evol. d. Coccidies chez les Arthrop., C. R. Soc. Biol., Paris, 1897 (10), iv, p. 382.

— Coccidies nouv. du tube digest. d. Myriap., C. R. Acad. Sci., Paris, 1897, cxxiv, p. 901.

LEUCKART, R. Die Parasiten des Menschen, 2. Aufl., 1879, i, p. 248.

LIEBERKÜHN, N. Über die Psorospermien, Müllers Arch. f. Anat. u. Phys., 1854, p. 1.

— Evolution des grégarines, Mém. cour. et Mém. d. sav. étrang., Acad. roy. de Belg., 1855, xxvi.

MILIAN, G. Les sporozooses humaines, Thèse, Paris, 1899.

MOUSSU, G., and G. MAROTEL. La coccidiose du mouton et son paras., Arch. de Paras., 1902, vi, p. 82.

NASSE, H. Üb. d. eiförmigen Zellen der tuberkelähnlichen Ablagerungen in den Gallengängen der Kaninchen, Müllers Arch. f. Anat. u. Phys., 1843, p. 209.

PFEIFFER, L. Beiträge z. Kenntnis d. pathogenen Gregarinen : II, Über Gregarinose, ansteckendes Epitheliom und Flagellaten-Diphtherie der Vögel, Zeitschr. f. Hyg. u. Inf., 1889, v, p. 363.

— Die Protozoen als Krankheitserreger : 1. Aufl., Jena, 1890; 2. Aufl., 1892.

PFEIFFER, R. Beiträge zur Protozoenforschung : I, Die Coccidienkrankheit der Kaninchen, Berlin, 1892.

REINCKE. Nonnulla quaedam de psorosp. cuniculi, Diss. inaug., Kiliae, 1866.

REMAK, H. Diagnost. und pathog. Untersuchungen, Berlin, 1845.

RIVOLTA, G. Psorospermi i psorospermosi negli anim. dom., Med. veter., 1869 (3), iv.

SCHAUDINN, F. Unters. über d. Generationswechsel d. Coccidien, Zool. Jahrb. Anat., 1900, Abt. xiii, p. 197.

— Studien über krankheitserr. Protozoen: I, *Cyclospora caryolytica*, der Erreger der perniciösen Enteritis des Maulwurfes, Arb. kais. Gesundheitsamt, 1902, xviii, p. 378.

SCHAUDINN, F., and M. SIEDLECKI. Beitr. z. Kenntnis d. Coccidien, Verh. d. D. zool. Ges., 1897, vii, p. 192.

SCHNEIDER, AI., and M. L. PFEIFFER. Le cycle évolutif des Coccidies, Tabl. zool., ii, p. 105.

SCHUBERG, A. Die Coccidien aus dem Darm der Maus, Verh. nat.-med. Ver. Heidelberg, N. F. V., 1895, p. 369.

SIMOND, P. L. L'évolution d. sporoz. du genre *Coccidium*, Ann. Inst. Pasteur, 1897, xi, p. 545.

— Note sur une Coccidie nouv. (*Cocc. kermorganti*) paras. de *Gavialis gangeticus*, C. R. Soc. Biol., Paris, 1901, liii, p. 483.

SMITH, TH., and H. P. JOHNSON. On a Coccidium (*Klossiella muris*) parasitic in the Renal Epithelium of the Mouse, Journ. Exp. Med., 1902, vi, p. 303.

STIEDA, L. Über die Psorospermien der Kaninchenleber, Virchows Arch. f. pathol. Anat., 1865, xxxii, p. 132.

WALDENBURG, L. De struct. et origine cystidum verminos, Diss. inaug., Berol, 1860; Virchows Arch. f. path. Anat., 1862, xxiv, p. 149.

— Zur Entwickelung der Psorospermien, *ibid.*, 1867, xl, p. 435.

Eimeria stiedae (pp. 145 to 148).

FELSENTHAL and STAMM. Veränder. i. Leber und Darm bei d. Coccidienkrankh. d. Kaninchen, Virchows Arch. f. path. Anat., 1893, cxxxii, p. 36.

LINDEMANN, KR. Weiteres über Gregarinen, Bull. soc. Imp. Nat., Moscow, 1865, xxxviii, 2, p. 385.

LÜHE, M. Über Geltung und Bedeutung. d. Gattungsnamen *Eimeria* und *Coccidium*, C. f. B., P. u. Inf., 1902, i Abt. Orig., xxxi, p. 771.

METZNER. Untersuchungen an *Coccidium cuniculi* I, Arch. f. Protistenkde., 1903, ii, p. 13.

PIANESE, G. Le fasi di sviluppo del coccidio oviforme e le lesioni istologiche che induce, Arch. d. Paras., 1899, ii, p. 387.

PODWYSSOTZKI, W. Zur Entwickel. d. Coccidium oviforme als Zellschmarotzer, Bibl. med., 1895, Abt. D., ii, p. 4, Cassel.

RIECK, M. Sporozoen als Krankheitserreger bei Haustieren, Deutsche Zeitschr. f. Tiermedizin u. vergl. Path., 1889, xiv, p. 52.

STILES, CH. W. *Eimeria stiedae*. Correct Name of the Hepatic Coccidia of Rabbits, Eleven Miscellaneous Papers on Animal Parasites, U.S. Dept. Agric., Bur. An. Ind., Bull. No. 35, Washington, 1902.

WASILIEWSKI, TH. v. Studien u. Microphot. z. Kenntn. d. pathog. Protozoen: I, Bau Entw. u. pathog. Bedeutung d. Coccidien, Leipzig, 1904.

Isospora bigemina (pp. 149, 150).

FINCK. Sur la physiol. de l'épith. intest., Thèse, Strasb., 1854, p. 17.

GRASSI, B. Intorno ad alc. prot. endopar., Atti Soc. Ital. Sci. Nat. Milano, 1882, xxiv.

GRUNOW. Ein Fall von Protozoen- (Coccidien?) Erkrankung des Darmes, Arch. f. exp. Path. u. Pharm., 1901, xlv, p. 262.

RAILLIET, A., and A. LUCET. Notes s. quelq. esp d. Cocc. encore peu conn., Bull. Soc. Zool. France, 1891, xvi, p. 249.

STILES, CH. W. Notes on Parasitology, No. 11, Journ. Comp. Med. and Vet. Arch., 1892, xiii, p. 517; Bull. Soc. Zool. France, 1891, xvi, p. 163.

VIRCHOW, R. Helminth. Notiz. 3, Virchows Arch. f. path. Anat., 1860, xviii, pp. 342 and 527.

WASILIEWSKI, TH. V. Studien u. Mikrophot. zur Kenntnis d. path. Prot., I, Leipzig, 1904, pp. 88 ff.

Doubtful Species (p. 150).

BLANCHARD, R. Les cocc. et leur rôle path., Caus. scient. Soc. Zool. France, 1900, No. 5.

BORINI, A. Assoc. paras. ed il nuovo prot. di Perroncito, Giorn. R. Accad. Med., Torino, 1899, No. 7.

KUNSTLER, J., and A. PITRES. Sur une psorospermie trouv. dans une humeur pleurét., Journ. Microgr., 1884, viii, p. 469.

MONIEZ, R. Traité de parasit., Paris, 1896, p. 52.

PERRONCITO, E. Di un nuovo protoz. dell' uomo e di talune specie, Giorn. R. Accad. Med., Torino, 1899, No. 1; Cinquantenn. de la Soc. Biol., Paris, 1899, p. 184.

— Il coccidio jalino ed il microspor. poliedrico nell' uomo, *ibid.*, ann. 65, 1902, p. 378.

SEVERI, A. Gregarinosi polmonale in infante natomorto, Rif. med., 1892, ii, p. 54; Boll. Accad. med., Genova, 1892, vii, No. 2.

ORDER. *Hæmosporidia* (pp. 151 to 155, and 742).

BALFOUR, A. A Hæmogregarine of Mammals, Journ. Trop. Med., 1905, viii, p. 241.

BÖRNER, C. Unters. über Haemosporidien, I, Zeitschr. f. wiss. Zool., 1901, lxix, p. 398.

BÜTSCHLI, O. Einige Bemerk. über d. rot. Blutk. d. Frosches, Abh. Senckenb. nat., Ges., Frankf. a. M., 1876, p. 49.

CASTELLANI, A., and A. WILLEY. Hæmatozoa of Vertebrates in Ceylon, Spolia zeylanica, Colombo, 1904, ii, p. 2.

CELLI, A., and F. SANFELICE. Paras. d. rot. Blutk. d. Mensch. u. d. Thiere, Fortschr. d. Med., 1891, Nos. 11-15; Ann. ist. d'igien. esp., Roma, N.S.I., 1891.

CHAUSSAT. Des hématozoaires, Thèse, Paris, 1850.

DANILEWSKY, B. Die Haematozoen der Kaltblüter, Arch. f. mikr. Anat., 1885, xxiv, p. 588.

— Matér. pour servir à la paras. du sang, Arch. slav. de biol., 1886, i, pp. 89, 364; 1887, ii, pp. 33, 157, 370; Biol. Centralb., 1885, v, p. 529.

DURHAM, H. E. Drepanidium in the Toad, Liverpool School of Trop. Med. Memoir VII, Liverpool, 1902, p. 78.

GAULE, J. Über Würmchen, welche a. d. Froschblutkörp. auswandern, Arch. f. Anat. u. Phys., Phys. Abt., 1880, p. 57.

— Die Beziehungen der Cytozoen zu den Zellkernen, *ibid.*, 1881, p. 297.

GRASSI, B., and R. FELETTI. Malariaparas. in den Vögeln, C. f. B. u. Par., 1891, ix, p. 403; 1891, x, p. 449.

HINTZE, R. Lebensweise u. Entw. v. *Lankesterella minima* (Chauss)., Zool. Jahrb., Anat. Abt., 1902, xv, p. 693.

KRUSE, W. Über Blutparasiten, Arch. f. path. Anat., 1890, cxx, p. 541, and cxxi, p. 359.

LABBÉ, A. Rech. zool. et biol. sur les paras. endoglob. du sang. d. vertébrés, Arch. Zool. exp., 3 sér., 1894, ii, p. 55.

LANKESTER, E. RAY. On *Undulina*, the Type of a New Group of Infusoria, Quart. Journ. Micros. Sci., 1871, xi, p. 387.

— On *Drepanidium ranarum*, *ibid.*, 1882, xxii, p. 53.

LEBAILLY, CH. Rech. sur les hémat. par. des téléastéens marins, Arch. de Paras., 1906, x, 3, p. 370.

OSLER, W. An Account of Certain Organisms occurring in the Liquor Sanguinis, Proc. Roy. Soc. Lond., 1874, xxii, p. 391.

RUGE, R. Unters. über d. deutsche *Proteosoma*, C. f. B., P. u. Inf., 1901 (1), xxix, p. 398.

SIEGEL. Die geschlechtliche Entw. v. *Haemogregarina stepanovi* im Rüsselegel *Placobdella catenigera*, Archiv für Protistenkunde, 1903, ii, p. 339, with additions by F. Schaudinn.

SIMOND, P. L. Contrib. à l'étude des hématoz. endoglob. d. reptiles, Ann. Inst. Pasteur, 1901, xv, p. 319.

WALLERSTEIN. Über *Drepanidium ranarum*, Inaug.-Diss., Bonn, 1882.

MALARIAL PARASITES OF MAN (pp. 155 to 172).

(*a*) *Comprehensive Works.*

CELLI, A. La malaria sec. le nuove ricerche, Roma, 1900.

KERSCHBAUMER, FR. Malaria, ihr Wesen, ihre Entstehung und ihre Verhütung, Wien, 1901.

LAVERAN, A. Traité des fièvres palustres, Paris, 1884.

LÜHE, M. *Cf.* p. 765, Die im Blute schmar. Prot., 1906.

MANNABERG, J. Die Malariaparasiten, Wien, 1893.

NEVEU-LEMAIRE, M. Les hématozoaires du paludisme, Paris, 1901.

REINHARDT, LUDW. Die Malaria und deren Bekämpfung nach den Ergebn. d. neuesten Forschg., Würzb., 1905.

RUGE, R. Einführung in das Studium der Malariakrankh. mit bes. Berücksicht. d. Technik, Jena, 1901.

STEPHENS, J. W. W., and S. R. CHRISTOPHERS. The Practical Study of Malaria and other Blood Parasites, 3rd edition, London, 1908.

ZIEMANN, H. Über Malaria- und andere Blutparasiten, Jena, 1898.

— Malaria, Handb. d. Tropenkrankh., Lpzg., 1906, iii, p. 269.

(*b*) *Special Studies.*

ARGUTINSKY, P. Malariastudien, Arch. f. mikros. Anat., 1901, lix, p. 315; 1902, lxi, p. 331.

— Zur Kenntn. d. Tropica-Paras., C. f. B., P. u. Inf., i Abt. Orig., xxxiv, p. 144.

ATTI della società per gli studi della malaria, Roma, 1899-1906, i-vii.

BIGNAMI, A. Das Tropenfieber u. die Sommer-Herbstfieber d. gemäss. Klimate, C. f. B., P. u. Inf., 1898, (1), xxiv, p. 650.

BIGNAMI and BASTANIELLI. Osserv. nelle febbre malar. estivo-autunn., Rif. med., 1890, p. 1334.
— — Studi sull' inf. mal., Bull. R. Accad. med., Roma, 1893-94, xx.
— — Sulla strutt. dei par. mal. e in specie dei gameti d. par. est.-aut., Atti Soc. stud. d. mal., 1899, i.

CELLI, A., and F. SANFELICE. Über d. Paras. d. roth. Blutk. im Menschen u. in Thieren, Fortschr. d. Med., 1891, pp. 499, 541; Ann. istit. d'igiene sperim., Roma, 1891, N.S. i.

DANILEWSKI, B. Zur Parasit. d. Blutes, Biol. Centralbl., 1885-86, v, p. 529.
— La parasitologie comp. du sang, Charkow, 1889.
— Sur les microb. d' infect. malar. aiguë et chron. chez les oiseaux et chez l'homme, Ann. Inst. Pasteur, 1890, p. 753; 1891, p. 758.
— Über den Polymitus malariae, C. f. B. u. Par., 1891, ix, p. 397.

DIONISI, A. La malaria di alcune pipistrelli, Ann. d'igiene sperim., 1899, ix, 4; Atti soc. ital. p. stud. d. malaria, 1899, i.

GERHARDT. Über Intermittensimpfungen, Arch. f. klin. Med., 1884, vii.

GOLGI, C. Sull' infezione malarica, Arch. p. le sci. med., 1886, x; Arch. ital. de biol., 1887, viii; Fortschr. d. Med., 1889, 3.
— Sul ciclo evolutivo dei paras. mal. nella feb. terz., Arch. p. le sci. med., 1889, xiii.

GRASSI, B. Preliminary Communication in: Rend. R. Accad. d. Lincei, Roma, 1898, ser. 5, vii, pp. 163, 234, 314; 1899, viii, p. 165.
— Studi di un zoologo sulla malaria, Atti R. Accad. dei Lincei, Mem. cl. fis., 1900, ser. 5, iii; Roma, 1900; Die Malaria, Studien eines Zoologen, 2. Aufl., Jena, 1901; also in Italian, Roma, 1901.
— Documenti rig. la storia della scop. del modo di trasmiss. della malaria umana, Milano, 1903.

GRASSI, B., and A. DIONISI. Il ciclo. evol. degli emosporidi, Rend. R. Accad. d. Lincei, Roma, 1898, ser. 5, vii, 2 sem., p. 308.

GRASSI, B., and R. FELETTI. Über d. Paras. d. Malaria, C. f. B. u. P., 1890, vii, pp. 396, 340; Malariapares. in d. Vögeln, *ibid.*, 1891, iv, pp. 403, 429, 461; Weiteres zur Malariafrage, *ibid.*, 1891, x, pp. 449, 481, 517.

JANCSÓ, N. Zur Frage d. Inf. d. *Anopheles claviger* mit Mal.-Paras. b. nied. Temp., C. f. B., P. u. Inf., 1904, i Abt. Orig., xxxvi, p. 624; Der Einfl. d. Temp. a. d. geschl. Generationsentw. der Mal.-Paras. u. auf d. exper. Mal.-Erkr., *ibid.*, 1905, xxxviii, p. 650.

KOCH, R., and R. PFEIFFER. Beiträge z. Protozoenforsch.: I, Die Coccidienkrankh. d. Kaninchen, Berlin, 1892.
— — Ärztl. Beob. i. d. Tropen, Verhandl. d. D. Kol.-Ges. Abt. Charlottenburg-Berlin, 1897-98, Heft 7, p. 280.
— — Die Malaria in Deutsch-Ostafrika, Arb. kais. Gesundheitsamt, 1898, xiv, p. 292.
— — Reiseberichte über Rinderpest . . . trop. Malaria . . . Berlin, 1898.
— — Ergebn. d. wiss. Exped. nach Italien z. Erf. d. Malaria, Deutsche med. Wochensch., 1899, p. 69.
— — [Zwei] Berichte üb. d. Tätigkeit d. Malaria-Exp., *ibid.*, p. 601; 1900, p. 88.
— — Über die Entwickelung d. Mal.-Paras., Zeitschr. f. Hyg. u. Inf., 1899, xxxii, p. 1.

KOSSEL, H. Über einen malariaähnl. Blutparas. b. Affen, Zeitschr. f. Hyg., 1899, xxxii, p. 25.

KRUSE, W. Über Blutparasiten, Virchows Arch. f. path. Anat., 1890, cxx, p. 451; 1891, cxxi, p. 1395.

LABBÉ, A. Rech. zool. et biol. sur les par. endoglob. du sang d. vertébr., Arch. Zool exp., 1894 (3), ii, p. 55.

LAVERAN, A. Note sur un nouveau paras. trouvée dans le sang de plus. malad. att. de fièvre palustre, Bull. Acad. de Méd., Paris, 1880, November 23 and December 28.

— Communication sur la nat. paras. des accid. de l'impalud., C. R. Acad. Sci., Paris, 1881, xciii, p. 627; 1882, xcv, p. 737.

— Nature parasitaire des accidents de l'impaludisme, Paris, 1881, 8vo.

McCALLUM, W. G. On the Hæmatozoan Infection of Birds, Journ. Exper. Med., Baltimore, 1898, iii, p. 117.

MARCHIAFAVA, E., and A. CELLI. Les altér. des glob. roug. dans l'infect. par malaria, Arch. ital de biol., 1884, v.

— — Nuove ricerche sulla infez. malarica, Annali di agric., 1885, 1886; Fortschr. d. Med., 1885, Nos. 11 and 24; Arch. p. le sci. med., 1886, ix; 1888, xii; 1889-90, xiv; Arch. ital. de. biol., 1887, viii, p. 131; 1888, ix.

MAURER, G. Die Tüpfelung der Wirtszelle des Tertianparasiten, C. f. B., P. u. Inf., 1900, i Abt., xxviii, p. 114.

— Die Malaria perniciosa, C. f. B., P. u. Inf., 1902, i Abt. Orig., xxxii, p. 695.

NUTTALL, G. H. F. Die Mosquito-Malariatheorie, C. f. B., P. u. Inf., 1899, xxv, pp. 161, 209, 245, 285, 337.

— Neuere Forsch. üb. d. Rolle d. Mosqu. bei d. Verbreit. d. Mal., *ibid.*, pp. 877, 903; xxvi, p. 140; 1900, xxvii, pp. 193, 218, 260, 328.

PANICHI, M. Sulla sede del par. mal. nell' eritrocito dell' uomo, Arch. Farmacol. sper. e scienze aff., 1902, i, pp. 418, 450.

PEZOPOULO, N., and J. P. CARDAMATIS. Die Malaria in Athen, eine biolog. u. histol. Studie üb. d. Malariaplasmodien, C. f. B., P. u. Inf., 1906, i Orig., xl, p. 344.

PLEHN, F. Beitr. z. Lehre d. Malariainf., Zeitschr. f. Hyg., 1890, p. 78.

Reports to the Malaria Committee, Roy. Soc. Lond., 1900-1903, i-viii.

ROMANOWSKY, D. Zur Frage d. Paras. . . . d. Malaria, St. Petersb. med. Wochenschr., 1891, Nos. 34, 35.

ROSS, R. Untersuchungen über Malaria (translated by Schilling), Jena, 1905.

RUGE, R. Über d. Plasmod. bei Malariaerkr., Deutsche mil.-ärztl. Zeitschr., 1892, xxi, pp. 49, 109.

— Ein Beitr. z. Chromatinfärb. d. Mal.-Par., Zeitschr. f. Hyg., 1900, xxxiii, p. 178.

— Zur Tüpfelung der rot. Blutscheib. bei Febr. interm. tert., Arch. f. klin. Med., 1902, lxxii, p. 208.

SCHAUDINN, F. Über d. Generationswechsel d. Coccid. u. die neueren Mal.-Forsch., Sitzungsb. Ges. nat. Frde., Berlin, 1899, p. 159.

— Stud. üb. Krankheitserreg. Prot.: II, *Plasmodium vivax*, d. Erreger d. Tertianfieb. b. Mensch., Arb. Reichsges.-Amt., 1902, xix, p. 169.

SCHOO, H. J. M. Over Malaria: I, Welke Temperatur ist noodig voor de Amphigonie von *Plasmodium vivax?* Nederl. Tijdschr. v. Geneeskde., 1901, ii, p. 1338.

SCHÜFFNER, W. Beitr. zur Kenntn. der Malaria, Deutsch. Arch. f. kl. Med., 1899, lxiv, p. 428; Zur Tüpfelung der r. Blutsch. bei Febr. int. tert., *ibid.*, 1901, lxxi.

SERRA. Contrib. allo stud. d. posiz. del par. mal. in rapp. glob. rossi, Giorn. Accad. di med., Torino, 1905, Nos. 5 and 6.

THAYER, W. S. Recent Investigations upon Malaria, Med. News, 1899, lxxiv, p. 617.

VASSALL, J. J. Sur un hématoz. endoglob. nouv. d'un mammifère, Annal. Inst. Pasteur, 1905, xxi, p. 224.

ZIEMANN, H. Blutparas. bei heim. und trop. Malaria, C. f. B., P. u. Inf., 1896, i Abt., xx, p. 653; Z. Morph. d. Malariaparas., *ibid.*, 1897, xxi, pp. 641, 805.

Babesia (pp. 174 to 178).

BABES, V. Die Ätiologie der seuchenhaften Hämoglobinurie des Rindes, Virch. Arch. f. path. Anat., 1889, cxv.

— Bemerk. über d. Paras. des "Carceag." der Schafe und die paras. Ictero-Hämaturie der Schafe, *ibid.*, 1895, cxxxix.

— Bemerk. über d. Entdeckung der seuchenhaften Hämoglobinurie des Rindes und des Carceag. des Schafes, C. f. B., Par. u. Inf., 1903, i Abt., xxxiii, p. 449.

BONOME. Über paras. Ictero-Hämaturie der Schafe, Virch. Arch. f. path. An., 1895, Bd. cxxxix, p. 1.

CELLI, A., and F. G. SANTORI. Die Rindermalaria in der Campagna von Rom, C. f. B., P. u. Inf., 1897, xix, p. 561.

CHAUVELOT, E. Les babésioses, Paris, 1904.

DSCHUNKOWSKI, E., and J. LUHS. Die Piroplasmosen der Rinder, C. f. B., P. u. Inf., 1904, i Abt. Orig., xxxv, p. 486, 3 Taf.

FANTHAM, H. B. *Piroplasma muris* from the Blood of the White Rat, Quart. Journ. Micros. Sci., 1906, l, p. 483, 1 pl.

KINOSHITA, K. Untersuchungen üb. *Babesia canis*, Arch. f. Protistenkde., 1907, viii, p. 294.

KLEINE, F. K. Kultivierungsversuche d. Hundepiroplasmen, Zeitschr. f. Hyg. u. Inf., 1906, liv, p. 10.

KOCH, R. Reiseberichte, über Rinderpest . . . Texas-Fieber, Berlin, 1898.

— Vorl. Mitt. über die Ergebn. einer Forschungsreise nach Ostafrika, Deutsche med. Wochenschr., 1905, No. 45.

— Beitr. z. Entwicklungsgesch. der Piroplasmen, Zeitschr. f. Hyg. u. Inf., 1906, liv, p. 1.

KOSSEL, H., WEBER, SCHÜTZ and MIESSNER. Über die Hämoglobinurie der Rinder in Deutschland, Arb. a. d. Kais. Gesundheitsamt, 1903, xx, 1, 3 Taf.

LAVERAN, A. Contrib. à l'étude de *Piroplasma equi*, C. R. Soc. Biol., Paris, 1901, liii (14), p. 385.

LEBLANC, P. *Piroplasma canis*, C. R. Soc. Biol., Paris, 1900, lii, p. 168.

LINGARD, A. Can the *Piroplasma bigeminum* find a Habitat in the Human Subject? C. f. B., P. u. Inf., 1904, i Abt. Orig., xxxvi, p. 214.

LINGARD, A., and E. JENNINGS. A Preliminary Note on a Piroplasmosis found in Man and in Some of the Lower Animals, Ind. Med. Gaz., 1904, xxxix, p. 161.

LÜHE, M. Zur Kenntnis von Bau und Entw. d. Babesien, Zool. Anz., 1906, xxx, p. 45.

MIYAJIMA and SHIBAYAMA. Über das in Japan beobachtete Rinderpiroplasma, Zeitschrift f. Hyg., 1906, lii, p. 189.

NOCARD and MOTAS. Contrib. à l'étude de la piropl. canine, Ann. Inst. Pasteur, 1902, xvi, 1, p. 257, 2 pl.

NUTTALL, G. H. F., and G. S. GRAHAM-SMITH, Canine Piroplasmosis V, Journ. of Hyg., 1906, vi, p. 586.

SCHMIDT, A. Die Zeckenkrankh. der Rinder, Arch. f. wiss. u. prakt. Tierheilkunde, 1904, xxx, p. 42.

SMITH, T., and F. KILBORNE. Investigations into the Nature, Causation, and Prevention of Texas or Southern Cattle Fever, Eighth and Ninth Annual Reports, Bureau of Animal Industry, Washington, U.S.A., 1893, pp. 177-304, 10 pl.

THEILER, A. Die Piroplasmose des Maultieres und des Esels, Zeitschr. f. Tiermed., 1904, viii, p. 383.

WILSON, L. B., and W. M. CHOWNING. Studies in Piroplasmosis hominis, Journ. Infect. Dis., 1904, p. 31, 2 pl.

NEOSPORIDIA.

ORDER. *Myxosporidia* (pp. 181 to 184).

BALBIANI, G. Sur l'organis. et la nature d. psorosp., C. R. Acad. Sci., Paris, 1863, lvii, p. 157.

BÜTSCHLI, O. Zur Kenntn. der Fischpsorosp., Zeitschr. f. wiss. Zool., 1881, xxxv, p. 629.

COHN, L. Über die Myxospor. von *Esox lucius* u. *Perca fluviatilis,* In.-Diss., Königsberg, 1895, u. Zool. Jahrb. Anat., 1895, ix.

— Zur Kenntnis der Myxospor., C. f. B., P. u. Inf., 1902, i Abt. Orig., xxxii, p. 628.

CREPLIN, J. C. H. Beschreibung der Psorosporm. des Kaulbarsch. nebst Bemerkung über die der Plötze, Arch. f. Naturg., 1842, viii, 1, p. 61.

DOFLEIN, F. Stud. z. Nat. d. Prot. : III, Über Myxospor., Zool. Jahrb., Anat., 1898, xi, p. 281.

DUJARDIN, F. Hist. nat. des helm., Paris, 1845, p. 643.

GURLEY, R. On the Classification of the Myxosporidia, Bull. U.S. Comm. of Fish and Fishermen, 1891, Washington, 1893, p. 407.

— The Myxosporidia or Psorosperms of Fishes and the Epidemics produced by them, Rep. U.S. Comm. of Fish and Fishermen, 1892, Washington, 1894, p. 65.

HOFER, B. Die sogen. Pockenkrankh. d. Karpfen, Allg. Fisch.-Ztg., 1896, pp. 2, 28; 1902, p. 22.

JOSEPH, H. *Chloromyxum protei* n. sp., Arch. f. Protistenkde., 1907, viii, p. 398.

LAVERAN, A., and F. MESNIL. Sur une myxosp. des voies biliaires de l'Hippocampe, C. R. Soc. Biol., Paris, 1900, lii, p. 380.

— — Sur la multiplic. endog. d. Myxosporidies, C. R. Soc. Biol., Paris, 1902, liv, p. 469.

LEYDIG, F. Über Psorosperm. u. Gregarinen, Arch. f. Anat. u. Phys., 1851, p. 221.

LIEBERKÜHN, N. Über d. Psorosp., Arch. f. Anat. u. Phys., 1854, p. 349.

LUDWIG, H. Über d. Myxospor. d. Barben in d. Mosel, Jahresber. d. Rhein. Fisch.-Ver., 1888-89, p. 27.

LÜHE, M. *Cystodiscus immersus* Lutz., Verh. d. D. zool. Ges., 1899, p. 291.

MERCIER, L. Phénomènes de sexualité chez le *Myxobolus pfeifferi,* C. R. Soc. Biol., Paris, 1906, lx, p. 427.

MÜLLER, J. Über eine eigent. krankh. paras. Bildung mit specif. organis. Samenkörp., Arch. f. Anat. u. Phys., 1841, p. 477.

MÜLLER, J., and A. RETZIUS. Über paras. Bildungen, *ibid.*, 1842, p. 193.

PERUGIA, A. Sulle myxosp. d. pesci marini, Bull. scientif., Ann. xii-xiii, 1889-90, p. 10.
PFEIFFER, L. Die Protoz. als Krankheitserreger, 2. Aufl., Jena, 1891.
— Unters. über d. Krebs, Jena, 1892.
PLEHN, M. Über die Drehkrankh. der Salmoniden, Arch. f. Protistenkde., 1905, v, p. 145.
RAILLIET, A. La maladie d. barbeaux de la Marne, Bull. soc. centr. d'aquicult. France pour 1890, ii, p. 117.
SCHRÖDER, OL. Eine neue Myxosporidienart aus den Kiemen von *Acerina cernua,* Arch. f. Protistenkde., 1906, vii, p. 186.
SCHUBERG, A., and O. SCHRÖDER. Myxosp. a. d. Nervensyst. u. d. Haut der Bachforelle, Arch. f. Protistenkde., 1905, vi, p. 47.
THÉLOHAN, P. Rech. sur les Myxospor., Bull. scientif. France et Belg., 1895, xlvi, p. 100.
— Observ. sur les myxosp. et essai de classific. d. ces. org., Bull. soc. philom., Paris, 1892 (8), iv, p. 165.
WELTNER, W. Über Myxospor. in d. Eiern v. *Esox lucius,* Sitzungsber. Ges. naturf. Frde., Berl., 1892, p. 28.
ZSCHOKKE, F. Myxospor. d. Gattg. *Coregonus,* C. f. B., P. u. Inf., 1898 (1), xxiii, p. 602; Mitt. nat. Ges., Lucerne, 1898, 2, p. 205.

ORDER. *Microsporidia* (pp. 184 to 186).

BALBIANI, G. Rech. sur les corpusc. de la pébrine, Journ. de l'Anat. et de la Phys., 1866, iii, p. 599.
— Etud. sur la maladie psorosperm. des vers à soie, *ibid.,* 1867, iv, pp. 263, 329.
BOLLE, J. Der Seidenbau in Japan, Budapest, Wien, Leipzig, 1898, p. 94.
GLUGE. Tumeurs enkystées observées sur la peau des épinoches, Bull. Acad. roy. de Belg., 1838, v, p. 772.
HENNEGUY. Note sur un paras. d. muscl. du *Palaemon rectirostris*, Mém. soc. philom. à l'occas. du centenn. de sa fondat, Paris, 1888.
HENNEGUY and THÉLOHAN. Myxospor. par d. muscl. chez quelq. crust. décap., Ann. microgr., Paris, 1892, iv, C. R. Soc. Biol., Paris, 1892 (9), iv, C. R. Acad. Sci., Paris, 1892, cxiv.
HESSE, E. Sur une nouv. microsp. tétraspor. du genre *Gurleya,* C. R. Soc. Biol., Paris, 1903, lv, p. 495.
— Sur la prés. d. microsp. du genre *Thelohania* chez les insectes, C. R. Acad. Sci., Paris, 1903, cxxxvii, p. 418.
— *Thelohania legeri* n. sp., microsp. nouv. d. larves d'*Anopheles maculipennis* Meig., C. R. Soc. Biol., Paris, 1904, lvii, p. 570.
— Sur *Myxocystis mrázeki,* microsp. par de *Limnodrilus hoffmeisteri* Clap., C. R. Soc. Biol., Paris, 1905, lviii, pp. 12-15.
KOROTNEFF, A. *Myxosporidium bryozoides*, Z. f. w. Zool., 1892, liii, p. 591.
KULAGIN, N. Zur Entw. v. *Glugea bombycis* Thél., Zool. Anz., 1898, xxi, p. 469.
LEBERT, H. Über die gegenwärtig herrsch. Krankh. des Insects d. Seide, Berl. entom. Ztschr., 1858, ii, p. 149.
LEYDIG, FR. Zur Anat. v. *Coccus hesperidum*, Z. f. w. Zool., 1854, v, p. 11.
— Zum fein. Bau d. Arthropoden, Arch. f. An. u. Phys., 1855, p. 397.
— Über Paras. nied. Tiere, Arch. f. path. Anat., 1858, p. 280.
— Der Parasit in der neuen Krankh. d. Seidenraupe, Arch. f. Anat. u. Phys., 1863.

LUTZ, A., and A. SPLENDORE. Über Pebrine u. verw. Microspor., C. f. B., P. u. Inf., 1903, i Abt., xxxiii, p. 150.
MONIEZ, R. Note sur des paras. d. helm., Bull. scient. du Départ. du Nord, 1879 (2), ii, p. 304.
— Observ. pour la revis. d. microsporid., C. R. Acad. Sci., Paris, 1887, civ, p. 1312.
MRÁZEK. Sporozoenstudien: II, *Glugea lophii* Dofl., Sitzungsber. k. böhm. Ges. der Wiss., math.-nat. Kl., 1899, Prag, 1900.
PASTEUR, L. Etude sur la maladie des vers à soie, Paris, 1870.
PÉREZ, CH. Sur une nouv. microsp. paras. d. *Carcinus maenas*, C. R. Soc. Biol., Paris, 1904, lvii, p. 214.
PERRONCITO, E. Il coccidio jalino ed il microsp. poliedrico nell' uomo, Giorn. Accad. Med., Torino, 1902, Ann. 65, p. 378.
PFEIFFER, L. Beitr. zur Kenntn. d. pathog. Gregar.: I, Die Microsporidien und die Fleckenkrankh. (Pébrine) d. Seidenspinners, Zeitschr. f. Hyg., 1888, iii.
STEMPELL, W. Über *Thélohania mülleri* (L. Pfr.), Zool. Jahrb. Anat., 1902, xvi, p. 235.
— Über *Nosema anomalum* Moniez, Arch. f. Protistenkunde., 1904, iv, p. 1.
VANEY, C., and A. CONTE. Sur une nouv. microsp., *Pleistophora mirandellae*, paras. de l'ovaire d'*Alburnus mirandella* Blanch., C. R. Acad. Sci., Paris, 1901, cxxxiii, p. 644.

ORDER. *Actinomyxidia* (p. 187).

Some earlier literature will be found quoted in :—

CAULLERY, M., and F. MESNIL. Recherches sur les Actinomyxidies, I, Arch. f. Protistenkde., 1905, vi, 3, p. 272.

ORDER. *Sarcosporidia* (pp. 187 to 194).

BERTRAM, A. Beitr. zur Kenntn. d. Sarcosp., Zool. Jahrb., 1892, v, p. 581.
BLANCHARD, R. Sur un nouv. type d. Sarcospor., C. R. Acad. Sci., Paris, 1885, c, p. 1599.
— Note sur les Sarcospor. et sur un ess. d. classif. d. ces sporoz., Bull. Soc. Zool. France, 1885, x, p. 244.
DAMMANN, C. Psorosp.-Krankh. beim Schaf., Arch. f path. Anat., 1867, xli, p. 283.
EECKE, J. VAN. Sarcosporidien, Geneesk. Tijdschr. v. Nederl.-Indie, 1892, xxxii; Jaarsverl. Labor. path. An. en Bact. te Weltevreden (1892), Batavia, 1893.
FORET, P. Observ. rel. au dével. de la cuticle chez le *Sarcocystis tenella*, Arch. d'Anat. Micr., 1903, vi, p. 86; C. R. Soc. Biol., Paris, 1903, lv, p. 1054.
HESSLING, V. Histol. Mittheil., Zeitschr. f. wiss. Zool., 1854, v, p. 189.
KOCH, M. Über Sarcosporidien, Verh. V. intern. Zool. Congr., Berlin, Jena, 1902, p. 674.
— Die experimentelle Übertrag. d. Miescherschen Schläuche, Berl. klin. Wochenschr., 1904, li, p. 321.
KORTÉ, W. E. de. On the Presence of Sarcosporidia in the Thigh Muscle of *Macacus rhesus*, Journ. of Hyg., Cambridge, 1905, v, p. 451.
LAVERAN, A., and F. MESNIL. Morph. d. sarcospor., C. R. Soc. Biol., 1899 (x), vi, p. 245.

LEISERING and WINKLER. Psorosp.-Krankh. beim Schaf., Ber. üb. Veterin.-Wesen, Königr., Sachsen, 1865; Arch. f. path. Anat., 1865, xxxvii, p. 431.

MANZ, W. Beitr. z. Kenntn. d. Miescherschen Schläuche, Arch. mikr. Anat., 1867, iii, p. 345.

MIESCHER, F. Über eigent. Schläuche in d. Musk. einer Hausmaus, Ber. über die Verh. d. naturf. Ges., Basel, 1843, v, p. 198; Reprinted in Verh. d. V. internat. Zool.-Congr., Berlin, Jena, 1902, p. 679.

PIANA, G. P. Fasi evol. d. Sarcosp., La clinica veter., 1896, p. 145; C. f. B., P. u. Inf. (1), xx, p. 39.

PLUYMERS, L. Des sarcosp. et de leur rôle dans la pathog. d. myositis, Arch. Méd. exp. et d'Anat. pathol., 1896, p. 761; C. f. B., P. u. Inf. (1), xxii, p. 245.

RAINEY, G. Structure and Development of Cysticercus Cells as found in the Muscles of the Pig, Phil. Trans. Roy. Soc., 1858, cxlvii, p. 111.

RIECK, V. Sporozoen als Krankheitserreger, Deutsche Zeitschr. f. Thiermed. u. vergl. Path., 1889, xiv, p. 75.

RIEVEL and BEHRENS. Beitr. zur Kenntn. d. Sarcosp. und deren Enzyme, C. f. B., P. u. Inf., 1903, i Abt. Orig., xxxv, p. 341.

RIVOLTA. Dei paras. veget., Torino, 1873; Giorn. an., fis. e pat. d. anim., 1874, vi, p. 25.

SCHNEIDEMÜHL, G. Über Sarcosporidien, Thiermed. Vortr., Leipzig, 1897, iii, p. 11.

SIEBOLD, C. TH. V. Zusatz [zu Hessling. histol. Mittheil.], Zeitschr. f. wiss. Zool., 1854, v, p. 199.

SIEDAMGROTZKY, O. Psorosp. in d. Musk. d. Pferde, Wochenschr. f. Thierheilkde. u. Viehz., 1872, xvi, p. 97.

SMITH, TH. The Production of Sarcosporidia in the Mouse by Feeding Infected Muscle Tissue, Journ. Exp. Med., Baltimore, 1902, vi, p. 1.

— Further Observations on the Transmission of *Sarçocystis muris* by Feeding, Journ. Med. Res., 1905, xiii, p. 429.

STILES, CH. W. Notes on Parasites: 18, Presence of Sarcosporidia in Birds, U.S. Dept. of Agric., Bur. of An. Ind., Bull. 3, 1893, p. 79.

Sarcosporidia observed in Man (pp. 193, 194).

BARABAN and ST. REMY. Sur un cas d. tub. psorosp. obs. chez l'homme, C. R. Soc. Biol., Paris, 1894 (x), i, p. 201.

— — Le parasitisme d. sarcosp. chez l'homme, Bibliogr. anat., 1894, p. 79.

BRAUN, M. Zum Vork. d. Sarcosporid. b. Menschen, C. f. B. u. Par., 1895 (1), xviii, p. 13.

KARTULIS. Über pathog. Protoz. b. Menschen, Zeitschr. f. Hyg., 1893, xiii, p. 1.

LINDEMANN. Über d. hygien. Bedeutung d. Gregarinen, Deutsche Zeitschr. f. Staatsarzneikde., 1868.

ROSENBERG. Ein Befund von Psorosp. im Herzmuskel d. Mensch., Zeitschr. f. Hyg., 1892, xi, p. 435.

VUILLEMIN, P. Le *Sarcocystis tenella,* paras. de l'homme, C. R. Acad. Sci., Paris, 1902, cxxxiv, p. 1152.

ORDER. *Haplosporidia* (pp. 194 to 197).

CAULLERY, M., and F. MESNIL. Rech. sur les Haplosporidies, Arch. de Zool. exp., 1905, sér. iv, iv, p. 101, in which a good bibliography is given.

MINCHIN, E. A., and H. B. FANTHAM. *Rhinosporidium kinealyi* n. g., n. sp., a New Sporozoon from the Mucous Membrane of the Septum Nasi of Man, Quart. Journ. Micros. Sci., 1905, xlix, p. 521.

Class IV.—Infusoria (pp. 198 to 210).

BÜTSCHLI, O. Studien über . . . die Conjugation d. Infusorien, Abh. d. Senckenb. naturf. Ges., 1876, x.

EHRENBERG, CH. G. Die Infusionsthierchen als vollkommene Organismen, Leipz., 1838.

GUIART, J. Sur un nouv. infus. paras. de l'homme, C. R. Soc. Biol., Paris, 1903, lv, p. 245.

HERTWIG, R. Über die Conjugation d. Infusorien, Abh. kgl. bayer. Akad. d. Wiss., 1889, ii, Kl., xvii.

KENT, SAV. A Manual of the Infusoria, London, 1880-1882.

MAUPAS, E. Rech. expér. sur la multipl. des Infusoires ciliés, Arch. Zool. exp., 1888 (2), vi.

— Le rajeunissement karyogamique chez les Ciliés, *ibid.*, 1889, vii.

STEIN, FR. V. Der Organismus der Infusionsthiere, Leipz., 1859-1867.

Balantidium coli (pp. 200 to 204 and 637).

ASKANAZY, M. Pathog. Bedtg. d. *Bal. coli*, Wien. med. Wochenschr., 1903, liii, p. 127; Verh. d. D. path. Ges., v (1902), Berlin, 1903, p. 224.

CASAGRANDI, O., and P. BARBAGALLO. *Bal. coli* s. *Param. coli*, Catania, 1896, 8vo.

COLLMANN, B. Fünf Fälle von *Bal. coli* im Darm d. Mensch., In.-Diss., Kgsbg., Pr., 1900.

EHRNROTH, E. Z. Frage der Pathogenität d. *Bal. coli*, Zeitschr. f. klin. Med., 1903, xlix, p. 321.

GRASSI, B. Signif. patol. d. prot. par. dell' uomo, Atti Accad. Lincei, Rendic., 1888 (4), iv, Sem. 1, p. 86.

JANOWSKI, W. Ein Fall von *Bal. coli* im Stuhl, Zeitschr. f. klin. Med., 1897, xxxii, p. 415. (With copious literature compiled by Shegalow, Solowjew and Klimenko.)

KLIMENKO, W. Beitr. z. Pathol. d. *Bal. coli*, Beitr. z. path. Anat. u. allg. Path., 1903, xxxiii, p. 281.

KOSLOWSKI, J. J. Zur Lehre v. d. Infus., die als Paras. im Verdauungskan. d. Mensch. vork., Arch. f. Verdauungskrankh., 1905, xi, p. 31.

KOSSLER, K. Ein Fall von *Balantidium*-Colitis, Wien. med. Wochenschr., 1906, lvi, p. 522.

MAGGIORA, A. Microsk. u. bacter. Beob. während einer epid. dysent. Dickdarmentzdg., C. f. B. u. Par., 1892, xi, p. 181.

MALMSTEN, P. H. Infusorien als Intestinalthiere b. Mensch., Arch. f. path. Anat., 1857, xii, p. 302.

NAGEL. Üb. ein. Fall v. Infusorienenteritis, Münch. med. Wochenschr., 1905, No. 44.

SHEGALOW, J. P. Ein Fall von *Bal. coli* bei einem 5 jähr. Mädchen, Jahrb. f. Kinderhlkde., 1899, xlix, p. 425.

SIEVERS, R. Über *Bal. coli* im menschl. Darm u. dessen Vork. in Schwed. u. Finland, Arch. f. Verdauungskrankh., 1900, v. Abstracted in C. f. B., P. u. Inf., 1900 (1), xxviii, p. 328.

SIEVERS, R. Zur Kenntn. d. Verbreit. v. Darmparas. d. Menschen in Finland, Helsingfors, 1905; Festschr. f. Palmén, No. 10.

SOLOWJEW. *Bal. coli* als Erreger chron. Durchfälle, C. f. B., P. u. Inf., 1901 (1), xxix, pp. 821, 849. [Solowjew's additional communication that appeared in "Wratsch," 1901, Nos. 12 and 14, as well as in the "Russki Wratsch," 1902, No. 14, has been translated into German by Klimenko (l. c.).]

STOKVIS, B. J. *Paramaecium* in sputa, Nederl. Tijdschr. v. Geneeskde., 1884 (2), xx.

STRONG, R. P., and W. E. MUSGRAVE. Preliminary Note of a Case of Infection with *Balantidium coli*, Bull. Johns Hopkins Hosp., Baltimore, 1901, xii, p. 31.

— — The Clinical and Pathological Significance of *Balantidium coli*, Dept. of Int. Bureau, Govt. Labor. Biol., Manila, No. 26, 1905, p. 1.

WLAJEFF, G. Zur Frage d. Ätiol. u. Behandlg. d. Dysenterie, Wracebraja Gaseta, Kemmern, 1905, xii, p. 913; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxvii, p. 757.

WOIT, O. Drei neue Fälle von *Bal. coli* i. menschl. Darm., Deutsch. Arch. f. klin. Med., 1898, lx, p. 363.

Balantidium minutum (pp. 204 and 637).

JAKOBY, M., and F. SCHAUDINN. Üb. zwei neue Infus. i. Darm. d. Mensch., C. f. B., P. u. Inf., 1899 (i), xxv, p. 487.

SCHULZ. *Colpoda cucullus* im Darm d. Mensch., Berl. klin. Wochenschr., 1899, No. 16, p. 353.

Nyctotherus (pp. 204 to 206 and 637).

CASTELLANI, A. Observations on some Protozoa found in Human Fæces, C. f. B., P. u. Inf., 1905, i Abt. Orig., xxxviii, p. 66.

JAKOBY, M., and F. SCHAUDINN. Über zwei Infus. i. Darm d. Mensch., *ibid.*, 1899 (1), xxv, p. 487.

KRAUSE, P. Üb. Infus. im Typhusstuhle nebst Beschreibg. einer bisher noch nicht beob. Art. (*Balantidium giganteum*), Deutsch. Arch. f. klin. Med., 1906, lxxxvi, p. 442.

Chlamydozoa (pp. 207 to 210).

BOSC, F. J. Les malad. bryocytiques (malad. à protozoaires), II, La maladie vaccinale (*Plasmodium vaccinæ*), C. f. B., P. u. Inf., i Orig., xxxvi, p. 630; xxxvii, pp. 39, 195.

— Les malad. bryocyt., III, La variole et son parasite (*Plasmodium variolæ*), *ibid.*, xxxix, pp. 36, 129, 247, 389, 594.

CALKINS, G. N. The Life-history of *Cytoryctes variola*, Journ. Med. Research, Boston, 1904, xi, p. 136.

COUNCILMAN, MAGRATH, BRINCKENHOFF, TYZZER, SOUTHARD, THOMPSON, BANCROFT and CALKINS. Studies on the Pathology and on the Etiology of Variola and of Vaccinæ, Journ. Med. Research, Boston, 1904, xi, 1, 1904.

GORINI, C. Über die bei der mit Vaccine ausgef. Hornhautimpf. vorkomm. Zelleinschlüsse, C. f. B., P. u. Inf., 1900, i, Abt. xxviii, pp. 233, 589; 1902, i Orig., xxii, p. 111.

GUARNIERI, G. Ric. sulla patogenesi ed etiol. dell' inf. vacc. e variolosa, Arch. sci. med., Torino, 1892, xvi.

— Ulteriori ric. sulla etiol. e sulla patog. della inf. vacc., Clinica moderna, Firenze, 1897, iii.

HÜCKEL. Die Vaccinekörperchen, Beitr. z. pathol. Anat. u. z. allg. Path., Supp. II, 1898.

LOEFF, A. VAN DER, in Weekbl. van het Nederl. Tijdschr. v. Geneeskde., 1886, No. 46.

MÜHLENS, P., and M. HARTMANN, Zur Kenntnis d. Vaccineerregers, C. f. B., P. u. Inf., 1906, i Orig., xxxxi, pp. 41, 203, 338, 435.

PRÖSCHER, F. Über d. künstl. Züchtung eines "unsichtbaren" Mikroorgan. aus der Vaccine, C. f. B., P. u. Inf., 1906, i Orig., xl, 3, p. 337.

PROWAZEK, S. Unters. üb. d. Vaccine, I, Arb. a. d. kais. Gesundheitsamt, 1905, xxii, p. 535.

— Unters. üb. d. Vaccine, II, *ibid.*, 1906, xxiii, p. 525.

SALMON, P. Rech. sur l'infect. dans la vaccine et la variole, Annal. Inst. Pasteur, 1897, xi, No. 4.

SCHULZE, F. E. *Cytorrhyctes luis* Siegel, Berl. klin. Wochenschr., 1905, No. 21.

SCHULZE, W. Impfungen mit Luesmaterial an Kaninchenaugen, Klin. Monatsbl f. Augenheilkde., 1905, xliii.

— Das Verhalten der *Cytorrhyctes luis* in der mit Syphilis geimpften Kanin cheniris, Beitr. z. path. Anat. u. z. allg. Path., 1906, xxxix, p. 180.

SIEGEL, J. Zur Kritik der bisherigen Cytorrhyctesarbeiten, C. f. B., P. u. Inf., 1906, i Orig., xlii, pp. 128, 225, 321, 480.

WASIELEWSKI, V. Beitr. z. Kenntnis d. Vaccineerregers, Zeitschr. f. Hyg., 1901, xxxviii, p. 212.

(B) PLATYHELMINTHES (pp. 211 to 359, 638 to 698 and 753 to 755).

Class II.—Trematodes (pp. 212 to 282, 638 to 644, 753, and 754).

[*N.B.*—The literature, which is very comprehensive, has, up to the year 1892, been quoted and critically examined in Braun's monograph on the Trematodes: Bd. iv, Abth. i, of Bronn's "Klass. u. Ord. d. Thierreichs," Leipz. Of works that have appeared later it is not possible to do more than enumerate the following.]

BETTENDORF, H. Musculatur u. Sinneszell. d. Tremat., Zool. Jahrb. Anat., 1897, x, p. 307.

BLOCHMANN, F. Die Epithelfrage bei Cestoden u. Trematoden, Hamburg, 1896.

BRAUN, M. Arten d. Gattg. *Clinostomum*, Zool. Jahrb., 1900, Syst. xiv, p. 1.

— Trematoden d. Chelonier, Mitt. zool. Mus. Berlin, 1901, ii, p. 1.

— Trematoden d. Chiroptera, Annal. K. k. naturh. Hofmus., Wien, 1900, xv, p. 217.

— Zur Kenntn. d. Tremat. d. Säugeth., Zool. Jahrb., 1901, Syst. xiv, p. 311.

— Fascioliden d. Vögel, *ibid.*, 1902, xvi, p. 1.

BRUGGE, G. Zur Kenntn. d. Excretionsgefässsyst. d. Cestoden u. Tremat., Zool. Jahrb. Anat., 1902, xvi, p. 208.

FISCHOEDER, F. Die Paramphistomiden d. Säugeth., Zool. Jahrb., 1903, Syst. xvii, p. 485.

GRONKOWSKI, C. V. Zum feineren Bau d. Tremat., Poln. Arch. f. biol. u. med. Wiss., 1902, i.

HEIN, W. Zur Epithelfrage d. Tremat., Zeitschr. f. wiss. Zool., 1904, lxxvii, p. 546.

LOOSS, A. Die Distomen unserer Fische und Frösche, Stuttg., 1894; Bibl. zool., xvi.
– Rech. faune paras. de l'Egypte, I, Mém. Inst. égypt., 1896, iii, p. 1.
–– Weit. Beitr. z. Kenntn. d. Tremat.-Fauna Ägypt, Zool. Jahrb., 1900, Syst. xii, p. 521.
— Über neue u. bekannte Tremat. aus Seeschildkröten, *ibid.*, 1902, xvi, p. 411.
MACLAREN, W. Beitr. z. Kenntn. einig. Tremat., Jen. Zeitschr. f. Naturw., 1903, xxxviii, p. 573.
MONTICELLI, F. S. Stud. tremat. Endopar., I, Zool. Jahrb., 1893, Suppl. iii.
ROEWER, C. F. Beitr. z. Histogenese v. Cercariaeum helicis, Jen. Zeitschr. f. Naturw., 1906, xli, p. 185.
SCHUBMANN, W. Eibildung u. Embryonalentw. v. *Fasciola hepatica*, Zool. Jahrb. Anat., 1905, xxi, p. 571.
ZIEGLER, H. E. Das Ectoderm d. Plathelminthen, Verh. D. zool. Ges., 1905, p. 35.

Watsonius watsoni (pp. 234, 235).

CONYNGHAM, H. F. A New Trematode of Man, Brit. Med. Journ., 1904, ii, p. 663; Lancet, 1904, ii, p. 464.
SHIPLEY, A. E. *Cladorchis watsoni* (Conyngham), a Human Parasite from Africa, Thompson, Yates and Johnston Lab. Report, Liverpool, 1905, vi, 1, p. 129.

Gastrodiscus hominis (pp. 236, 237).

GILES, G. M. A Report of an Investigation into the Causes of the Disease known in Assam as Kála-azár and Beriberi, Shillong, 1890, p. 125.
LEUCKART, R. Die Paras. d. Mensch., 2. Aufl., ii, p. 450, where the first discovery is reported in greater detail.
LEWIS, T. R., and MCCONNEL. A New Parasite Affecting Man, Proc. Asiatic Soc., Bengal, 1876, p. 182.

Fasciola hepatica (pp. 237 to 244, and 638).

AMMON. Klin. Darst. d. Krankh. d. menschl. Auges, Dresden, 1838.
BOSSUAT, E. Les helminth. dans le foie, Arch. de Paras., 1902, vi, p. 186. [The author is in error when he writes "The name *Dist. sibiricum* originated from M. Braun"!]
COE, W. R. Bau des Embryos v. *Dist. hep.*, Zool. Jahrb. Anat., 1896, ix, p. 561.
DUFFEK, E. *Dist. hep.* beim Mensch., Wien. klin. Wochenschr., 1902, p. 772.
GAIDE, *cf.* under *Clonorchis sinensis* (p. 787).
GESCHEIDT and AMMON. Die Entoz. d. Auges, Zeitschr. f. Ophth., 1833, iii, p. 405.
GREEFF, R. Über d. Vork. v. Würmern im Auge, Arch. f. Augenheilkde., 1907, lvi, p. 334.
HAVET, J. Contrib. à l'étud. d. syst. nerv. d. Trémat., La Cellule, 1900, xvii, p. 351.
HENNEGUY, L. F. Rech. sur la mode de form. de l'œuf du *Dist. hep.*, Arch. d'anat. micr., 1906, ix, p. 47.
KHOURI, A. Le Halzoun, Arch. de Paras., 1904, ix, 1, p. 78.
KÜCHENMEISTER, F. On Animal and Vegetable Parasites of the Human Body, translated by E. Lankester, London, 1857.
LEUCKART, R. Z. Entw. d. Lebereg., Arch. f. Naturg., 1882, i, p. 80.
LUTZ, A. Lebensgesch. d. *Dist. hep.*, C. f. B. u. P., xi, p. 783; xiii, p. 320.

MALHERBE. Progr. méd., 1898, vii, No. 4.

MARCINOWSKI, K. Das untere Schlundgangl. von. *Dist. hep.*, Jen. Zeitschr. f. Naturw., xxxvii, 1903, p. 544.

NORDMANN, A. v. Mikrograph. Beitr. z. Naturgesch. d. wirbellos. Thiere, Berlin, 1832, ii, p. 9.

PALLAS, P. S. De infestis viventibus intra viventia, Diss. in., Lugd., Batavia, 1760.

SAITO, S. Beitr. z. Kenntn. d. geogr. Verbr. d. *Dist. hep.*, C. f. B., P. u. Inf., 1906, i Orig., xli, p. 822.

SCHAPER. Die Leberegelkrankheit. d. Schafe, Deutsche Zeitschr. f. Tiermed., 1890, xvi, p. 1.

SOMMER, L. Anat. d. Leberegels, Z. f. w. Zool., 1880, xxxiv, p. 539.

STIEDA, L. Beitr. z. Anat. d. Plattw. : I, Arch. f. Anat. u. Phys., 1867, p. 52.

— Über d. angebl. inneren Zusammenhang d. männl. u. weibl. Org. b. Tremat., *ibid.*, 1871, p. 31.

STILES, C. W. Frogs, Toads and Carp as Eradicators of Fluke Diseases, Ann. Rep. Bur. of Anim. Ind., 1901, Wash., 1902, xviii, p. 220.

THOMAS, P. The Life-history of the Liver Fluke, Quart. Journ. Micros. Sci., 1883, xxiii, p. 99.

[*N.B.*—A bibliography of cases has been compiled by Davaine (1877), Leuckart (1889-1894), Moniez (1896), Blanchard (1889), and Huber (1895), in addition to Khouri (l. c.).]

Fasciola gigantica (pp. 244, 245).

COBBOLD, TH. SP. Description of a New Trematode Worm (*Fasciola gigantica*), Edin. New Phil. Journ., 1855, N.S. ii, p. 262.

— Entozoa, an Introduction to the Study of Helminthes, London, 1864, pl. i.

GOUVEA, H. DE. La distomatose pulm. par la douve du foie, Thèse, Paris, 1895.

LOOSS, A. Rech. sur la faune de l'Egypte, Mém. Inst. égypt., 1896, iii, p. 33.

— Obs. à prop. d'une note . . . C. f. B., P. u. Inf. (1), 1898, xxiii, p. 459.

RAILLIET, A. Sur une forme partic. de douve hépat. prov. de Sénegal, C. R. Soc. Biol., Paris, 1895, 10e sér., ii, p. 338.

Fasciolopsis buski (pp. 245, 246, and 638).

BUDD, G. On Diseases of the Liver, London, 1852.

COBBOLD, T. SP. On the Supposed Rarity of . . . *Dist. crassum*, Journ. Linn. Soc., 1875, xii, p. 285; Obs. on the Large Human Fluke, Veterinarian, 1876.

GILES, G. M., *cf.* under *Gastrodiscus hominis* (p. 784).

LANKESTER, E. Manual of Animal and Vegetable Parasites (Küchenmeister), London, 1857, App. i, B. p. 437.

LEIDY, J. On *Distomum hepaticum*, Proc. Acad. Nat. Sci., Philadelphia, 1873, p. 364.

ODHNER, TH. *Fasciolopsis buski*, C. f. B., P. u. Inf., i Orig., xxxi, p. 573.

Fasciolopsis rathouisi (pp. 246, 247).

POIRIER, P. Note sur une nouv. esp. de Dist. paras. de l'homme, Arch. Zool. exp., 1887 (2), v, p. 203.

Paragonimus ringeri (pp. 249 to 251, 639 and 640).

BAELZ, E. Über paras. Haemopt., Centralbl. f. med. Wiss., 1880, p. 721.
— Über einig. neue Paras. d. Mensch., Berl. klin. Wochenschr., 1883, p. 234.
INOUYE, J. Über d. *Dist. ringeri* Cobb, Zeitschr. f. klin. Med., 1903, l, p. 120, with list of Japanese literature.
JANSON, J. Die bish. in Japan bei Schweinen gef. Paras., Mitt. d. Ges. f. Natur- u. Völkerkde. Ostasiens, 1897, Heft 59-60.
KATSURADA, F. Beitr. z. Kenntn. d. *Dist. westerm.*, Beitr. z. path. Anat. u. z. allg. Path., 1900, xxviii, p. 506.
KERBERT, C. Zur Trem.-Kenntn., Zool. Anz., 1878, i, p. 271.
— Beitr. z. Kenntn. d. Tremat., Arch. f. mikros. Anat., 1881, xix, p. 519.
MANSON, P. *Dist. ringeri,* Med. Times and Gaz., 1881, ii, p. 8; 1882, ii, p. 42.
MIURA, M. Fibr. Tuberkel verurs. durch Parasiteneier, Arch. f. path. Anat., 1889, cxvi.
MONTEL, R. Distomiase pulm. en Cochinchine, Annal. d' Hyg. et de Méd. Col., 1906, ix, p. 258.
RAILLIET, A. Paras. des anim. domest. du Japon, Le Natural., 1891, xii, p. 143.
STILES, C. W. Notes on Parasites, No. 26; *Dist.* (*Mesogon.*) *westermanni,* Discovery of a Parasite of Man, new to the United States, Vet. Journ., 1894, p. 107.
STILES, C. W., and A. HASSALL. Notes on Parasites, No. 50: A Muscle Fluke in American Swine, XVI Ann. Rep., Bur. of Anim. Industry (1899), Wash., 1900, p. 559.
— No. 51, The Lung Fluke in Swine, *ibid.*, p. 560.
TANIGUCHI. Ein Fall von *Distomum*-Erkrankung des Gehirns mit dem Symptomenkomplex von Jacksonscher Epilepsie, Arch. f. Psych. u. Nervenheilk., 1904, xxxviii, No. 1.
WARD, H. B. *Dist. westerm.* in den Vereinigten Staaten, C. f. B. u. P., 1894, xiv, p. 362; 1895, xvii, p. 304.
YAMAGIVA, K. Lungendistomenkrankh. in Japan, Arch. f. path. Anat., 1892, cxxvii; Zur Ätiologie der Jacksonschen Epilepsie, *ibid.*, 1890, cxix.

Ophisthorchis felineus and *Metorchis truncatus* (pp. 252 to 255, 261 and 262).

ASKANAZY, M. Über Inf. d. Mensch. mit *Dist. felin.* in Ostpreussen u. ihren Zusammenhang mit Leberkrebs, C. f. B., P. u. Inf. (1), 1900, xxviii, p. 491; Verh. d. Deutsch. path. Ges., 1900, iii, p. 72.
— Die Ätiologie u. Path. d. Katzenegelerkrankg. d. Mensch., Deutsche med. Wochenschrift, 1904, xxx, p. 689; Verh. d. Ver. f. wiss. Heilkde. i. Königsb. i. Pr., 1904, iii, p. 3.
— Weitere Mitteil. üb. d. Quellen d. Inf. mit *Dist. felineum*, Schrift d. Phys.-oek. Ges., Königsberg i. Pr. (1905), 1906, xlvi, p. 127.
BRAUN, M. Die Leberdistomen d. Hauskatze u. verw. Arten, C. f. B. u. Par., 1893, xiv, p. 381.
— Über ein für den Menschen neues Distomum, *ibid.,* 1894, xv, p. 602.
CHOLODKOWSKY, N. Icones helm. hom., II, St. Petersb., 1898, Taf. xi, 115.
KAMENSKY, G. Not. helm., I, Charkow, 1900.
KHOLODKOWSKY, N. Sur quelq. rar. paras. de l'homme en Russie, Arch. de Paras., 1898, i, p. 354.
RIVOLTA. Sopra una spec. di *Distoma* nel gatto e nel cane, Giorn. anat., fisiol. e pat. d. animali, 1884, xvi, p. 20.

WARD, H. B. On *Dist. fel.* in the United States, Vet. Mag., 1895.
— Notes on Parasites of the Lake Fish : III, On the Structure and the Copulatory Organ in *Microphallus*, Stud. Zool. Lab., Univ. Nebraska, May, 1901, p. 174.
WINOGRADOFF, K. Ein neues Dist. a. d. menschl. Leber, Nachr. v. d. k. Tomskischen Univ. (1891), 1892, iv, p. 116; Ein zweiter Fall von *Dist. sib.*, *ibid.*, p. 131.
— Über Würmer, welche im menschl. Körper paras., *ibid.* (1892), 1893, v.
ZWAARDEMAKER, H. Cirrhosis parasit., Arch. f. path. Anat., 1890, cxx, p. 197.

Amphimerus noverca (p. 258).

COBBOLD, T. SP. Synopsis of the *Distomidæ*, Journ. Linn. Soc., London, 1859, Zool., v, p. 8; Further Observations on Entozoa, with Experiments, Trans. Linn. Soc., London, 1862; xxiii, p. 349, pl. 33, figs. 1 and 2.
LEWIS, T. R., and D. CUNNINGHAM. Micros. and Phys. Res., XI Ann Rep. San. Comm. Govt. India, Calcutta, 1872, Appendix C, p. 168.
MCCONNELL, J. F. P. On the *Dist. conj.* as a Human Entozoon, Lancet, 1876, i, p. 343; 1878, i, p. 476.

Clonorchis sinensis and *Cl. endemicus* (pp. 258 to 261, 640, and 641).

BAELZ, E. Über einige neue Parasiten des Menschen, Berl. klin. Wochenschr., 1883, p. 235.
BLANCHARD, R. Lésions du foie déterm. par la prés. des Douves, Arch. de Paras., 1901, iv, p. 581.
COBBOLD, T. SP. The New Human Fluke, Lancet, 1875, ii, p. 423.
GAIDE. De la distomatose hépatique au Tonkin, Ann. d'Hyg. et de Méd. Colon., 1905, viii, p. 568; abstracted in Arch. f. Schiffs- u. Trop.-Hyg., 1906, x, p. 256.
IJIMA, J. *Dist. endemicum*, Journ. Coll. Sci., Imp. Univ., Japan, 1886, i, p. 47.
INOUYE, Z. Über d. *Distom. spathulatum*, Arch. f. Verdauungskrankh., 1903, ix, p. 107.
KATSURADA, F. Beitr. z. Kenntn. d. *Dist. spathulat.*, Beitr. z. path. Anat. u. z. allg. Path., 1900, xxviii, p. 479.
LOOSS, A. On some Parasites in the Museum of the School of Trop. Med., Liverpool, Ann. Trop. Med. and Par., 1907, i, p. 123.
MCCONNELL, J. F. P. Remarks on the Anatomical and Pathological Relations of a New Species of Liver-fluke, Lancet, 1875, ii, p. 271; 1878, i, p. 406.
MCGREGOR. A New Form of Paralytic Disease Associated with the Presence of a New Species of Liver Parasite, Lancet, 1877, i, p. 775.
MOTY. Lésions anat. prod. par le *Dist. sinense*, C. R. Soc. Biol., Paris, 1893, p. 224.
SAITO, S. Über den Eiinhalt d. Dist. spathul. u. d. morphol. Beschaffenh. seines Embryos, C. f. B., P. u. Inf., i Orig., 1906, xlii, p. 133.

Heterophyes heterophyes (pp. 262 to 264).

BLANCHARD, R. Note prél. sur le *Dist. heterophyes*, C. R. Soc. Biol., Paris, 1891 (9), iii, p. 792.
LOOSS, A. Über d. Bau von *Dist. heteroph.* u. *D. fraternum* n. sp., Cassel, 1894.

LOOSS, A. Not. z. Helminth. Ägypt., I, C. f. B., P. u. Inf., 1896 (1), xx, p. 836.
— Weitere Beitr. z. Kenntn. d. Tremat.-Fna. Ägypt., Zool. Jahrb., Syst. 1899, xii, p. 699.
— Notz. z. Helminth. Ägypt, V, C. f. B., P. u. Inf., 1902, i Orig., xxxii, p. 886.
SANDWITH, F. M. *Dist. heterophyes* in a Living Patient, Lancet, 1899, ii, p. 888.
SIEBOLD, C. TH. v. Beitr. zur Helminth. hum., Z. f. wiss. Zool., 1852, iv, p. 52.

Dicrocœlium dendriticum (pp. 266, 267).

ANGLAS, J., and E. de RIBAUCOURT. Etude anat. et hist. du *Dist. lanceolatum*, Ann. Sci. Nat., 8vo, sér. xv, 1902, p. 313; *cf.* Zool. Centralbl., 1902, ix, p. 840.
ASCHOFF, L. Ein Fall von *Dist. lanc.* i. d. menschlichen Leber, Arch. f. path. Anat., 1892, cxxx, p. 493.
BRERA, V. L. Memor. fis.-med. sopra i princ. vermi di corpo, Roma, 1811.
DUBINI, A. Entozoograf. umana, Milano, 1850.
GALLI-VALERIO, B. Notes de parasitol., B, Paras. anim. (4) Œufs de *Dicr. lanc.* dans les fèces de l'homme, C. f. B., P. u. Inf., 1905, i Orig., xxxix, p. 239.
HOLLACK, J. Z. Kenntn. der sexuellen Amphitypie bei Dicrocoel., C. f. B., P. u. Inf., 1902, i Orig., xxxii, p .867.
KAMENSKY, S. Notes helm. No. 2, Sur la prés. réelle du *Dicroc. lanceol.* chez le chien, Trav. Soc. Nat. Univ. Charkow, 1902, xxxvi, p. 63.
MEHLIS, C. F. S. Observ. anat. de *Dist. hep.* et *lanceol.*, Gotting., 1825.
PIANA, G. P. Le cercarie d. moll. stud. in rapp. colla pres. del *Dist. epat.* e *D. lanc.*, La clinica veter., 1882, v.
WALTER, G. Beitr. zur Anat. und Histol. einig. Tremat., Arch. f. Naturg., 1858, xxiv (1), p. 269.
ZSCHOKKE, F. Selt. Paras. des Menschen, C. f. B. u. P., 1892, xii, p. 500.

Schistosoma hæmatobium (pp. 270 to 277 and 641 to 644).

BALFOUR, A. Eosinophilia in Bilharzia dis. and Dracontiasis, Lancet, 1903, ii, p. 1649.
BEYER, H. G. A Second Chinese Case of Infection with the Asiatic Blood Fluke, Amer. Med., 1905, x, p. 578.
BILHARZ, TH. Beitr. zur Helminth. hum., Z. f. w. Zool., 1852, ii, pp. 53, 454.
CATTO, J. *Schistosoma cattoi*, a New Blood Fluke of Man, Brit. Med. Journ., January 7, 1915; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxvii, p. 617.
CHAKER, M. Et. sur l'hématurie d'Egypt, Thèse, Paris, 1890.
CHATIN, J. Obs. sur le dével. et l'org. du proscol. de la Bilh., Ann. sc. nat. Zool., 1881 (6), xi.
FRITSCH, G. Zur Anat. d. *Bilh. haemat.*, Arch. f. mikr. Anat., 1888, xxxi, p. 192.
FUJINAMI, A. Weitere Mitt. über die path. Anat. d. sog. Katayama-Krankh. und der Krankheits-Er. ders, Kyoto Igaku Zassi, March 1, 1904. (In Japanese, with German abstract.)
FUJINAMI, A., and J. KON. Beitr. z. Kenntn. der pathol. Anat. der sog. Katayama-Krankheit, *ibid.*, 1904, i, 1; abstracted in C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 499.
GUNN. Bilharzia Disease, Journ. Amer. Med. Assoc., 1906, No. 14; abstracted in C. f. B., P. u. Inf., 1907, i, Ref. xxxix, p. 217.

KARTULIS. Vorkommen d. Eier von *Dist. haemat.*, Arch. f. path. Anat., 1885, xcix, p. 139.
— Weitere Beitr. z. path. Anat. d. Bilharz., *ibid.*, 1898, clii, p. 474.
KASAI, K. Unters. über die sog. Katayama-Krankh., Mitt. der med. Ges., Tokio, 1904, xviii, p. 4; abstracted in C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 499.
KATSURADA, F. *Schistosomum japonicum*, ein neuer menschl. Paras., durch welchen eine endem. Krankh. in versch. Gegend. Japans verursacht wird, Annot. zool. japon., 1904, v, 3, p. 147.
LAHILLE, A. La bilharziose intest. aux Antilles, Ann. d'Hyg. et de Méd. Colon., 1906, ix, p. 262.
LETULLE, M. Bilharziose intestinale, Arch. de Paras., 1905, ix, p. 329.
LOOSS, A. Beob. über Eier und Embr. v. Bilh., in Leuckart: Die Paras. d. Menschen, 2. Aufl., i, p. 521.
— Bemerkungen zur Lebensgeschichte der *Bilh. haem.*, C. f. B. u. P., 1894, xvi, pp. 286, 340.
— Rech. faun. paras. de l'Egypt, Mém. Inst. égypt., 1895, iii, p. 158.
— Zur Anat. und Histol. d. *Bilh. haem.*, Arch. f. mikr. Anat., 1895, xlvi, p. 1.
— Bilharziosis, Handb. d. Tropenkrankh., 1905, i, p. 93.
— *Schistosomum japonicum*, eine neue asiatische Bilharzia d. Menschen, C. f. B., P. u. Inf., 1905, i Orig., xxxix, p. 280.
LORTET and VIALLETON. Etud. sur la *Bilh. hæm.*, Paris, 1895; Ann. de l'Univ. de Lyon, 1894, ix.
OGAWA. Beitr. zur Kenntn. der Katayama-Krankh., Kyoto Igaku Zassi, 1904, i, p. 3; with German abstract.
RAILLIET, A. Obs. sur l'embr. du *Gynæcoph. hæm.*, Bull. Soc. Zool. France, 1892, xvii, p. 101.
RÜTIMEYER, L. Über Bilharzia-Krankheit, Mitt. klin. u. med. Inst. d. Schweiz., i, 1894, xii, p. 871.
SCHEUBE, B. Ein neues *Schistosomum* beim Menschen, Arch. f. Schiffs- u. Tropen-Hyg., 1905, ix, p. 150.
SONSINO, P. Ric. s. sviluppo d. Bilh., Giorn. R. Ac. med., Torino, 1889, xxxii, p. 380.
STILES, C. W. The New Asiatic Blood Fluke . . . of Man and Cats, Amer. Med., 1905, ix, p. 821.
WILLIAMSON. *Bilharzia hæmatobium* in Cyprus, Brit. Med. Journ., 1902, p. 956.
WOOLLEY, P. G. The Occurrence of *Schistosoma japonicum* vel *cattoi* in the Philippine Islands, Philipp. Journ. Sci., 1906, i, p. 83.

Class III.—Cestodes (pp. 282 to 359 and 644 to 674).

[An almost complete collection of the literature relating to Cestodes up to 1895 is to be found in Braun's monograph on the tapeworms in Bronn's "Klassen und Ordnung des Thierreiches," iv, p. 2; of later books the following may be mentioned.]

BARTELS, E. *Cysticercus fasciolaris*, Anat., Beitr. zur Entw. und Umwandl. in *Taenia crassicollis*, Zool. Jahrb. Anat., 1902, xvi, p. 511.
BLANCHARD, R. Sur quelq. Cest. monstr., Progr. méd., 1894 (2), xx.
BLOCHMANN, F. Die Epithelfrage bei Cestoden und Tremat., Hambg., 1896.
BOAS, J. E. V. *Triplotaenia mirabilis*, Zool. Jahrb., 1902, Syst. xvii, p. 329.
BRANDES, G. Teratol. Cestoden, Ztschr. f. d. ges. Nat., Halle, 1899, p. 105.
BUGGE, G. Zur Kenntn. der Excretionsgefäss-Syst. der Cestoden und Tremat., Zool. Jahrb. Anat., 1902, xvi, p. 177.

CHILD, C. M. Abnormality in *Moniezia expansa*, Biol. Bull. Woods Holl., 1902, iii, pp. 95, 143.

COHN, L. Zur Anat. und Syst. der Vogelcestoden, Nov. Act. Acad. Caes. Leop.-Carol. Nat. Cur., Halle, 1901, lxxix, No. 3.

DRAGO, U. Azione sperim. dei succhi diger. sull' involucro della ova di alc. Tenie, Arch. de Paras., 1906, x, p. 321.

FUHRMANN, O. Ein getrenntgeschlechtlicher Cestode, Zool. Jahrb., 1904, Syst. xx, p. 131.

GROHMANN, W. Die Abnormitäten in den Progl. der Cestoden, Inaug.-Dissert., Giessen, 1906.

KUNSEMÜLLER, F. Zur Kenntnis der polycephalen Blasenwürmer, insbesondere des *Coenurus cerebralis* Rud. und des *C. serialis* Gerv., Zool. Jahrb. Anat., 1903, xviii, p. 507.

LÜHE, M. Zur Anat. und Syst. der Bothrioceph., Verhandl. der Deutsch. zool. Ges., 1899, p. 30.

— Review of Braun's Bothr.-Syst., C. f. B., P. u. Inf., 1902, i Orig., xxi, p. 318.

MESSINEO, G. Sul veleno conten. in alcune Tenie dell' uomo, Atti Accad. Gioenia sci. nat., Catania, 1901 (4), xiv, No. 6.

MINGAZZINI, P. Sul vario modo di fissaz. delle Tenie alla parete intest., Rich. Labor. anat., Roma, 1904, x, p. 5.

RÖSSLER, P. Über den fein. Bau der Cysticerken, Zool. Jahrb. Anat., 1902, xvi, p. 423.

SAINT-RÉMY, G. Dévelop. embr. *Taenia serrata*, Arch. de Paras., 1901, iv, p. 143.

SCHAAF, H. Zur Kenntn. der Kopfanlage der Cysticerken, insbes. des Cysticercus der *Taenia solium* L., Zool. Jahrb. Anat., 1906, xxii, p. 435.

SPENGEL, J. W. Die Monozootie der Cestoden, Ztschr. f. w. Zool., 1905, lxxxii, p. 252.

STILES, CH. W. Revision of Ad. Tapeworm of Hares and Rabbits, Proc. U.S. Nat. Mus., 1896, xix.

STILES, C. W., and A. HASSALL. Tapeworms of Poultry, U.S. Dept of Agric., Bur. of Anim. Ind., 1896, Bull. 12.

VIGENER, J. Über dreikant. Bandwürmer a. d. Fam. d. Taeniiden, Jahrb. nass. Ver. f. Naturke., Wiesb., 1903, p. 115.

ZERNECKE, F. Unters. über d. fein. Bau d. Cestod., Inaug.-Diss., Rostock, 1895.

Dibothriocephalus latus (pp. 310 to 315, and 658).

(*a*) *Anatomy.*

BÖTTCHER, A. Studien über den Bau des *Bothr. latus*, Arch. f. path. Anat., 1864, xxx, p. 97; 1869, xlvii, p. 370.

ESCHRICHT, D. F. Anat.-phys. Untersuchung. über die Bothrioceph., Nov. Act. Ac. Caes. Leop.-Carol. nat. curios., 1841, xix, Suppl. ii.

SCHMIDT, F. Beitr. z. Kenntn. d. Entwickl. d. Geschlechtsorg. d. Cestoden, Z. f. w. Zool., 1888, xlvi, p. 155.

SOMMER, F., and L. LANDOIS. Beitr. z. Anat. d. Plattw. : I, *Bothr. latus*, Z. f. w. Zool., 1872, xxii, p. 40.

STIEDA, L. Zur Anat. d. *Bothr. latus*, Arch. f. Anat. u. Phys., 1864, p. 174.

(b) Development of Embryos.

BERTOLUS. Sur le dévelopm. du Bothrioceph. de l'homme, C. R. Acad. Sci., Paris, 1863, lvii, p. 569.

KNOCH, J. Die Naturg. d. breiten Bandw. mit bes. Berücks. sein. Entw., Mém. Acad. d. Sci., St. Pétersbourg, 1862 (7), v, p. 5; Journ. de l'Anat., 1879, vi, p. 140.

SCHAUINSLAND, H. Die embryon. Entw. d. Bothrioceph., Jen. Zeitschr. f. Naturw., 1885, xix, p. 520.

(c) Infection.

ALESSANDRINI, G. *Bothr. latus* Br. nella prov. di Roma, Boll. soc. zool. ital., 1906, ser. 2, vii, p. 231.

BRAUN, M. Zur Frage d. Zwischenwirth. von *Bothr. latus*, Zool. Anzeiger, 1881, iv, p. 593; 1882, v, pp. 39, 42, 194; 1883, vi, p. 97.

— *Bothriocephalus latus* u. seine Herkunft., Arch. f. path. Anat., 1883, xcii, p. 364.

— Zur Entwickel. d. breit. Bandw., Würzburg, 1883.

— Salm oder Hecht? Berl. klin. Wochenschr., 1885, xxii, p. 807.

— Über den Zwischenwirth des breit. Bandw., eine Entgegnung an Küchenmeister, Würzburg, 1886.

— *Bothriocephalus*-Finnen im Hecht des St. Petersb. Fischmarktes, St. Petersb. med. Wochenschr., 1892, xvii, No. 28.

— Helminth. Notizen, I, C. f. B. u. Par., 1893, xiv, p. 802.

GRASSI, B., and FERRARA. Zur Bothriocephalusfrage, D. med. Wochenschr., 1886, p. 699.

GRASSI, B., and G. ROVELLI. Contrib. allo studio d. svil. d. *Bothr. latus*, Giorn. R. Accad. Med., 1887, No. 11.

— — Bandwürmerentwickelung, C. f. B. u. Par., 1888, iii, p. 173.

IJIMA, J. The Source of *Bothr. latus* in Japan, Journ. Coll. Sci., Imp. Univ., Tokio, 1888, ii, 1, p. 49.

KÜCHENMEISTER, F. Wie steckt sich der Mensch mit *Bothr. latus* an? Berl. klin. Wochenschr., 1885, xxii, pp. 505, 527.

— Die Finne des Bothrioceph. u. seine Übertrag. a. d. Menschen, Leipzig, 1886.

— Weit. Bestätigung meiner Behamptung, die Finne des Hechts hat nichts mit *Bothr. latus* zu thun, D. med. Wochenschr., 1886, p. 551.

LEUCKART, R. Zur Bothriocephalusfrage, C. f. B. u. Par., 1887, i, pp. 1, 33.

LÖNNBERG, E. Über das Vork. d. breit. Bandw. in Schweden, C. f. B. u. Par., 1892, xi, p. 189.

PARONA, E. The *Bothr. latus* in Lombard., Rend. R. Istit. Lomb., 1886 (2), xix, fasc. 14.

— Sulla quest. d. *Bothr. latus*, Gazz. med.-ital.-lomb., 1887.

SCHROEDER, A. V. Wie bek. die Einwohner St. Petersb. d. breit. Bandw., St. Petersb. med. Wochenschr., 1892, xvii, No. 22.

— im Wratsch, 1894, No. 12; 1895, No. 15; Jesched. journ. prakt. med., 1896, Nos. 19 and 27; abstracted in C. f. B. u. Par., xvi, p. 314; xviii, p. 24; xx, p. 621.

ZSCHOKKE, F. Weit. Zwischenwirthe des *Bothr. latus*, C. f. B. u. Par., 1888, iv, p. 417; 1890, vii, pp. 393, 435.

(*d*) *Geographical Distribution Statistics*

Bavay. Sur la prés. du *Bothr. latus* à Madagascar, Bull. Soc. Zool. France, 1890, xv, p. 134.

Beneden, E. van. Sur la prés. en Belgique du *Bothr. latus*, Bull. Acad. roy. Belg., 1886, 3e sér., xi, 8, p. 265.

Berkeley, W. N. A Case of Bothriocephalus with Remarks on the Occurrence of Bothriocephalus in America, Med. Rec., New York, 1903, lxiii, p. 355.

Bollinger, O. Über das autochth. Vork d. *Bothr. latus* in München nebst Bemerk. über die geogr. Verbreitung der Bandw., Dtsch. Arch. f. klin. Med., 1885, xxxvi, p. 277.

Grusdieff, S. S. Zur Frage der Verbreit. tier. Darmparas. bei der Schuljugend, Wratsch, 1891, No. 13.

Hahn, L. Le Bothriocéph., son dével., ses migrat., sa distrib. géogr. et sa prophyl., Gaz. hebd. méd. et chir., 1885 (2), xxii, p. 450.

Huber, J. Über die Verbreitung der Cestoden in Schwaben., Ber. d. naturhist. Ver., Augsburg, f. 1886, p. 85.

Kerbert, E. *Bothr. latus* Br. (in Nederland), Nederl. Tijdschr. v. Geneeskde., 1889, i, p. 424; Handel van het II Nederl. Nat. en Geneesk. Congr., Leiden, 1889.

Kessler, D. A. Beitr. z. Statistik der Eingeweidew. bei den Einwohnern Petersburgs, Wratsch, 1888, pp. 109, 128.

Kiaer, F. C. Baendelorm hos mennesk. i Norge, Tidsskrift. f. pr. med., Kristiania, 1889, p. 1; abstracted in C. f. B. u. Par., 1889, v, p. 353.

Krabbe, H. 300 Tilfälde af bändelorm hos mennesket jagt. i Danmark, Nord. med. Arkiv, 1887, xix, 1.

— Über das Vork. von Bandw. beim Menschen in Dänemark, *ibid.*, 1905, Abt. ii, i, No. 2.

Leon, N. Note sur la fréq. des Bothrioc. en Roumanie, Bull. Soc. d. Sci. de Bucarest, 1904, xiii, p. 286.

Nickerson, W. S. The Broad Tapeworm in Minnesota, Journ. Amer. Med. Assoc., 1906, p. 711.

Schor, M. Contrib. à l'ét. du *Bothr. latus* dans le canton de Vaud, Thèse, Lausanne, 1902; abstracted in C. f. B., P. u. Inf., 1903, Abt. i, Ref. xxxiii, p. 286.

Sievers, R. Zur Kenntnis der Verbreit. von Darmparas. des Menschen in Finnland, Festschr. f. Palmén, No. 10, Helsingfors, 1905.

Szydlowski. Beitr. zur Mikroskopie der Faeces, Inaug.-Diss., Dorpat, 1879.

Vanlair, C. Un nouv. cas de bothriocéphalie en Belg., Bull. Acad. roy. Belg., 1889, 3e sér., xviii, p. 379.

Wellman, C. Notes on Tropical Diseases of the Angola Highlands, New York Med. Journ., August 12, 1905, and Phil. Med. Journ., September 2, 1905.

Willson, R. N. *Bothr. latus* . . . Amer. Journ. Med. Sci., Philadelphia, 1902, p. 262.

Zaeslin, Th. Über die geogr. Verbreit. u. Häufigkeit der Entozoen in der Schweiz, Corresp.-Bl. f. schweiz. Ärzte, 1881, xi, p. 673.

Zschokke, F. Der *Bothr. latus* in Genf, C. f. B. u. Par., 1887, i, pp. 377, 409.

(*e*) *Bothriocephalus Anæmia.*

Askanazy, M. Über Bothrioceph.-Anämie und die progn. Bedeutung d. Megaloblast, Ztschr. f. klin. Med., xxvii, p. 492.

Babes, V. Über den *Bothr. latus* und die Bothr.-Anämie, Arch. f. path. An., 1895, cxli, p. 204.

FÉDOROV, N. L'anémie bothriocéph., Arch. de Paras., 1902, vi, p. 207.

ISAAC, S., and VAN DEN VELDEN. Eine specif. Präcipitinreaktion bei *Bothr. latus* beherb. Menschen, Dtsche. med. Wchschr., 1904, xxx, p. 982.

MESCHEDE. In: Tagebl. d. 45. Vers. dsch. Naturf. u. Ärzte in Leipzig, 1872, p. 186; Ztschr. f. Psych., 1874, xxx, p. 109.

MÖLLER, W. Stud. öfv. de hist. förändr. i. dig.-Kan. . . . vid Bothrioc. anaem., Helsingfors, 1897.

NEUBECKER, O. Bothrioc.-Anämie ohne Bothrioceph., Inaug.-Diss., Königsb., 1898.

REYHER, G. Beitr. zur Ätiol. u. Heilbark. der pernic. Anämie, Dtsch. Arch. f. klin. Med., xxix, p. 31.

ROSENQUIST, E. Über den Eiweissstoffwechsel bei der pernic. Anämie, mit spezieller Berücks. der Bothrioc.-Anämie, Ztschr. f. klin. Med., 1903, xlix, p. 193.

RUNEBERG, J. W. *Bothr. latus* und pernic. Anämie, *ibid.,* 1886, xli, p. 304.

SCHAPIRO, H. Heilung der Biermerschen pernic. Anämie durch Abtreibung von *Bothr. latus,* Ztschr. f. klin. Med., 1889, xiii, p. 416.

SCHAUMANN, O. Zur Kenntnis der sog. Bothr.-Anämie, Berlin, 1894.

THOMSON, W. G. A Case of *Dibothriocephalus latus* Infection causing Pernicious Anæmia with Complications; Recovery, Med. News, 1905, lxxxvi, p. 635.

ZINN, W. Tödl. Anämie durch *Bothr. latus,* D. med. Wchschr., 1903, xxix, p. 264.

(*f*) *Duration of Life.*

BREMSER. Über lebende Würmer im leb. Menschen, Wien, 1819.

LEUCKART, R. Die Paras. d. Mensch., &c., Leipz., 1881, 2. Aufl., i, 2; and Arch. f. Naturg., 40. Jahrg., 1874, ii, p. 446.

MOSLER, F. Über Lebensdauer u. Renitenz d. *Bothr. latus*, Arch. f. path. Anat., 1873, lvii, p. 529.

Dibothriocephalus cordatus (pp. 315, 316).

BRAUN, M. Berichtig. betr. d. Vork. v. *Bothr. cordatus* in Dorpat, Zool. Anz., 1882, v, p. 46.

LEUCKART, R. Jahresb. üb. d. wiss. Leist. i. d. Naturgesch. d. nied. Thiere f. 1861-62, Arch. f. Naturgesch., 29. Jahr., 1863, p. 149.

— Die menschl. Paras., 1863, i, p. 437.

Diplogonoporus grandis (pp. 316, 317).

BLANCHARD, R. Not. sur les paras. de l'homme, IV, C. R. Soc. Biol., Paris, 1894 (10), i, p. 699.

IJIMA and T. KURIMOTO. On a New Human Tapeworm, Journ. Coll. Sci., Imp. Univ., Tokio, 1894, vi, p. 371.

KURIMOTO, T. *Diplogonoporus grandis*, Zeitschr. f. klin. Med., 1900, xl, p. 1.

Sparganum mansoni (pp. 317, 318, and 659).

COBBOLD, P. SP. Description of *Ligula mansoni*, Linn. Soc. Journ. Zool., Lond., 1883, xvii, p. 78.

IJIMA, J., and MURATA. Some New Cases of the Occurrence of *Bothriocephalus ligula,* Journ. Coll. Sci., Imp. Univ., Tokio, 1888, ii, p. 149.

LEUCKART, R. Demonstr. eines selt. menschl. Entoz., Tagebl. 57, Vers. d. Naturf. u. Ärzte zu Magdeburg, 1884, p. 321.
— Die Paras. d. Mensch., 2. Aufl., i, p. 941.
MANSON, P. Case of Lymph Scrotum associated with Filariæ and other Parasites, Lancet, 1882, ii, p. 616.
MIYAKE, H. Beitr. z. Kenntn. d. *Bothrioc. ligul.*, Mitt. Grenzgeb. Med. u. Chir., 1904, xiii, p. 145.
STILES, C. W., and L. TAYLER. A Larval Cestode of Man . . . U.S. Dept. of Agric., Bur. of Anim. Ind., Bull. No. 35, Wash., 1902, p. 47.

Sparganum proliferum (pp. 318 to 320).

IJIMA, J. On a New Cestode Larva Parasitic in Man, Journ. Coll. Sci., Imp. Univ., Tokio, 1905, xx, Article 7.

Dipylidium caninum (pp. 320 to 323 and 659 to 661).

(*a*) *Anatomy and Development.*

DIAMARE, V. Il genere *Dipylidium,* Atti R. Accad. sci. fis. e met. Napoli, 1893, 2 ser., ii, No. 7.
GRASSI, B., and G. ROVELLI. Embryol. Forsch. an Cestoden, C. f. B. u. Par., 1889, v, p. 370.
— — Ric. embryol. sui Cestodi, Atti Gioen. sci. nat., Catania, 1892, 4 ser., iv.
MELNIKOW, W. Über d. Jugendzust. d. *Taen. cucum.,* Arch. f. Naturg., 1869, xxxv, 1, p. 62.
SONSINO, P. Ric. s. ematoz. del cane e sul ciclo evol. d. *T. cucum.*, Atti soc. tosc. sci. nat., 1888, x, p. 1.
STEUDENER, F. Unters. über d. fein. Bau d. Cestod., Abh. nat. Ges., Halle, 1877, xiii, p. 295.

(*b*) *Case Histories* (*New Cases Only*).

ASAM, W. *Taenia cucumerina* bei einem Kinde, Münch. med. Wochenschr., 1903, l, p. 334.
BOLLINGER, O. Über *T. cucum.* beim Mensch., Deutsch. Arch. f. klin. Med., 1905, lxxxiv, p. 50.
BRANDT, E. Zwei Fälle von *T. cucum.* beim Mensch., Zool. Anz., 1888, xi, p. 481.
FRERIKS, B., and C. W. BROERS. Een *T. cucum.* bij een Kind, Weekbl. Nederl. Tijdsch. v. Geneesknde., 1904, Deel. ii, p. 33.
HOFFMANN, A. *Taen. cucum.* bei einem 4 Monate alten Kinde, Jahrb. f. Kinderheilkde., 1887, N.F. xxvi.
KÖHL, O. *Taen. cucum.* bei einem sechs Wochen alten Kinde, Münch. med. Wochenschr., 1904, li, p. 157.
KRÜGER, F. In St. Petersb. med. Wochenschr., 1887, No. 41.
ROSENBERG, L. Zehn Bandwürm. bei einem vierzehn Monate alten Kinde, Wien. med. Wochenschr., 1904, liv, p. 427.
SONNENSCHEIN, G. *Taen. cucum. s. elliptica* bei einem sechs Monate alten Kinde, Münch. med. Wochenschr., 1903, No. 52.
TRIIS. In Nord. Med. Arkiv., 1884, xvi, No. 6.
ZSCHOKKE, F. Ein neuer Fall von *Dipylidium caninum* beim Mensch., C. f. B., P. u. Inf., 1903, i Abt., xxxiv, p. 42.
— *Dipyl. canin.* als Schmarotz. d. Mensch., *ibid.,* 1905, i Orig., xxxviii, p. 534.

Hymenolepis nana (pp. 323 to 326, 661 and 662).

BLANCHARD, R. Hist. zool. et méd. d. Téniad. du genre *Hymenolepis*, Paris, 1891.

CAPAZZO, Z. Due casi di *T. nana*, Riv. clin. pediatr., 1904, ii, p. 829.

CARRER, C. Un caso di *T. nana*, Riv. venet. sci. med., 1905, xxii, T. xliii, 2, p. 509.

COMINI, E. Epilessia rifl. da *T. nana*, Gazz. d. osp., 1887, viii, p. 174.

— Due casi di *T. nana*, Gazz. med. ital.-lomb., 1888, p. 81.

FOSTER, CH. L. Two Cases of Infection with *T. nana* in the Philippine Islands, Journ. Amer. Med. Assoc., 1906, xlvii., p. 685.

GRASSI, B. Die *T. nana* und ihre med. Bedeutung, C. f. B. u. Par., 1887, i, p. 97.

— Einige weit. Nachr. üb. *T. nana, ibid.*, 1887, ii, p. 282.

— Entw. d. *T. nana, ibid.*, p. 305.

— Cenno prev. int. ad una nuov. mal. par. nell' uomo, Gazz. d. osp., 1886, viii, pp. 450, 619.

GRASSI, B., and G. ROVELLI. Ric. embr. sui Cestodi, Atti Accad. Gioen. sci. nat., Catania, 1892, 4. ser., iv.

HALLOCK. *Tænia nana*, Report of Two Cases, Journ. Amer. Med. Assoc., April 2, 1904.

LINSTOW, V. Über *Taenia nana* u. *T. murina*, Zeitschr. f. d. ges. Naturw., 1896, p. 571.

LUTZ, A. Beobacht. üb. d. als *Taenia nana* u. *T. flavopunct.* bek. Bandw. d. Mensch., C. f. B. u. P., 1894, xvi, p. 61.

MERTENS, in Berl. klin. Wochenschr., 1892, Nos. 44, 45.

MIURA, K., and YAMAZAKI. Über *T. nana*, Mitt. med. Facult., kais. Univ., Tokio, 1897, iii, p. 239.

MONIEZ, R. Sur la *Tænia nana*, C. R. Acad. Sci., Paris, 1888, cvi, p. 368.

ORSI, F. Sei casi d. *T. nana*, Gazz. med. ital.-lomb., 1889, 9 ser., ii, xlviii, p. 235.

PERRONCITO, E. Caso di *T. nana*, Giorn. R. Accad. Med., Torino, 1887, xxxv, p. 7.

PERRONCITO, E., and P. AIROLDI. Caso di *T. medioc.* e di molte *T. nana*, *ibid.*, 1888, xxxvi, p. 312; Gazz. d. osp., 1888, p. 554.

RANSOM, B. H. An Account of the Tapeworms of the Genus *Hymenolepis*, Parasites of Man, U.S. Hygien. Lab., Bull. No. 18, 1904.

RANSOM, W. H. Probable Existence of *T. nana* . . . in England, Lancet, 1888, ii.

RASCH, CHR. *Taenia nana* in Siam, D. med. Ztg., 1895, p. 143.

ROEDER, H. Über ein. weit. Fall v. *T. nana* in Deutschland, Münch. med. Wochenschr., 1899, p. 344.

SENNA. Stor. clin. dei sei casi d. *T. nana*, Gaz. med. ital.-lomb., 1889, xlviii, 9 ser., ii, p. 245.

SIEBOLD, C. TH. V. Ein Beitr. z. Helminthogr. hum., Z. f. w. Zool., 1852, iv, p. 64.

SONSINO, P. Tre casi d. *T. nana* nei dint. di Pisa, Riv. ital. clin. med., 1891, iii.

— Nuov. oss. di *T. nana*, Boll. soc. med., Pisa, 1895, i, p. 4.

SPOONER, E. A. Species of *T. nana*, Amer. Journ. Med. Sci., 1873 (2), lxv, p. 163.

STILES, C. W. The Dwarf Tapeworm (*H. nana*), etc., New York Med. Journ. and Philad. Med. Journ., 1903, p. 1.

W. S. Wiener Bericht., Med. Klin., 1904, i, p. 71.
WANI, S. Über *T. nana* in Japan; abstracted in C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 500.
WERNICKE, O. *T. nana*, Anal. circ. med. Argent., 1890, xiii, p. 349; C. R. Soc. Biol., 1891 (9), iii, p. 441.
ZOGRAF, N. Note sur la myol. d. Cestod., Congr. int. Zool., IIe sess., Moscou, 2e part., p. 23.

Hymenolepis diminuta (pp. 326 to 328 and 662).

CREPLIN, F. C. H. Observ. de entozois., I, Gryphisw., 1825, p. 71.
GRASSI, B. Bestimmung d. 4 v. Parona . . . gefundenen Taenien, C. f. B. u. Par., 1887, i, p. 257.
— *Taenia flavop., leptoceph., diminuta*, Atti R. Accad. Sci., Torino, 1888, xxiii, p. 492.
GRASSI, B., and G. ROVELLI. Ric. embr. s. Cestodi, Catania, 1892.
LEIDY, J. Occurrence of a Rare Human Tapeworm, Amer. Journ. Med. Sci., 1884 (2), lxxxiii, p. 110; Proc. Accad. nat. sci., Philadelphia, 1884, p. 137.
LUTZ, A. Beob. über d. als *T. nana* u. *flavop.* bek. Bandw. d. Mensch., C. f. B. u. Par., 1894, xiv, p. 61.
MAGALHAES, P. G. DE. Ein zweit. Fall von *Hym. diminuta* als menschl. Paras. in Brasil, *ibid.*, 1896 (1), xx, p. 673.
PACKARD, F. A. *Tænia flavop.*, with Description of a New Species, Journ. Amer. Med. Assoc., 1900, xxxv, p. 1551.
PARONA, E. Di un caso di *T. flavopunct.*, Giorn. R. Accad. Med., Torino, 1882, xxxii, p. 99.
PREVITERA, G. Due casi prob. di *T. leptoceph.* nei minat. d. zolfare, Boll. Acc. Gioen. sci. nat., Catania, 1900, S.N., fasc. 63, p. 9.
SONSINO, P. Su paras. dell' uomo con un nuovo caso di *T. flavopunct.*, C. f. B., P. u. Inf., 1896 (1), xix, p. 937.
ZSCHOKKE, F. Seltene Paras. d. Mensch., *ibid.*, 1892, xii, p. 497.

Hymenolepis lanceolata (pp. 328, 329 and 662).

BLOCH, M. E. Abhandlung v. d. Erzeugung d. Eing.-Würmer, Berlin, 1782.
DADAY, E. v. Helminth. Stud. Einige in Süsswasser-Entomostr. leb. Cercocystis-Form, Zool. Jahrb., 1901, Syst. xiv, p. 161.
FEUEREISEN, J. Beitr. z. Kenntn. d. Taenien, Z. f. w. Zool., 1868, xviii, p. 161.
MRÁZEK, A. Zur Entwicklung einiger Taenien, Sitzungsber. kgl. böhm. Ges. d. Wiss., math.-nat. Kl., Prag, 1896, Art. xxxviii.
WOLFFHÜGEL, F. *Drepanidot. lanceol.*, C. f. B., P. u. Inf., 1900 (1), xxviii, p. 49.
ZSCHOKKE, F. *Hymenol. lanc.* als Schmarotzer d. Menschen, *ibid.*, 1902, Orig., xxxi, p. 331.

Davainea madagascariensis (pp. 329, 330 and 662).

BLANCHARD, R. Note sur quelq. vers par. de l'homme, C. R. Soc. Biol., Paris, 1891 (9), iii, p. 604.
— Le *Dav. madag.* à Guyane, Bull. Acad. Med., 1897 (3), xxxvii, p. 34.
— Un cas inéd. de *Dav. madag.*, consid. sur le genre *Davainea*, Arch. de Paras., 1899, ii, p. 200.
CHEVREAU, P. Le *Tænia madag.*, Bull. Soc. Méd. de l'île Maurice, ix, p. 134.
DANIELS, C. W. *Tænia demerariensis*, Brit. Guiana Med. Ann. Hosp. Rep. for 1895, Lancet, 1896, ii, p. 1455.

GRENET and DAVAINE. Note sur une nouv. esp. de Taenia rec. à Mayotte, Mém. Soc. Biol., Paris, 1869 (5), i, p. 233; Arch. Méd. nav., 1870, xiii, p. 134.

LEUCKART, R. Über *Taenia madagascariensis*, Verh. d. D. zool. Ges., Leipzig, 1891, i, p. 68.

Davainea (?) *asiatica* (pp. 330 and 662).

LINSTOW, V. *Taenia asiatica*, eine neue Taenie des Menschen, C. f. B., P. u. Inf., 1901 (1), xxix, p. 982.

Tænia solium and *T. saginata* (pp. 331 to 336, 338 to 342, and 662 to 674).

BENEDEN, E. VAN. Rech. sur le dével. embryol. d. quelq. Tén., Arch. de Biol., 1881, ii, p. 183.

BÉRENGER-FERAUD, L. J. B. Leç. clin. sur les Ténias de l'homme, Paris, 1888.

BORCHMANN. Über die Häufigkeit von *Cyst. cellul.* beim Reh., Zeitschr. f. Fleisch- u. Milchhyg., 1904, xv, p. 39.

DIRKSEN, E. Über schwere Anämie d. *Taenia solium*, Deutsche med. Wochenschr., 1903, No. 29.

GERLACH, A. C. Fütterungsvers. bei Schweinen mit *T. solium*, Jahresber. klg. Thierarzneisch., Hannover (1869), 1870, ii, pp. 66, 69.

HAUBNER, G. C. Über d. Entw. d. Band- u. Blasenw. . . . Mag. f. d. ges. Thierheilk., 1854, xx, pp. 243, 366; 1855, xxi, p. 100.

KÜCHENMEISTER, E. Über Cysticerk. im allg. u. die des Mensch. insbes. Zittau, 1853.

— Experimenteller Nachweis, dass *Cyst. cellulosae* sich in *Taenia solium* umwandelt., Wiener med. Wochenschr., 1855, p. 1; 1856, p. 319; Deutsche Klinik, 1860, xii, p. 187.

LEUCKART, R. Die Blasenbandw. u. ihre Entw., Giessen, 1856.

— Finnenzustand d. *Taenia mediocan.*, Gött .Nachr., 1862, pp. 13; 195.

MONIEZ, R. Ess. monogr. sur les Cysticerques, Trav. Institut. Zool., Lille, 1880, iii, p. 1.

— Mém. sur les cestodes, *ibid.*, 1881, iii, p. 2.

MOSLER, F. Helminthol. Studien u. Beobacht., Berlin, 1864.

PERRONCITO, E. Gli Abissini e la *Tænia mediocanellata*, Giorn. R. Accad. d. Med., Torino, 1891, Nos. 3, 4.

— Esper. s. prod. del Cystic. della *T. medioc.* . . . Ann. R. Accad. Agric., Torino, 1877, xx; Zeitschr. f. Vet.-Wiss., 1877, v.

SCHWARZ. Zur Unterscheidung d. *Cyst. cell.* v. *C. tenuicollis*, Zeitschr. f. Fleisch- u. Milchhyg., 1893, iii, p. 89.

SOMMER, F. Bau u. Entwickl. d. Geschlechtsorg. von *T. medioc.* u. *T. solium*, Z. f. w. Zool., 1874, xxiv, p. 499.

STEUDENER, F. Unters. über d. Bau d. Cestod., Halle, 1877.

Cysticercus cellulosæ and *C. bovis* in Man (pp. 332 to 337, and 340 to 342).

GROSS, J. Über *Cyst. racemosus* d. Gehirns, Inaug.-Diss., Leipzig, 1903.

HENNEBERG, R. Über Gehirncysticerken, insbesondere d. basale Cysticerkenmeningitis, Charité-Annal., 1906, xxx, p. 202.

HIRSCHBERG, J. Die Verminderung der Finnenkrankheiten, Berl. klin. Wochenschr., 1904, xli, p. 661.

KÜHN, H. *Cystic. cellul.* i. d. Lungen, Inaug.-Diss., Leipzig, 1905.

LEWIN. *Cystic. cellul.* u. sein Vork. in der Haut d. Menschen, Charité-Annal., 1877, ii, p. 609; Arch. f. Dermatol., 1894, xxvi, pp. 71, 217.

MARCHAND, F. Über Gehirncysticerken, Volkmanns Sammlung klin. Vortr., 1904, No. 371.
UTZ, F. Ein Fall von *Cyst. racem.* d. Gehirnbasis, Inaug.-Diss., München, 1902.
VOLOVATZ, E. Ladrerie ou cysticercose de l'homme, Thèse, Paris, 1902.
ZENKER, F. A. *Cystic. racemosus* d. Gehirns, Bonn, 1882.

Cysticercus acanthotrias (pp. 336, 337).

BRAUN, M. Helminth. Notiz. III: *Cyst. tenuicollis* u. *C. acanthotrias* beim Mensch., C. f. B. u. Par., 1894, xv, p. 409.
COBBOLD, T. SP. On a Rare and Remarkable Parasite from the Collection of the Rev. W. Dallinger, Rep. 40th Meeting Brit. Assoc. Adv. Sci., 1870-71, Note, p. 135.
DELORE, X. *Cystic. acanthotrias* obs. chez une jeune fille, Mém. et C. R. Soc. Sci. Med., Lyon, 1863, ii, p. 202.
LEUCKART, R. Die menschl. Paras., 1863, i, p. 310.
REDON. Exp. sur le dével. rubanaire de Cyst. de l'homme, C. R. Acad. Sci., Paris, 1877, lxxxv, p. 675; Gaz. méd., Paris, 1877, xlviii, p. 519; Arch. vétér. publ. à l'École d'Alfort, 1877, ii, p. 910; Ann. Sci. Nat. Zool., 1877 (6), vi, No. 4.
WEINLAND, D. F. An Essay on the Tapeworms of Man, Cambridge, U.S., 1858.
— System. Catalog aller Helminth., die im Menschen gefunden werden, Arch. f. Naturg., 1859, xxv, i, p. 276.
— Beschreibg. zweier neuer Taenien a. d. Mensch., Nov. Act. Acad. Leop.-Caes. nat. cur., 1861, xxviii.

Tænia marginata (p. 338).

ESCHRICHT, D. F. Afhdlg. om de Hydat. d. fremkalde den i Island endem. Leversyge, Overs. K. Dansk. Selsk. Forhdlg., 1853, p. 211.
HODGES. *Cysticercus tenuicollis* in the Human Body, Boston Med. and Surg. Journ., 1866, lxxv, p. 185.
KRABBE, H. Helminthol. Unders. in Danmark og paa Island, Rech. helm. en Danemark et en Islande, Copenh., 1866, p. 43.

Tænia serrata (p. 338).

GALLI-VALERIO, B. Not. helminthol. et bactériol., C. f. B., P. u. Inf., 1898 (1), xxiii, p. 940.
VITAL, A. Les entozoaires à l'hôpital de Constantine, Gaz. méd., Paris, 1874, p. 285.

Tænia africana (pp. 342, 343).

LINSTOW, V. *Taenia africana,* eine neue Taenie d. Mensch. aus Afrika, C. f. B., P. u. Inf., 1900 (1), xxviii, p. 485.
— Helminth. vom Ufer d. Nyassasees, Jen. Zeitschr. f. Naturw., 1900, xxxv, p. 420.

Tænia confusa (pp. 343, 344).

GUYER, M. F. On the Structure of *T. confusa*, Zool. Jahrb., 1898, Syst. xi, p. 469.
WARD, H. B. Report of the Zoologist, Ann. Rept. Nebraska State Board Ag. for 1895 (1896), p. 257; for 1896 (1897), p. 173.
— A New Human Tapeworm, West. Med. Rev., 1896, i, p. 35; Proc. Nebraska State Med. for 1896, p. 83.
— Note on *T. confusa*, Zool. Anz., 1897, xx, p. 321.

Tænia echinococcus (pp. 344 to 347).

BLANCHARD, R. Prophyl. de la maladie hydatique, Arch. de Paras., 1905, ix, p. 451.
BRAULT, A., and M. LOEPER. La glycogène dans la membr. germ. d. kystes hydat., Journ. d. Phys. et Path. gén., 1904, vi, p. 295; abstracted in C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 689.
BREMSER, J. G. Üb. lebende Würmer im leb. Menschen, Wien, 1819.
DÉVÉ, F. De l'echinococcose secondaire, Paris, 1901.
— Sur l'évolution kystique du scolex échinoc., Arch. de Paras., 1902, vi, p. 54.
— Inoculations échinoc. aux cobayes, C. R. Soc. Biol., Paris, 1903, lv, p. 122.
— Les kystes hydat. du foie, Paris, 1905; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxix, p. 64.
— Les deux scolex échinoc., C. R. Soc. Biol., Paris, 1906, lx, p. 956.
ERLANGER, R. v. Der Geschlechtsapparat d. *Taenia echinococcus*, Z. f. w. Zool., 1890, l, p. 555.
ESCHRICHT, F. F. Om the hydatider, Overs. K. Danske Vid.-Selsk. Forh., 1853, p. 211; 1856, p. 127; Zeitschr. f. d. ges. Naturwiss., Halle, 1857, x, p. 231.
GOELLNER, A. Die Verbreitung der Echinococcenkrankh. in Els.-Loth., Mitt. a. d. Grenzgeb. Med. Chir., 1903, xi, p. 80.
GOLDSCHMIDT, R. Zur Entwickel. d. Echinococcusköpfchen, Zool. Jahrb. Anat., 1900, xiii, p. 467.
JOEST, E. Studien über Echinokokken- und Zystizerkenflüssigkeit [*sic*], Zeitschr. f. Infekt.-Krankh., paras. Krankh. u. Hyg. d. Haust., 1906, ii, p. 1, and the literature there referred to.
KRABBE, H. Die isländ. Echinococcen, Arch. f. path. Anat., 1863, xxvii, p. 225; Deutsch. Zeitschr. f. Thiermed., xvii.
LEBEDEW, A. J., and N. J. ANDREJEW. Transplant. v. Echinoc. v. Menschen auf Kaninchen, Arch. f. path. Anat., 1889, cxviii, p. 552.
LENDENFELD, R. *Tænia echinococcus*, Zool. Jahrb., 1886, i, p. 409.
LEUCKART, R. Über Echinococcus, Götting. Nachr., 1862, p. 13; Die Paras. d. Mensch., 1. and 2. Aufl.
LICHTENFELD. Über Fertilität u. Sterilität der Echinococcen, C. f. B., P. u. Inf., 1904, i Orig., xxxvi, p. 546; 1904, xxxvii, p. 64.
MADELUNG, O. W. Beitr. mecklenb. Ärzte z. Lehre v. d. Echinococcenkrankheiten, Stuttg., 1885.
MONIEZ, R. Essai monogr. sur les Cysticerques, Thèse, Paris, 1880; Trav. de l'Inst. Zool., Lille, 1880, iii, 1.
MOSLER, F. Über Mittel zur Bekämpf. endem. vork. Echinococcuskrankh., Deutsche Med.-Ztg., 1889, No. 72.
NAUNYN, B. Entwickel. d. Echinococcus, Arch. f. Anat. u. Phys., 1862, p. 612; 1863, p. 412.

NEISSER, A. Die Echinococcenkrankheit, Berlin, 1877.

PEIPER. Verbreitg. d. Echinococcenkrankh. in Vorpommern, Stuttg., 1894.

PERRONCITO, E. Dévelop. de nouv. kyst. aux dépens des scolex cont. dans les kyst. hydat., Bull. Soc. Zool., France, 1902, xxvii, p. 150.

— Osservaz. fatte sulla tenia ech. e sulla rapidità del suo svil. dai dentoscolici, Giorn. R. Accad. di med., Torino, 1906, Nos. 1 and 2.

RASMUSSEN, V. Bidr. til kundsk. om Echinococcernes udvikl., Vidensk. meddel. fra naturh. Foren., Kjobenhavn (aar 1865), 1866, p. 1; translation in Australian Med. Journ., Melbourne, 1869, xiv, pp. 33, 65.

RIEMANN, H. Über die Keimzerstreuung der Echinoc. im Peritoneum, Beitr. z. klin. Chirurgie, xxiv; In.-Diss., Rostock, 1899.

SABRAZÈS, J., L. MURATET and P. HUSNOT. Motiité due scol. echinoc., C. R. Acad. Sci., Paris, 1906, i; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxix, p. 145.

SIEBOLD, C. TH. V. Zur Entwickelung der Helminthen, in K. F. Burdach, Die Physiol. als Erfahrungswiss., Leipzig, 1837, 2. Aufl., ii, p. 183.

— Über die Verwandlung von Echinococcusbrut in Taenien, Z. f. w. Zool., 1853, iv, p. 409.

THOMAS, J. D. Hydatid Disease . . . in Australia, Adelaide, 1884.

TSCHÖTSCHEL, K. Zur Casuist. d. Echinoc.-Krankheit in Vorpommern, Inaug-Diss., Greifswald, 1900.

WIEDEMANN, C. Zur Statistik d. Ech.-Krankheit in Vorpommern, Inaug.-Diss., Greifswald, 1895.

Echinococcus multilocularis (pp. 356 to 359).

BEHA, R. Zur Kenntnis der *Echinoc. alveol.* der Leber, Inaug.-Diss., Freiburg i. B., 1904.

DÉVÉ, F. Sur quelq. caract. zool. de *l'Echinococcose alvéol.* bavaro-tyrol, C. R. Soc. Biol., Paris, 1905, lviii, p. 126.

GUILLEBEAU, A. Zur Histol. d. multil. Echinoc., Arch. f. path. Anat., 1890, cxix, p. 108.

LINSTOW, V. *Echinoc. alveolaris* und *Plerocercus lachesis*, Zool. Anz., 1902, xxvi, p. 162.

MANGOLD. Über die multil. Echinoc. und seine Taenie, Berlin. klin. Wochenschr., 1892, No. 2; In.-Diss., Tübingen, 1892.

MELNIKOW-RASWEDENKOW, N. Stud. über die Echin. alveol. s. multil., Beitr. z. path. Anat. u. z. allgem. Path., Suppl., 1901, iv.

MÜLLER, A. Beitr. zur Kenntnis der *Taenia echinoc.*, Münch. med Wochenschr., 1893, No. 13.

OSTERTAG, R. Über die *Echinoc. multiloc.* bei Rind und Schwein, Deutsch. Zeitschr. f. Thiermed., 1891, xvii, p. 172.

PERRONCITO, E. Particol. interess. relat. alla cisti di echinococco, Giorn. R. Accad. di med. di Torino, 1906, Nos. 1 and 2.

POSSELT, A. Die Stellung des Alveolarechinococcus, Münch. med. Wochenschr., 1906, liii, Nos. 12 and 13.

SCHMIDT, W. Über die geogr. Verbr. der *Echin. multil.* u. Hydat. in Bayern, In.-Diss. München, 1899.

(C) NEMATHELMINTHES (pp. 360 to 470, 674 to 698, 754, and 755).

BASTIAN, H. C. On the Anatomy and Physiology of the Nematodes, Phil. Trans. Roy. Soc., London, 1866, clvi, p. 2.

BÖMMEL, A. V. Über d. Cuticularbld. bei Nemat., Arb. zool.-zoot. Inst., Würzburg, 1895, x, p. 189.

BRANDES, G. Das Nervensyst. der als Nemathelm. zusammengef. Wurmtypen, Abh. nat. Ges., Halle, 1899, xxi, p. 273.

BÜTSCHLI, O. Beitr. zur Kenntnis des Nervens. der Nemat., Arch. f. mikr. Anat., 1874, x, p. 74.

DEWITZ, J. Lebensfähigkeit der Nemat. ausserhalb des Wirtes, Zool. Anz., 1899, xxii, p. 91.

DOMASCHKO, A. Die Wandung der Gonade von *Ascaris megalocephala*, Arb. zool.-zoot. Inst., Wien, 1905, xv, p. 257.

GOLDSCHMIDT, R. Histol. Unters. an Nematoden: I, Die Sinnesorg. v. *Asc. lumbricoides* und *A. megalocephala*, Zool. Jahrb. Anat., 1903, xviii, p. 1.

— Histol. Unters. an Nematoden: II, Der Chromidialapparat lebhaft funkt. Gewebszellen, *ibid.*, 1905, xxi, p. 49.

— Über die Cuticula vom *Ascaris*, Zool. Anz., 1905, xxviii, p. 259.

— Mitteil. zur Histol. von *Ascaris*, *ibid.*, 1906, xxix, p. 719.

HAMANN, O. Die Nemathelminthen, Jena, 1895, ii.

HESSE, R. Über das Nervensystem von *Ascaris megalocephala*, Zeitschr. f. w. Zool., 1892, liv, p. 548.

JAEGERSKIOLD, L. A. Über die Oesoph. der Nematoden, Bih. kgl. Svensk. Vet.-Akad. Handl., 1897, xxiii, p. 4.

— Beitr. zur Kenntnis der Nemat., Zool. Jahrb. Anat., 1894, vii, p. 449.

— Weitere Beiträge zur Kenntnis der Nemat., Svensk. Vet.-Akad. Handl., 1901-02, xxxv.

JAMMES, L. Contrib. à l'étud. de la couche sous-cutic. d. Némat., Ann. Sci. Nat. Zool., 1892 (7), xiii, p. 321.

LOOSS, A. Bau des Ösophag. bei einigen Ascariden, C. f. B., P. u. Inf., 1896 (1), xix, p. 1.

— The Sclerostomidæ of Horses and Donkeys in Egypt, Rec. Egypt. Govt. School of Med., 1901.

MARCUS, H. Ein Rhachiskern bei Ascariden, Biol. Centralbl., 1905, xxv, p. 479.

MAYER, A. Zur Kenntnis der Rhachis im Ovarium und Hoden der Nematoden, Zool. Anz., 1906, xxx, p. 289.

NASSONOW, N. Sur les org. phagocyt. d. Ascar., Arch. de Paras., 1898, i, p. 170; Arch. f. mikr. Anat., 1900, lv, p. 488.

NEDKOFF, P. Die Metamorph. d. Geschlechtsapp. b. *Ascaris nigrovenosa*, Inaug.-Diss., Leipzig, 1897.

RAUTHER, M. Über den Bau des Oesophagus und die Lokalisation der Nierenfunktion bei freilebenden Nematoden, Zool. Jahrb. Anat., 1907, xxiii, p. 703.

RETZIUS, G. Zur Kenntniss der Hautschicht der Nematoden, Biol. Unters., 1906, N.F. xiii, No. 12.

ROHDE, E. Beiträge zur Kenntnis der Nematoden, Zool. Beiträge (A. Schneider), 1885, i, p. 11.

SCHNEIDER, A. Monographie der Nematoden, Berlin, 1866.

Toldt, C. Über den feineren Bau der Cuticula von *Ascaris megalocephala*, Arb. zool.-zoot. Inst., Wien, 1899, p. 289.
— Die Saftbahnen in der Cuticula von *Asc. megalocephala*, Zool. Anz., 1904, xxvii, p. 728.
Voltzenlogel, E. Unters. über d. anat. u. histol. Bau d. Hinterendes v. *Ascaris megalocephala* u. *A. lumbricoides*, Zool. Jahrb. Anat., 1902, xvi, p. 481.

Rhabditis pellio (p. 377).

Baginsky. Haemoglobinurie mit Auftreten von Rhabditiden im Urin, Deutsche med. Wochenschr., 1887, p. 604.
Oerley, L. Die Rhabditiden und ihre medic. Bedeutung, Berlin, 1886.
Peiper and Westphal. Über d. Vorkom. v. Rhabditiden im Harne bei Haematurie, Centralbl. f. klin. Med., 1888, ix, p. 145.
Scheiber, S. H. Ein Fall von mikrosk. kleinen Rundwürm. i. Urin eines Kranken, Arch. f. path. Anat., 1880, lxxxii, p. 161.

Rhabditis nieillyi (p. 378).

Glatzel. Drei Monate im Serra Hadji Hospital zu Dar-es-Salam, Arch. f. Schiffs- u. Tropen-Hyg., 1906, p. 284.
Künnemann. Rundwürmer (*Rhabditis strongyloides*) als Ursache eines Hautausschlages beim Hunde, Deutsche tierärztl. Wochenschr., 1905, No. 24.
Nielly. Un cas de dermatose paras. obs. pour la première fois en France, Arch. méd. nav., 1882, xxxvii, pp. 337, 488; Bull. Acad. Méd., 1882 (2), xi, pp. 395, 581.
O'Neill, J. On the Presence of a Filaria in Craw-craw, Lancet, 1875, i.
Schneider, J. G. Nematodenembr. i. d. Haut d. Hundes, In.-Diss., Basel, 1891.
Whittles, J. D. A Case of General Infection by a Nematode accompanied by Hypertrophic Gingivitis, Lancet, 1903, i, p. 1435; 1903, ii, p. 57.

Rhabditis sp. (pp. 378, 379).

Frese, O. Über mikroskop. Würmer (Rhabditiden) im Magen einer Ozaenakranken, Münch. med. Wochenschr., 1907, No. 11.

Anguillula aceti (p. 379).

Henneberg, W. Zur Biologie des Essigaales. Berlin, 1900, Deutsche Essigind. Institut für Gährungsgewerbe, 1899, Nos. 45-52; 1900, Nos. 1-5.
Pallechi, P. Sulla resistenza vitale dell' Anguillula dell' aceto, Boll. Mus. Zool. ed Anat. comp., Genova, 1893, No. 17.
Stiles, Ch. W., and W. A. Frankland. A Case of Vinegar Eel (*Anguillula aceti*) Infection in the Human Bladder (eleven miscellaneous papers on animal parasites), U.S. Dept. of Agric., Bur. of Animal Ind., Bull. No. 35, Washington, 1902, p. 35.

Strongyloides stercoralis (pp. 380 to 384, 674, 675, and 755).

Askanazy, M. Über Art und Zweck der Invasion der *Anguillula intestinalis* in die Darmwand, C. f. B., P. u. Inf., 1900, i Abt., xxvii, p. 569.
Bavay. Sur l'*Anguillule stercorale*, C. R. Acad. Sci., Paris, 1876, lxxxiii, p. 694.
— Sur l'*Anguillule intestinale*, *ibid.*, 1877, lxxxiv, p. 266.

BRAUN, M. Bemerk. üb. d. sporad. Fall von *Anguill. intest.* in Ostpreussen, C. R. Acad. Sci., Paris, 1899, xxvi, p. 612.

BROWN, PH. K. Report of Three Cases in which Embryos of the *Strong. intest.* were found in the Stool, Boston Med. and Surg. Journ., 1903, cxlviii, p. 583.

CHAUVIN. L'*Anguillule stercorale* dans la dysenterie des Antilles, Arch. Méd. Nav., 1878, xxix, p. 154.

DURME, P. VAN. Quelq. notes sur les embryons de *Strongyloides intestin.* et leur pénétrat par la peau, Thompson Yates Lab., Liverpool, 1902 (2), iv, p. 471.

GRASSI, B. Sovra l'*Anguillula intestinale,* Rend. Istit. lomb. sc. e lett., 1879 (2), xii, p. 228.

GRASSI, B., and C. PARONA. Sovra *Anguillula intest.,* Arch. sci. med., 1879, iii, p. 10.

GRASSI, B., and R. SEGRÈ. Nuove osserv. sull' eterogonia del *Rhabdon. intest.*, Atti R. Accad. d. Lincei Rendic., 1887 (4), iii, p. 100.

KURLOW, M. V. *Anguillula intestinal.* als Ursache akuter, blut. Durchfälle beim Menschen, C. f. B., P. u. Inf., 1902, i Orig., xxxi, p. 614.

LEICHTENSTERN, O. Über *Anguillula intestinalis*, Deutsche med. Wochenschr., 1898, No. 8, p. 118.

— Zur Lebensgeschichte d. *Ang. int.*, C. f. B., P. u. Inf., 1899, xxv, p. 226.

— Stud. üb. Strongyl. intest. nebst Bemerk. üb. *Ancylost. duodenale*, Arb. kais. Gesundheitsamt, 1905, xxii, p. 309.

LEUCKART, R. Über d. Lebensgesch. d. sogen. *Anguillula stercoralis,* Ber. d. math.-phys. Class. d. k. sächs. Ges. d. Wiss., 1883, p. 85.

LOOSS, A. Die Wanderung der Ancylostomum- u. Strongyloides-Larven von d. Haut nach dem Darm, C.R. 6me Congr. intern. de Zool., Berne, 1904 (1905), p. 225.

NORMAND, A. Sur la maladie dite diarrhée de Cochinchine, C. R. Acad. Sci., Paris, 1876, lxxxiii, p. 316.

— Mém. sur la diarrh. de Cochinchine, Arch. Méd. Nav., 1877, xxvii, p. 35.

— Du rôle étiol. de l'anguillule dans la diarrh. de Cochinchine, *ibid.,* 1878, xxx, p. 214.

PAPPENHEIM. Ein sporad. Fall von *Ang. intest.* in Ostpreussen, C. f. B., P. u. Inf., 1899, i Abt., xxvi, p. 608.

PERRONCITO, E. Obser. sur le dévelop. de l'*Anguillula intestinalis,* Journ. de l'Anat. et de la Physiol., 1887, xvii, p. 499.

— Il *Rhabdonema strongyloides* Leuck., *Anguillula intestinalis* e *Pseudorhabditis stercoralis,* Giorn. R. Accad. di Med., Torino, 1906, p. 3.

PRICE, MARSHALL LANGTON. Occurrence of *Strongyloides intestinalis* in the United States, Journ. Amer. Med. Assoc., 1903, xli, p. 713.

ROVELLI, G. Ric. s. org. genit. d. *Strongyloides,* Como, 1888.

SCHLÜTER, H. Zur Kenntn. d. Anguillula-Erkrank. b. Menschen, In.-Diss., Kiel, 1905.

SEIFERT. Über *Anguillula stercoralis,* Sitzungsber. phys.-med. Ges., Würzburg, 1883, p. 22.

SONSINO, P. Tre casi d. mal. du *Rhabdonema intest.* o Rhabdonemiasi, Suppl. d. Riv. gen. ital. di Clinica med., July 20, 1891.

STRONG, R. P. Cases of Infection with *Strongyloides intestinalis;* First reported cases in North America, Johns Hopk. Hosp. Rept., 1901, x, p. 91.

STURSBERG. Über *Anguillula intestinalis,* Sitzungsber. niederrh. Ges. f. Natur- u. Heilkde., Bonn., 1905, p. 28.

TEISSIER, P. Nouv. contrib. à l'étude de l'*Anguill. stercoralis;* Anguillulose experim. de la grenouille, Arch. Méd. expér., 1896, p. 358.

TESTI, A. Contrib. allo studio dell' anguillulosi intest., Riv. crit. di clin. med., 1904, v, Nos. 6-8.

THAYER, W. G. On the Occurrence of *Strongyloides intestinalis* in the United States, Journ. Exper. Med., 1901 (1), vi, p. 75.

ZINN, W. Über *Anguillula intestinalis*, C. f. B., P. u. Inf., 1899, i Abt., xxvi, p. 696.

Gnathostoma siamense (pp. 384, 385).

LEVINSEN, G. M. R. Om en ny rundworm hos mennesket, Vidensk. meddel. fra naturh. Foren., Kjöbenhavn, f. 1889, p. 323; abstracted in C. f. B., P. u. Inf., 1890, viii, p. 182.

Dracunculus medinensis (pp. 386 to 390, 675, and 676).

BASTIAN, A. On the Structure and Nature of the *Dracunculus*, Trans. Linn. Soc. Lond., 1863, xxiv, p. 101.

BLANCHARD, R. Malad. paras., paras., paras. animaux, Paris, 1895, p. 768.

CHARLES, R. H. Hist. of the male *Filaria medin.*, Sci. Mem. Med. Offi., Army of India, Calcutta, 1892, vii.

COPPOLA, N. *Filaria medin.* nella Colon. Eritrea, Giorn. med. del R. esercito, 1906, liv, p. 92; abstracted in Arch. f. Schiffs- u. Tropen-Hyg., 1906, x, p. 518.

FEDSCHENKO. Bau u. Entw. d. *Filaria*, Ber. d. k. Ges. d. Frd. d. Nat., Anthrop. u. Ethnogr., 1879, viii (1), p. 71.

LEUCKART, R. Die menschlichen Parasiten, 1876, 1. Aufl., ii, p. 644.

MANSON, P. On the Guinea-worm, Brit. Med. Journ., London, 1895, ii, p. 1350; Lancet, 1895, ii, p. 309.

— The Life-span of *Filaria medinensis*, Brit. Med. Journ., 1903, ii, p. 10.

MOSLER, F. Über die medic. Bedeutung d. Medinawurmes, Wien, Leipzig, 1885.

PLEHN, F. Die Kamerunküste, Berlin, 1898, p. 294.

POWELL, S. A. The Life-span of the Guinea-worm, Lancet, 1904, i, p. 76; Brit. Med. Journ., 1904, i, p. 73.

RAILLIET, A. De l'occurr. de la Filaire de Médine chez les animaux, Bull. Soc. Zool. France, 1889, xiv, p. 73.

VORTISCH, H. Erfahrungen über einige spezifische Krankheiten an der Goldküste, Arch. f. Schiffs- u. Tropen-Hyg., 1906, x, p. 537.

Filaria bancrofti (pp. 390 to 403, and 676 to 678).

ANNETT, H. E., J. E. DUTTON and J. H. ELLIOT. Report of the Malaria Expedition to Nigeria, II, Filariasis, Liverpool, 1901.

BANCROFT, TH. On the Metamorphosis of the Young Form of *Filaria bancrofti* in the body of *Culex ciliaris*, Proc. Roy. Soc. N. S. Wales, 1898, xxiii, p. 48; 1901, xxxv.

BIONDI, D. Chiluria da *Filaria sanguinis hominis nocturna* in Europa, Atti Accad. d. Lincei, January 12, 1903 (5), p. 538.

BLANCHARD, R. Transmiss. de la filariose par les moustiques, Arch. de Paras., 1900, iii, p. 280.

BOURNE, G. A. Note on *Filaria sanguinis hominis* with description of a Male Specimen, Brit. Med. Journ., 1888, No. 1429.

COBBOLD, T. S. The Life-history of *Filaria bancrofti*, Journ. Linn. Soc., London, 1879, xiv, p. 356.

DEMARQUAY. Note sur une tumeur de bourse . . . renferm. . . . des helm. némat., Gaz. méd., Paris, 1863 (3), xviii, p. 665.

LEWIS, T. R. On a Hæmatozoon inhabiting Human Blood, Calcutta, 1872; 2nd. edit., 1874.

— The Pathological Significance of Nematode Hæmatozoa, Calcutta, 1874.

LINSTOW, V. Über die Arten d. Blutfil. d. Menschen, Zool. Anz. 1900, xxiii, p. 76.

LOW, G. C. A Recent Observation on *Fil. nocturna* in *Culex*, Brit. Med. Journ., 1900, i, p. 1456.

— The Development of *Filaria nocturna* in Different Species of Mosquitoes, Brit. Med. Journ., London, 1901, i, p. 1336.

— Malaria and Filaria Diseases in Barbados, West Indies, Brit. Med. Journ., 1901, ii, p. 687

LYNCH, G. W. A. Note on the Occurrence of *Filaria* in Fijians, Lancet, 1905, i, p. 21.

MAITLAND, J. Note on the Etiology of Filariosis, Brit. Med. Journ., 1900, ii, p. 537.

MANSON, P. The *Filaria sanguinis hominis* . . . London, 1883.

— The Metamorphosis of *Fil. sanguinis hominis* in the Mosquito, Trans. Linn. Soc., Lond., 1884 (2), ii, pp. 10, 367.

— The *Filaria sanguinis* and Filariasis, Trop. Diseases, New Edit., London, 1903, p. 545.

PENEL, R. Les filaires du sang de l'homme, 2e édit., Paris, 1905; abstracted in Arch. de Paras., 1905, ix, p. 187.

SCHEUBE. Die Filariakrankheit, Volkmanns Samml. klin. Vortr., 1883, No. 232.

SIBTHORPE. On the Adult Male of *Filaria sanguinis hominis*, Brit. Med. Journ., 1889, No. 1485.

SOLIERI, S. Chiluria da *Filaria bancrofti* in Europa, Atti Accad. fisiocrat. sci., 1904 (4), xv, p. 429.

TANIGUCHI, N. Über *Filaria bancrofti*, C. f. B., P. u. Inf., 1904, i Abt. Orig., xxxv, p. 492.

THIESING, H. Beitr. zur Anat. der *Filaria sang. hom.*, Inaug.-Diss., Basel, Leipzig, 1892.

TRIBOUDEAU. Note sur la Filaria aux îles de la Société, C. R. Soc. Biol., Paris, 1903, lv, p. 996.

VINCENT, G. A. Observations on Human Filariasis in Trinidad, Brit. Med. Journ., 1902, i, p. 189.

ZIEMANN, H. Beitr. z. Filariakrankh. d. Menschen u. d. Tiere in d. Tropen, Dtsche. med Wchschr., 1905, No. 11.

Filaria demarquayi (pp. 403 and 404).

DANIELS, C. W. Filariæ and Filarial Disease in British Guiana, Brit. Med. Journ., 1898, ii, p. 878.

— Adult Form of *Filaria demarquayi*, Journ. Trop. Med., 1902, v, p. 357.

GALGEY, O. *Filaria demarquayi* in St. Lucia, Brit. Med. Journ., 1891, i, p. 145.

LOW, G. S. Notes on *Filaria demarquayi*, *ibid.*, 1902, i, p. 196.

MANSON, P. On Certain New Species of Nematode Hæmatozoa occurring in America, *ibid.*, 1897, ii, p. 1837.

OZZARD, A. T. Description of a Female Form of the *Filaria demarquayi*, Journ. Trop. Med., 1902, v, p. 259.

Filaria (?) conjunctivæ (pp. 404 to 406).

ADDARIO, C. Si di un nemat. dell' occhio umano, Ann. d. ottalmol., 1885, xv.
ALESSANDRINI, G. Nuovo caso di *Filaria conjunctivæ* Add., Boll. soc. zool. ital., 1906, 2a ser., vii, p. 233.
BABES, V. Über einen neuen Parasiten d. Menschen, Med.-chir. Ctrlbl., Wien, 1879, xiv, p. 554.
— Über einen im menschl. Peritoneum gefund. Nemat., Arch. f. path. Anat., 1880, lxxxi, p. 158.
GRASSI, B. *Filaria inermis*, ein Parasit d. Menschen, d. Pferdes u. d. Esels, C. f. B. u. Par., 1887, i, p. 617.

Agamofilaria oculi humani (p. 406).

GESCHEIDT. Die Entozoen des Auges, Zeitschr. f. Ophthalmol., 1833, iii, p. 405.
KRAEMER, A. Die thier. Schmarotzer des Auges, Graefe-Saemischs Handb. d. ges. Augenheilkde., Leipz., 1899, x, 2, chap. xviii.
KUHNT, H. Extract. ein. neuen Entozoon a. d. Glaskörper, Arch. f. Augenheilkde., 1891, xxiv, p. 205.
NORDMANN, A. v. Mikrograph. Beitr. z. Naturgesch. d. wirbellos. Thiere, Berlin, 1831, Heft 1, p. 7; Heft 2, p. 9.

Agamofilaria labialis (p. 407).

PANE. Nota su di un elminte nematode, Annal. Accad. degli aspiranti naturalisti, Napoli, 1864 (3), iv.

Filaria (?) romanorum-orientalis (p. 407).

SARCANI, A. *Filaria romanorum orientalis*, Wien. med. Presse, 1888, No. 7, p. 222.

Filaria (?) kilimaræ (p. 407).

KOLB, G. *Filaria kilimaræ* in Britisch-Ostafrika, Arch. f. Schiffs- u. Tropen-Hyg., 1898, ii, p. 28.

Filaria (?) sp. ? (p. 407).

CHOLODKOWSKY, N. A., in Wratsch, 1896, No. 3.
— Über einige selten beim Menschen vork. Parasit., Sitzgsber. St. Petersb. naturf. Ges., 1897, p. 185.

Mikrofilaria powelli (p. 407).

PENEL, R. Les filaires du sang de l'homme, 2e ed., Paris, 1905, p. 126.
POWELL, A. A Species of Blood Filaria, probably hitherto undescribed, Brit. Med. Journ., 1903, i, p. 1145.

Setaria equina (pp. 408, 409).

BLANCHARD, R. Traité de Zool. méd., Paris, 1890, ii, p. 16.
BRERA. Mem. phys.-med. sopra i princip. vermi del corpo umano, Crema, 1811, p. 31.
DEUPSER. Zur Entw. d. *Filaria papillosa*, Zool. Anz., 1892, xv, p. 129; In.-Diss., Breslau, 1894.

LINSTOW, V. Beobacht. an neuen u. bekannten Nemathelm., Arch. f. mikr. Anat. u. Entw., 1902, lx, p. 222.

TREUTLER, F. A. Observat. pathol.-anat. auct. ad helminthol. humani corporis continentes, Lipsiae, 1793.

Loa loa (pp. 409 to 414, and 678).

BILLET, A. Un nouv. cas de *Filaria loa* male, C. R. Soc. Biol., Paris, 1906, lxi, p. 507.

BLANCHARD, R. La Filaire sous-conjonctivale, Progr. Méd., Paris, 1886 (2), iv, pp. 591, 611.

— Nouveau cas de *Filaria loa*, Arch. de Paras., 1899, ii, p. 504.

BRUMPT, E. La *Filaria loa* est la forme adulte de la microfilaire designée sous le nom *Filaria diurna* Mans., C. R. Soc. Biol., Paris, 1904, lvi, p. 630.

GAUTHIER, C. Microfilaires du sang coïncidant avec une filaire de l'œil, Semaine méd., 1905, p. 176; C. R. Soc. Biol., Paris, 1905, lviii, p. 632.

HABERSHON, J. H. Calabar Swellings on the Upper Congo, Journ. Trop. Med., 1904, vii, p. 3.

LINON, J., and PÉNAUD Un cas de *Filaria loa* avec oedèmes intermitt., microfil. dans le sang, l'urine et la salive, C. R. Soc. Biol., 1906, lxi, p. 510.

LOOSS, A. Zur Kenntnis des Baues der *Filaria loa* G., Zool. Jahrb., 1904, Syst. xx, p. 549.

LUDWIG, H., and TH. SAEMISCH. Über *Filaria loa* im Auge des Menschen, Z. f. w. Zool., 1895, lx, p. 726.

MANSON, P. The *Filaria sanguinis hominis* major and minor, Two New Species of Hæmatozoa, Lancet, 1891, i, p. 4; Ctrlbl. f. allg. Path., ii, p. 298.

— Geographical Distribution of *Filaria sanguinis hominis diurna* . . . Trans. VII. Int. Cong. of Hyg. and Demography, London, 1891, i, p. 79.

MONGIN. Observ. sur un ver trouvé sous la conjonctive à Maribaron, île St.-Domingue, Journ. de Méd., Chirurg., Pharmacie, Paris, 1770, xxxii, p. 338.

PENEL, R. Les Filaires du sang de l'homme, 2e édit., Paris, 1905, p. 127.

PLEHN, F. Die Kamerunküste, Berlin, 1898, p. 296.

SAMBON, L. W. Remarks on the Individuality of *Filaria diurna*, Journ. Trop.

THOMPSTONE, S. W. Calabar Swellings, Journ. Trop. Med., 1899-1900, ii, p. 89.

WARD, H. B. The Earliest Record of *Filaria loa*, Zool. Ann., 1906, i, p. 376; Med., London, 1902, v, p. 381; vi, p. 26.

— Studies on Human Parasites in North America: I, *Filaria loa*, Stud. Zool. Lab., Univ. Nebraska, 1906, No. 63.

WURTZ, R., and A. CLERC. Nouv. observ. de *Filaria loa*, Arch. Méd. exp. et d'Anat. path., 1905, xvii, p. 261.

Acanthocheilonema perstans (pp. 414 to 416).

CHRISTY, C. The Distribution of Sleeping Sickness; *Filaria perstans* . . . in East Equatorial Africa, Rep. Sleeping Sickness Comm., London, 1903, ii, p. 1.

DANIELS, C. W. The *Filaria sanguinis hominis perstans* found in the Aboriginals of British Guiana, Brit. Guiana Med. Ann., 1897, p. 28.

— Discovery of the Parental Form of a British Guiana Bloodworm, Brit. Med. Journ., 1898, i, p. 1011.

DANIELS, C. W. The *Filaria ozzardi* and their Adult Form, Brit. Guiana Med. Ann., 1898, x, p. 1.
— Filariæ and Filarial Disease in British Guiana, Brit. Med. Journ., 1898, ii, p. 878.
— The Probable Parental Form of a Sharp-tailed *Filaria* found in the Blood of the Aboriginals of British Guiana, *ibid.,* 1899, i, p. 1459.
— The Sharp-tailed *Filaria* in British Guiana, Journ. of Trop. Med., 1899-1900, ii, p. 11.
— Filariasis in British Central Africa, Journ. Trop. Med., 1901, p. 193.
FIRKET, C. M. Filariose du sang chez les nègres du Congo, Bull. Acad. Roy. méd. Belg., 1895 (4) ix; abstracted in C. f. B., P. u. Inf. (1), xix, p. 791.
HENRY. Remarks on Filaria, Proc. Acad. Nat. Sci., Philadelphia, 1896, p. 271.
HODGES, A. Sleeping Sickness and *Filaria perstans* in Busoga, Journ. Trop. Med., 1902, v, p. 298.
LOW, G. C. *Filaria perstans,* Brit. Med. Journ., London, 1903, i, p. 722.
MANSON, P. *Cf.* under *Loa loa* and *Filaria demarquayi* (pp. 805, 806).
OZZARD, A. T. A Supposed New Species of *Filaria sanguinis hominis* found in the Interior of British Guiana, Brit. Guiana Med. Ann., 1897, p. 24.
PENEL, R. *Cf.* under *Loa loa* (p. 806).
ZIEMANN, H. Über das Vorkommen von *Filaria perstans* und von Trypanosomen beim Schimpansen, Arch. f. Schiffs- u. Tropen-Hyg., 1902, vi, p. 362.
— Beitr. zur Filariakrankheit d. Menschen u. d. Tiere in d. Tropen, Dtsche. med. Wchschr., 1905, No. 11.

Dirofilaria magalhãesi (p. 417).

BLANCHARD, R. Maladies parasitaires . . . Paris, 1895, p. 782.
LINSTOW, V. Über *Filaria bancrofti* Cobb., C. f. B. u. Par., 1892, xii, p. 88.
— Über die Arten d. Blutfil. d. Menschen, Zool. Anz., 1900, xxiii, p. 79.
MAGALHAES, P. S. DE. Die *Filaria bancrofti* Cobb. u. die *Fil. immitis* Leidy, C. f. B. u. Par., 1892, xii, p. 511.

Filaria gigas.

PROUT, W. T. Filariasis in Sierra Leone, Brit. Med. Journ., 1902, ii, p. 879; Journ. Trop. Med., 1902, v, p. 317.

Oncocerca volvulus (pp. 417 to 419, and 755).

BRUMPT, E. A propos de la *Filaria volvulus* Leuck., Rev. d. Méd. et d'Hyg. trop., 1904, i, p. 43; abstracted C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 148.
LABADIE-LAGRAVE and DEGUY. Un cas de *Filaria volvulus,* Arch. de Paras., 1899, ii, p. 451.
LEUCKART, R. (in Manson, P.). Diseases of the Skin in Tropical Climates; Davidson: Hygiene and Diseases of Warm Climates, Edinb., London, 1893, p. 963.
PENEL, R., *cf.* under *Filaria bancrofti* (p. 804).
PROUT, W. T. A *Filaria* found in Sierra Leone, Brit. Med. Journ., 1901, i, p. 209.
— Observations on *Filaria volvulus*, Arch. de Paras., 1901, iv, p. 301.

Trichuris trichiura (pp. 419 to 421, and 678 to 680).

ASKANAZY, M. Der Peitschenwurm ein blutsaug. Parasit., Deutsch. Arch. f. klin. Med., 1896, lvii, p. 104.

DAVAINE. Rech. sur le dévelop. et la propag. de l'*Asc. lombr.* et du Trichoc. de l'homme, C. R. Acad. Sci., Paris, 1858, xlvi, p. 1217.

EBERTH, J. G. Beitr. z. Anat. u. Phys. d. *Trichoc. dispar.*, Z. f. w. Zool., 1860, x, pp. 233, 383; 1862, xi, p. 96.

FRENCH, H. S., and A. E. BOYCOTT. The Prevalence of *Trichocephalus dispar*, Journ. of Hyg., 1905, v, p. 274.

GALLI-VALERIO, B. Die Verbreitg. d. Helminthen d. Mensch., Therap. Monatshefte, July, 1905.

GOEZE, J. A. E. Vers. ein. Naturgesch. d. Eingeweidewürmer, 1782, p. 182.

GRASSI, R. Trichocephalus- und Ascaris-Entwickelung, C. f. B. u. Par., 1887, i, p. 131.

LEUCKART, R. Die menschlichen Paras., 1876, ii, p. 492.

MAYER, F. J. C. Beiträge zur Anat. der Entozoen, Bonn, 1841.

MORGAGNI, J. B. Epist. anat. XVIII ad scripta pertinentium celeb. viri A. M. Valsalvae, Venetiis, 1740, ii Ep., xiv, p. 45.

RAILLIET, A. Not. helminth., Bull. Soc. centr. méd. vétér., 1884, p. 449.

ROEDERER, J. G. Nachr. von den Trichiuriden, Göttinger gel. Anz., 1761, No. 25.

WICHMANN. Über das Verhalt. der Trichoceph. zur Darmschleimhaut, Inaug.-Diss., Kiel, 1889.

Trichinella spiralis (pp. 421 to 431, 680, and 681).

ASKANAZY, M. Zur Lehre von der Trichinosis, C. f. B. u. Par., 1894, xv, p. 225.

— Arch. f. path. Anat., 1895, cxli, p. 42.

BABES, V. Ein 21 Jahre alter Fall von Trichinose mit lebenden Trichinen, C. f. B., P. u. Inf., 1906, i Abt., Orig. xlii, p. 541.

BROWN, T. R. Studies on Trichinosis, Bull. Johns Hopkins Hosp., 1897, viii, No. 73.

CERFONTAINE, P. Contribution à l'étude de la trichinose, Arch. de Biol., 1893, xiii, p. 125; Bull. Acad. roy. de Belg., 1893 (3), xxv, p. 454.

CHATIN, J. La trichine et la trichinose, Paris, 1883.

EHRHARDT, O. Zur Kenntnis der Muskelveränderung bei der Trichinose der Kaninchen, Beitr. z. pathol. Anat. und zur allg. Path., 1896, xx, p. 1.

— Zur Kenntnis der Muskelveränderung bei der Trichinose des Menschen, *ibid.*, p. 44.

GEISSE, A. Zur Frage der Trichinenwanderung, In.-Diss., Kiel, 1894.

GOUJON, L. Expér. sur la *Trichina spir.*, Thèse, Paris, 1866.

GRAHAM, J. Y. Beitr. zur Naturgesch. der *Trichina spiralis*, Arch. f. mikros. Anat., 1897, l, p. 219.

HERBST, G. Beobacht. über *Trichina spiralis*, Göttinger Nachr., 1851, p. 260; 1852, p. 183.

HERTWIG, R. Entwickelung der Trichinen, Münch. med. Wochenschr., 1895, No. 21.

HÖYBERG, H. M. Fütterungsvers. mit trichinös. Faekal., C. f. B., P. u. Inf., 1906, i Abt., Orig. xli, p. 210.

JOHNE, A. Der Trichinenschauer, 4. Aufl., Berlin, 1893.

LEUCKART, R. Untersuchungen über *Trichina spiralis*, 1. Aufl., 1860; 2. Aufl., 1866.

LÜBKE. Über das Vork. der Trichinen beim Dachs, Zeitschr. f. Fleisch- u. Milchhyg., 1903, xiii, p. 116.

MARK, E. L. Trichinæ in Swine, 20th Ann. Rep. Mass. State Board of Health for 1888, p. 113.

OPALKA, L. Beitr. zum Vork. der Trichinen beim Menschen mit Rücksicht auf die Prophylaxe, In.-Diss., Giessen, 1904, Arb. a. d. hyg. Inst. d. kgl. tierärztl. Hochschule, Berlin, No. 3, Berlin, 1904.

OSSIPOW, N. Über histol. Veränderungen in Spätstadien der Muskeltrichinose. Beitr. z. path. Anat. u. z. allg. Path., 1903, xxxiv, p. 253.

OWEN, R. Description of a Microscopical Entozoon infesting the Muscles of the Human Body, Trans. Zool. Soc., Lond., 1835, i, p. 315.

PAGENSTECHER, H. A. Die Trichinen, Wiesbaden, 1865.

PIRL. Das Vorkommen von Trichinen im Hundefleisch, Zeitschr. f. Fleisch- u. Milchhyg., 1899, x, p. 5.

SCHLEIP, K. Die Homberger Trichinosisepidemie und die für Trichinosis pathognomische Eosinophilie, Deutsch. Arch. f. klin. Med., 1904, lxxx, p. 1.

STÄUBLI, C. Beitr. z. Kenntnis d. Verbreitungsart der Trichinenembryomen, Vierteljahrsschr. der naturf. Ges., Zürich, 1905, l, p. 163.

— Klin. u. exp. Unters. über Trichinosis u. über die Eosinophilie im allg., Deutsch. Arch. f. klin. Med., 1905, lxxxv, p. 286.

STILES, CH. W. Trichinosis in Germany, U.S. Dep. of Agric., Bur of Anim. Ind., Bull. No. 30, Washington, 1901.

— *Trichinella spiralis*, Trichinosis and Trichina Inspection, Proc. Path. Soc., Philadelphia, 1901, N.S. iv, p. 137.

VIRCHOW, R. Zur Trichinenlehre, Arch. f. path. Anat., 1865, xxxii, p. 332.

— Darstellung der Lehre von den Trichinen, Berlin, 1864 and 1866.

WILLIAMS, H. U. The Frequency of Trichinosis in the United States, Journ. of Med. Res., 1901, vi, p. 64.

ZENKER, F. A. Über die Trichinenkrankh. des Menschen, Arch. f. path. Anat., 1860, xviii, p. 561.

— Beitr. zur Lehre von der Trichinenkrankh., Deutsch. Arch. f. klin. Med., 1866, i, p. 90; 1871, viii, p. 387.

Dioctophyme (*Eustrongylus*) *gigas* (pp. 431, 432, 681 and 682).

BALBIANI, G. Recherch. sur le dévelop. et le mode de propagation du Strongyle géant, Journ. de l'Anat., 1870, vii, p. 180; C. R. Soc. Biol., Paris, 1874 (6), i, p. 125.

BLANCHARD, R. Nouv. observ. de Strongyle géant chez l'homme, C. R. Soc. Biol., Paris, 1886 (8), iii, p. 379.

MAGUEUR. Strongyle géant du rein expulsé en partie par le canal de l'urètre chez un enfant de deux ans et demi, Journ. méd., Bordeaux, 1887-88, p. 337.

ROTHSTADT, J. Über das Vork. v. *Eustrongylus gigas* in Hunden der Stadt Warschau, Arb. zool. Labor. Kais. Univ., Warschau, 1897.

STILES, CH. W. Notes on Parasites, 49, Med. Rec., 1898, liii, p. 469; abstracted in C. f. B., P. u. Inf., xxiv, p. 505.

STUERTZ. *Eustrongylus gigas* im menschl. Harnapparat mit einseit. Chylurie, Dtsch. Arch. f. klin. Med., 1903, lxxviii, p. 557.

TRUMBULL, J. A Case of *Eustrongylus gigas*, Med. Rec., 1897, lii, p. 256; abstracted in C. f. B. u. Par., xxii, p. 619.

Metastrongylus apri (pp. 432, 433).

CHATIN, J. Le strongyle paradoxal chez l'homme, Bull. Acad. Méd., Paris, 1888, p. 483.
DIESING, C. M. Systema helminthum, II, Vindob, 1851, p. 317.
— Revision der Nematoden, Sitzungsb. K. Akad. d. Wiss., Wien, Math.-anat. Kl., 1860, xlii, p. 722.
JELKMANN, F. Über den fein. Bau v. *Strong. pulm. apri*, In.-Diss., Basel, 1895.
RAINEY. Entozoon found in the Larynx, Trans. Path. Soc., Lond., 1855, vi, p. 370.
SPEMANN, H. Zur Entw. des *Strongylus paradoxus*, Zool. Jahrb. An., 1895, viii, p. 301.
WANDOLLECK, B. Zur Embryonalentw. d. *Strong. paradoxus*, In.-Diss., Berlin, 1891, Arch. f. Naturg., 1892, lviii, p. 123.

Trichostrongylinæ (p. 433).

IJIMA, J. *Strongylus subtilis* in Japan, Zool. Mag., 1896, vii, p. 155.
LOOSS, A. *Strongylus subtilis*, ein bisher unbekannter Parasit des Menschen in Ägypten, C. f. B. u. Par., 1895 (1), xviii, p. 161.
— Notizen zur Helminthol. Ägyptens, I, *ibid.*, 1896, xx, p. 864.
— Notizen zur Helminthol. Ägyptens, VI, *ibid.*, 1905, i Abt. Orig., xxxix, p. 409.
RAILLIET, A. Traité de Zool. méd. et agric., 2e édit., Paris, 1895, p. 442.
— Sur les variations des Strongyles de l'appar. digest. et sur un nouv. Strongyle du Dromadaire, C. R. Soc. Biol., Paris, 1896 (10), iii, p. 540.

Ternidens deminutus (pp. 440, 441).

LOOSS, A. Notiz z. Helminthol. Ägyptens, III, C. f. B., P. u. Inf., 1900 (1), xxvii, p. 190.
— The Sclerostomidæ of Horses and Donkeys in Egypt, Records Egypt. Govt. School of Med., 1901.
RAILLIET, A., and A. HENRY. Un nouv. Sclérostom., paras. de l'homme, C. R. Soc. Biol., Paris, 1905, lviii, p. 569; Bull. Mus. d'Hist. nat., 1905, p. 269.

Œsophagostomum brumpti (pp. 441 to 443).

RAILLIET, A., and A. HENRY. Encore un nouveau Sclérostomien parasite de l'homme, C. R. Soc. Biol., Paris, 1905, lviii, p. 643.

Ancylostoma and *Necator* (pp. 445 to 459, 682 to 687, and 754).

ALESSANDRINI, G. Brevi osserv. sull. svil. e ciclo evolut dell' *Anchyl. duod.*, Boll. soc. zool. ital., Roma, 1904, xiii, p. 147.
— Ulter. ric. sul ciclo del svil. dell' *Uncinaria duod.*, *ibid.*, 1904, xiv, p. 173.
— Su di alcune Uncinariæ paras. dell' uomo e di altri vertebrati, *ibid.*, xiv, p. 23.
BENTLEY, C. A. On the Causal Relationship between "Ground Itch" or "Pani ghao" and the Presence of the *Ancylostoma duodenale* in the Soil, Brit. Med. Journ., 1902, p. 1900.
BOYCOTT, A. E. A Case of Skin Infection with Ancylostoma, Journ. of Hyg., 1905, v, p. 280; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxvii, p. 749.

BOYCOTT, A. E., and J. S. HALDANE. An Outbreak of Ancylostomiasis in England, Journ. of Hyg., 1903, iii, p. 95; 1904, iv, p. 73.

— — Uncinariasis in the Southern States, Journ. Amer. Med. Assoc., 1903, xl, p. 36.

BRUNS and W. MÜLLER. Die Durchwanderung d. *Ancylostoma*-Larven durch die menschl. Haut, Münch. med. Wochenschr., 1905, No. 31.

BUGNION, E. L'*Ankylost. duodén.* et l'anémie du St. Gotthard, Rev. méd. suisse romande, Genève, 1881, Nos. 5, 7.

CALMETTE, A., and M. BRETON. L'Ancylostomiase, Paris, 1905.

DUBINI, A. Nuovo verme dell' intest. umano, Annal. Univ. di Medic. d'Omodei, 1843, cvi, p. 51.

FERRIER. L'uncinariose en Algérie, Arch. de Paras., 1905-06, x, pp. 77, 458.

FIRKET. Rech. sur le trajet des larves de l'Ancylost. à travers les org. après pénétrat. par voie ent., Bull. Acad. Roy. méd. Belg., 1905.

GALLI-VALERIO, B. Notes de parasit.; B. Paras. anim., 6, 7, 8, C. f. B., P. u. Inf., 1905, i Orig., xxxix, p. 241.

GRASSI, B. Anchilostomi ed Anguillule, Gas. d. ospit., 1882, No. 41; Giorn. R. Accad. Med., Torino, 1883, xxxi, p. 119.

GRIESINGER. Klin. u. anat. Beob. üb. d. Krankh. v. Ägypten, Arch. f. phys. Heilkde., 1854, xiii, p. 55.

HERMANN. Note sur la pénétrat. des larves de l'*Anchyl. duod.* à travers la peau humaine, Bull Acad. Roy. Méd. Belg., 1905, 4e sér., xix, p. 181.

INOYE, J. Über *Ancylostoma duodenale* in Japan, Arch. f. Verdauungskrankh., 1905, xi, p. 58.

ISOLA, D. Esiste in Italia l'*Uncinaria americana?* Boll. Mus. zool. e anat. comp., Univ. Genova, 1904, No. 129.

KARSCHIN. Ein Fall von Ancylostomiasis (in Sibirien), Sibir. ärztl. Nachr., 1904, ii, No. 23; C. f. B., P. u. Inf., 1905, i, Ref. xxxvii, p. 504.

LAMBINET, J. Recherch. sur la mode d'infect. de l'organ. anim. par les larves d'Anchylost., Bull. Acad. Roy. méd. Belg., 1905, 4e sér., xix, p. 56.

LEICHTENSTERN, O. Über *Ancylostoma duodenale* bei d. Ziegelarbeitern in der Umgebung Cölns, Deutsche med. Wochenschr., 1885, xi, Nos. 28-30.

— Weitere Beitr. z. Ancylostomenfrage, *ibid.*, 1886, xii, Nos. 11-14.

— Fütterungsvers. mit Ancylost.-Larven Centralbl. klin. Med., 1886, No. 39.

— Einiges über *Ancylostoma duodenale*, D. med. Wochenschr., 1887, xiii, Nos. 26-32.

LIEFMANN, H. Beitr. zum Studium der Ancylostomiasis, Zeitschr. f. Hyg., 1905, l, p. 349.

LINSTOW, v. Zwei wenig bekannte Ankylostomen . . . C. f. B., P. u. Inf., 1906, i Orig., xliii, p. 89.

— Helminth. Beob. *Ancyl. americ.* aus *Simia troglodytes*, C. f. B., P. u. Inf., 1903, i Orig., xxxiv, p. 526.

LÖBKER and H. BRUNS. Über das Wesen u. die Verbreitung der Wurmkrankh. mit besond. Berücks. ihres Auftretens in deutschen Bergwerken, Arb. kais. Gesundheitsamt, 1906, xxiii, p. 421.

LOEB, L., and A. J. SMITH. Über eine die Blutgerinnung hemmende Substanz in *Ancylostoma caninum*, C. f. B., P. u. Inf., 1904, i Orig., xxxvii, p. 93; 1906, xl, p. 738.

LOOSS, A. Notizen z. Helminthol. Ägypt., I, C. f. B., P. u. Inf., 1896 (1), xx, p. 865.

— Notizen z. Helminthol. Ägypt., II, *ibid.*, 1897, xxi, p. 913.

— Zur Lebensgesch. d. *Ancyl. duod.*, *ibid.*, 1898, xxiv, p. 484.

LOOSS, A. Die Ancylostomafrage, *ibid.*, 1899, xxv, p. 662.

— Über d. Eindringen der Ancylostomalarven in die menschliche Haut, *ibid.*, i Abt., xxix, p. 733.

— Weiteres über d. Einwanderung der Ancylostomen von der Haut aus, *ibid.*, 1903, i Orig., xxxiii, p. 330.

— Zum Bau d. erwachs. *Ancylostomum duodenale* Dub., *ibid.*, 1904, xxxv, p. 752.

— Die Wanderung d. *Ancylostomum-* u. *Strongyloides*-Larven von der Haut nach dem Darm, C. R. 6e Congr. int. de Zool. (Berne, 1904), 1905, p. 225.

— Note on Intestinal Worms found in African Pygmies, Lancet, 1905, ii, p. 430.

— The Anatomy and Life-history of *Agchylostoma duodenale* Dub., Records of Egypt. Govt. School of Medicine, Cairo, 1905, iii.

— Einige Betracht. über die Inf. mit *Ankylost. duod.*, Zeitschr. f. klin. Med., 1905, lviii, p. 1.

LUTZ, A. Über *Ancylost. duodenale*, Volkm. Samml. klin. Vortr., 1888, Nos. 255, 256 and 265.

MENCHE. *Anchyl. duoden.* bei d. Ziegelbrenner-Anaemie i. Deutschland, Centralbl. f. klin. Med., 1882, p. 161; Zeitschr. f. klin. Med., 1883, vi, p. 161.

PARONA, C., and B. GRASSI. Sull. svilup. dell' *Anchilost. duod.*, Atti soc. ital. sci. nat., 1878, xxi, p. 53.

PERRONCITO, E. Helminth. Beobacht., Moleschotts Unters. z. Naturl. d. Mensch., xii, p. 532.

— Der *Dochmius* und verwandte Helminth. in ihren Beziehungen zur sogen. Bergcachexie, Centralbl. f. d. med. Wiss., 1881, No. 24.

— Les ancylostomes en France et la maladie des mineurs, C. R. Acad. Sci., Paris, 1882, p. 29.

— L'anémie d. mineurs au point de vue parasitol., Arch. ital. de biol., 1882, ii, p. 315; 1883, iii, p. 7.

PIERI, G. Sol modo di trasmissione dell' *Anchilost. duodenale*, Rendic. R. Accad. Lincei, Roma, Cl. fis., mat. e nat., 1902, xi, p. 217; Arch. ital. de biol., 1902, xxxvii, p. 269.

— Nuove ricerche sul modo in cui avviene l'infezione da Anchylostoma, Rendic. R. Accad. Lincei., Cl. fis., mat. et nat., 1903, xii, p. 393.

— Osservaz. sulla biol. dell' Ancylostoma, *ibid.*, 1905, No. 12.

SCHAUDINN, F. Über die Einwanderung d. Ancylostomenlarven von der Haut aus, Deutsche med. Wochenschr., 1904, xxx, p. 1338.

SCHÜFFNER, W. Über den neuen Infektionsweg der Ancylostomalarve durch die Haut, C. f. B., P. u. Inf., 1906, i Orig., xl, p. 683.

SCHULTHESS, W. Beitr. z. Anat. von *Ancylostoma duodenale*, Z. f. w. Zool., 1882, xxxvii, p. 163.

SICCARDI, P. D. Osserv. su l'Anchilostomiasi. L'*Ancylostoma americanum*, Atti R. Ist. Veneto di sci., lett. e arti, 1904-05, lxiv, p. 1473.

— Per lo studio dell' Anchilostomiasi (da *Ancyl. amer.*), *ibid.*, 1905-06, lxv, p. 69.

SIEBOLD, C. TH. v. Ein Beitrag zur Helminthograph. humana, Z. f. wiss. Zool., 1852, iv, p. 55.

SMITH, C. A. Uncinariasis in the South, Journ. Amer. Med. Assoc., 1903, xli, p. 709; 1904, xlii.

STILES, CH. W. A New Species of Hookworm (*Uncinaria americana*), parasitic in Man, Amer. Med., 1902, iii, p. 777.
— The Signification of the Recent American Cases of Hookworm Disease in Man, Eighteenth Ann. Rept. of the Bur. of Anim. Ind. (1901), Washington, 1902.
— Report upon the Prevalence and Geographical Distribution of Hookworm Disease, 2nd ed., Washington, 1903 (Hyg. Lab. Bull. No. 10).
— Address on Hookworm Disease, or Uncinariasis, Journ. Mississ. State Med. Assoc., 1904, ix, p. 123.
STILES, CH. W., and J. GOLDBERGER. A Young Stage of the American Hookworm, Eight to Twelve Days after Skin Infection in Rabbits and Dogs, Amer. Med., 1906, xi, p. 63.
TENHOLT. Die Untersuch. auf Anchylostomiasis mit bes. Berücks. d. wurmbehafteten Bergleute, 2. Aufl., Bochum, 1904.
— Über die Ancylostomiasis, Deutsche Vierteljahrsschr. f. öffentl. Ges., 1906, xxxviii, p. 271.
WUCHERER. Über Anchylostomenkrankheit, trop. Chlorose oder trop. Hyperämie, Dtsch. Arch. f. klin. Med., 1872, x, p. 379.
ZINN, W., and M. JACOBY. *Ancylostomum duodenale*, Leipzig, 1898.

Physaloptera caucasica (p. 461).

LINSTOW, V. Zwei neue Parasiten d. Menschen, C. f. B., P. u. Inf., 1902 (1), Orig. xxxi, p. 769.
MOLIN, R. Una monografia del genere *Physaloptera*, Sitzungsber. kais. Akad. d. Wiss., Wien, Math-phys. Cl., 1860, xxxix, p. 637.
STOSSICH, M. Il genere *Physaloptera*, Boll. Soc. Adriat. Sc. nat., Trieste, 1889, xi.

Ascaris lumbricoides (pp. 463 to 465, 687 to 694, and 754).

DAVAINE, E. Rech. sur le dévelop. . . . de l'*Ascar. lombr.*, C. R. Acad. Sci., Paris, 1858, xlvi, p. 1217; Mém. Soc. Biol., Paris, 1862 (3), iv, p. 261.
EPSTEIN, A. Über die Übertrag. d. menschl. Spulwurms, Jahrbüch f. Kinderheilk., 1892, N.F. xxxiii, p. 3.
EPSTEIN, W. Die Strangulationsmarke beim Spulwurm in ihrer diagnostischen Bedeutung, Deutsches Arch. f. klin. Med., 1904, lxxxi, p. 543; *cf.* Huber in: C. f. B., P. u. Inf., 1907, i, Ref. xxxix, p. 481.
GRASSI, B. Trichocephalus- und Ascarisentwickelung, C. f. B. u. Par., 1887, i, p. 131; 1888, iii, p. 748.
GUIART, J. Rôle pathol. de l'*Asc. lumbr.*, Arch. de Paras., 1900, iii, p. 70.
HALLEZ, P. Rech. sur l'embryol. et sur les condit. du dével. de quelq. némat., Paris, 1885.
LEUCKART, R. Die Übergangsweise der *Asc. lumbric.*, C. f. B. u. Par., 1887, ii, p. 713.
LINSTOW. Über d. Zwischenwirt von *Asc. lumb.*, Zool. Anz., 1886, ix, p. 525.
LUTZ, A. Zur Frage der Invas. von . . . *Asc. lumbric.*, C. f. B. u. Par., 1887, ii, p. 713.
— Weiteres zur Übertrag. d. Spulwurms, *ibid.*, 1888, iii, p. 265.
MAURIZI, A. Un nuovo caso di ascaridi nel fegato, Boll. soc. zool. ital., 1903 (2), xi, p. 198; collection of 130 cases.
MIURA, K., and N. NISHIUCHI. Über befruchtete und unbefruchtete Ascarideneier im menschl. Kote, C. f. B., P. u. Inf., 1902, i Orig., xxxii, p. 637.
SICK, C. Über Spulwürmer i. d. Gallenwegen, Tübingen, 1901.

Ascaris texana (p. 465).

SMITH, A. J., and R. A. GOETH. *Ascaris texana*, a Note on a Hitherto Undescribed Ascaris Parasitic in the Human Intestine, Journ. Amer. Med. Assoc., 1904, xliii, p. 542; abstracted in C. f. B., P. u. Inf., 1905, i, Ref. xxxvi, p. 499.

Toxascaris limbata (p. 466).

BELLINGHAM, O. B. Undescribed Species of Human Intestinal Worm, Dub. Med. Press, 1839, i, p. 104; Gaz. des Hôp., 1839 (2), i, p. 97.

COBBOLD, T. SP. On the Occurrence of *Ascaris mystax* in the Human Body, Lancet, 1863, i, p. 31.

DAVAINE, C. Sur la constitution de l'œuf des cert. entoz., Mém. Soc. Biol., Paris, 1862 (3), iv, p. 273.

GRASSI, B. Intorno all' *Ascaris mystax*, Gazz. med. it.-lomb., 1878, xxxix, p. 276.

— Beitr. z. Kenntn. d. Entwickelungscyclus von 5 Paras. d. Hundes, C. f. B. u. Par., 1888, iv, p. 609.

HELLER, C. Über *Ascaris lumbricoides*, Sitzgsber. Erlang. phys.-med. Societät, 1872, iv, p. 71.

HERING. Beitr. z. Entwickel. einig. Eingeweide-Würmer, Württemb. nat. Jahreshefte, 1873, p. 305.

KELLY, H. A. The Occurrence of the *Ascaris mystax* in the Human Body, Amer. Journ. Med. Sci., 1884 (2), lxxxviii, p. 483.

LEUCKART, R. Menschl. Paras., 1. Aufl., ii, p. 261.

MORTON, F. *Ascaris mystax*, Lancet, 1865, i, p. 278.

PETIT, G., and M. MOTAS. Pénétration de l'*Ascaris mystax* dans les canaux hépatiques du chien, Bull. Soc. Centr. Méd. Vétér., Paris, 1902 (2), xix, p. 146.

RAGAZZI, V. Sulla presenza dell' *Ascaris mystax* nell' uomo, Ann. med. nav. Ann., May 2, 1904, ix, p. 509; abstracted in C. f. B., P. u. Inf., 1906, i, Ref. xxxvii, p. 613.

Oxyuris vermicularis (pp. 467 to 469, and 694 to 698).

BLANCHARD, R. L'appendicite et la typhlo-colite sont très fréq. des affections vermineuses, Arch. de Paras., 1906, x, p. 404.

EDENS. Über *Oxyuris vermicularis* in der Darmwand, C. f. B., P. u. Inf., 1905, i Orig., xl, p. 499.

FLÖGEL, J. H. L. Über die Lippen einiger *Oxyuris*-Arten, Z. f. w. Zool., 1869, xix, p. 234.

GRASSI, B. I malefizi delle mosche, Gaz. Ospit., 1883, No. 59.

HELLER, A. Über *Oxyuris vermicularis*, Deutsch. Arch. f. klin. Med., 1903, lxxvii, p. 21.

KOLB, R. Über d. Befund von auf dem Peritoneum des Cavum Douglasi angewachs. Oxyuriden, C. f. B., P. u. Inf., 1902, i Orig., xxxi, p. 268.

MICHELSON. Die Oberhaut der Genitocruralfalte und ihre Umgebung als Brutstätte von *Oxyuris vermicularis*, Berl. klin. Wochenschr., 1877, xiv, No. 33.

PROSKAUER, TH. Embryonen von *Oxyuris* in der Nase, Zeitschr. f. Ohrenheilkde., 1891, xxi, p. 310.

SCHNEIDER, P. *Oxyuris vermicularis* im Beckenperitoneum eingekapselt, C. f. B., P. u. Inf., 1904, i Orig., xxxvi, p. 550.

SCHÖPPLER, H. Eier von *Oxyuris vermicularis* im Wurmfortsatz, C. f. B., P. u. Inf., 1906, i Orig., xli, p. 453.
STRICKER, W. Phys.-path. Bemerkungen über *Oxyuris vermicularis*, Arch. f. path. Anat., 1861, xxi, p. 360.
VIX, E. Über Entozoën bei Geisteskranken, insbes. über . . . *Oxyuris vermicularis*, Allg. Zeitschr. f. Psych., 1860, xvii, p. 149.
VUILLEMIN, P. Sur la pénétration des femelles d'*Ox. vermic.* à travers les parois de l'intestin, C. f. B., P. u. Inf., 1903, i Orig., xxxii, p. 358.
WAGENER, O. *Oxyuris vermicularis* in der Darmwand, Deutsch. Arch. f. klin. Med., 1904, lxxxi, p. 328.
— Weitere Unters. über *Oxyuris vermicularis* in der Darmwand des Menschen, Arch. f. path. Anat., 1905, clxxxii, p. 145.

Mermis hominis oris (p. 469).

LEIDY, J. Description of Three *Filariæ*, Proc. Acad. Nat. Sci., Philadelphia, 1850, v, p. 117.

Agamomermis restiformis (p. 470).

LEIDY, J. On a *Filaria* reported to have come from a Man, Proc. Acad. Nat. Sci., Philadelphia, 1880, p. 130.

(D) ACANTHOCEPHALA (pp. 475 to 478).

GRASSI, B., and CALANDRUCCIO. Über einen *Echinorhynchus*, der auch im Menschen parasitiert, C. f. B. u. Par., 1888, iii, p. 521.
HAMANN, O. Die Nemathelminthen, I, Monogr. d. Acanthocephalen, Jena, 1891.
KAISER, J. Über die Entwickelung d. *Echinorhynchus gigas*, Zool. Anz., 1887, x, p. 414.
KAISER, J. E. Die Acanthocephalen und ihre Entwickelung, Cassel, 1893, Bibl. Zool., vii.
LAMBL, W. Mikroskop. Untersuch. d. Darmexcrete, Prag. Vierteljahresschrift f. prakt. Heilkde., 1859, lxi, p. 45.
LEUCKART, R. Commentatio de statu embryonali et larv. Echinorhynch., Lipsiae, 1873.
SCHNEIDER, A. Entwickelung d. *Echinorhynchus gigas*, Sitzgsb. Oberhess. Ges. für Natur- u. Heilkde., 1871, p. 1.
STILES, CH. W. Sur l'hôte interméd. de l'*Echinorh. gigas* en Amérique, C. R. Soc. Biol., Paris, 1891 (9), iii, p. 764.

(E) GORDIIDÆ (p. 479).

ALDROVANDI, UL. De animalibus insectis, 1638, Lib. vii, cap. x, p. 720.
BLANCHARD, R. Pseudoparas. d'un Gord. chez l'homme, Bull. Acad. Méd., Paris, 1897, xxxvii, p. 614.
CAMERANO, L. Ricerche intorn. al. parasit. ed al polimorf. dei Gordii, Mem. R. Accad. Sci., Torino, 1887 (2), xxxviii, p. 495.
— Monografia d. Gordii, *ibid.*, 1897, xlvii.
DEGLAND, C. D. Descript. d'un ver filiforme rendu par vomissem, Rec. trav. soc. d'amat. d. sci., de l'agricult. et des arts de Lille, 1819-1822, p. 166.
GUÉGNEU, F. Nouv. cas de pseudopar. d'un *Gordius* dans le tube digest. de l'homme, C. R. Soc. Biol., Paris, 1905, lix, p. 398.

MONTGOMERY, TH. H. The Adult Organism of *Paragordius,* Zool. Jahrb. Anat., 1903, xviii.
PARONA, C. Altro caso di pseudopar. d. Gordio nell' uomo, Clinica med., 1901, No. 10.
PATRUBAN, V. Vorkommen von *Gordius aquaticus* beim Menschen, Wien. med. Jahrb., 1875, p. 69.
RAUTHER, M. Beitr. z. Kenntn. d. Morphol. u. d. phylogen. Beziehung. d. Gordiiden, Jen. Zeitschr. f. Naturwiss., 1905, xl.
TOPSENT, E. Sur un cas de pseudopar. chez l'homme du *Gordius viol.,* Bull. soc. sci. et méd. de l'Ouest, 1900, ix, No. 1.
VILLOT, A. Evolution des Gordiens, Ann. Sci. Nat. Zool., 1891 (7), xi.

(F) HIRUDINEI (pp. 480 to 482, and 699 to 701).

APATHY. Analyse d. äuss. Körperf. d. Hirudineen, Mitt. zool. Stat. Neapel, 1888, viii, p. 153.
— Süsswasserhirudineen, Zool. Jahrb., Syst. iii, 1888, p. 725.
BLANCHARD, R. Article Hirudinées, Dict. encycl. d. Sci. méd., 1888, xiv, p. 129.
— Many articles in Bull. Soc. Zool. France, 1890-1899.
EBRARD. Nouv. monogr. des sangsues méd., Paris, 1857.
LEUCKART, R. Die Paras. d. Mensch., 2. Aufl., i, ii, Hirudineen, fortges. von G. Brandes, Lpzg., 1886-1901.
MOQUIN-TANDON. Monogr. de la famille des Hirudinées, 2e éd., Paris, 1846.
WHITMAN, C. O. The External Morphology of the Leech, Proc. Amer. Acad. of Arts and Sci., 1884, xx, p. 76.
— The Segmentary Sense Organs of the Leech, Amer. Natural., 1884, xviii, p. 1104.
— The Leeches of Japan, Quart. Journ. Micros. Sci., 1886 (2), xxvi, p. 317.

(G) ARTHROPODA (pp. 483 to 616 and 702 to 732).

(*A*) Arachnoidea (pp. 483 to 529).

Arachnida in General.

LANKESTER, E. RAY. Structure and Classification of the Arachnida, Quart. Journ. of Micros. Sci., 1905, xlviii, p. 165.

ORDER. *Acarina* (pp. 484 to 523 and 702 to 709).

Acarina in General.

BANKS, N. A Treatise on the Acarina or Mites, Proc. U.S. Nat. Mus., xxviii.
MEGNIN, P. Les Acariens Parasites, 1892.
OUDEMANNS, A. C. A Short Survey of the more Important Families of Acari, Bull. Ent. Res., 1910, i, pt. 2.

Leptus autumnalis (pp. 485, 486, 702 and 703).

BRANDIS, F. Über *Leptus autumnalis,* Festschr. z. 50 jähr. Best. d. Prov. Irrenanst., Nietleben bei Halle a. S., 1897, p. 417.
BRUCKER. Sur le rouget de l'homme, C. R. Acad. Sci., Paris, 1897 (2), cxxv, p. 879.
FLÖGEL, J. H. L. Über eine merkw. durch Paras. hervorger. Gewebsneubild, Arch. f. Naturgesch., 1876 (1), xlii, p. 106.

GRUBY. Herbsterytheme, Allg. Wien. med. Ztg., 1861, p. 19.
HANSTEIN, R. v. Beitr. z. Kenntn. d. Gttg. *Tetranychus* Duf. nebst Bemerk. 1871, lii, p. 255.
HANSTEIN, R. v. Beitr. z. Kenntn. d. Gttg. *Tetranychus* Duf. nebst. Bemerk. über *Leptus autumnalis*, Zeitschr. f. wiss. Zool., 1901, lxx, p. 58.
HELM, F., and A. OUDEMANS. Sur deux nouv. formes larv. de Thrombidium, paras. de l'homme, C. R. Acad. Sci., Paris, 1904, cxxxviii, p. 704.
— —. Deux nouv. espèc. de Thrombidium de France, Bull. Soc. Ent. de France, 1904, p. 91.
HENKING, H. Beitr. z. Anat., Entw. u. Biol. von *Trombidium fuliginosum*, Zeitschr. f. wiss. Zool., 1882, xxxvii, p. 553.
KRAEMER. Beitr. z. Kenntn. d. *Leptus autumnalis*, Arch. f. path. Anat., 1872, lv, p. 354.
KÜCHENMEISTER, F. Über die sog. Stachelbeer- und Erntemilbe, Varga's Ztschr. f. Med., Chir. u. Geburtsh., 1862, N.F. i, p. 289.
MÉGNIN, P. Mém. sur la metamorph. des Acariens, Ann. sci. nat. Zool., 1876 (6), iv, Art. No. 5.
— Les Acarid. paras., Encycl. scientif. des aide-mém., Paris.
— Observations sur le Rouget, C. R. Acad. Sci., Paris, 1897, cxxv, p. 967.
MONIEZ, R. Sur les differ. Acar., qui s'attaq. à l'homme et qui ont reçu le nom de Rouget, Rev. biol. du Nord de la France, 1894-95, vii, p. 301.
THIELE, J. Die Gras- oder Erntemilbe, eine Plage der Feldarbeiter, Dtsche. landw. Presse, 1898, No. 98, p. 1016.
TROUESSART, E. L. Sur la piqûre du Rouget, Arch. de Paras., 1899, ii, p. 286.

Other *Leptus*, including Genus *Trombidium* (p. 486).

ALTAMIRANO, F., and A. DUGÈS. El tlalsahuate, El estudio, 1892, iv, p. 196.
BONNET, G. Contrib. à l'étude du parasit., Thèse de Montpellier, 1870, p. 53.
LEMAIRE. Import. en France du tlalsahuate, C. R. Acad. Sci., Paris, 1867, lxv, p. 215.
RILEY, C. V. The Mexican Jigger or Tlalsahuate, Insect Life, 1893, iv, p. 211; American Naturalist, 1873; abstracted in Handbook of the Med. Sci., 1887, v, p. 745.

Kedani Mite (pp. 487, 613, and 703).

BAELZ, E., and KAWAKAINI. Das japanische Fluss- oder Überschwemmungsfieber, Arch. f. path. Anat., 1879, lxxviii, p. 373.
SCHÜFFNER. Far East Assoc. Trop. Med., C. R. Trois. Congrès Biennal, Saigon, 1914.
TANAKA, K. Über Ätiol. u. Pathol. der Kedani-Krankh., C. f. B., P. u. Inf., 1899 (1), xxvi, p. 432.
— Über meine japanische Kedani-Krankh., *ibid.*, 1906 (1), Orig. xlii, pp. 16, 104, 205, 320.

Tetranychus (p. 488).

ARTAULT, L. Le platane et ses méfauts; un nouv. Acar. par. accid. de l'homme, Arch. de Paras., 1900, iii, p. 115.
FRITSCH, G. Bemerkgn. zu Herrn Hallers Aufs., Zool. Anz., 1866, x, p. 229.
HALLER, G. Vorl. Nachr. über einige noch wenig bekannte Milben, *ibid.*, p. 52.

Pediculoides, &c. (pp. 489, 615 and 616).

BRUCKER, C. A. Monographie de *Pediculoides ventricosus*, Bull. scientif. de la France et de la Belg., 1900, xxxv, p. 365.

FLEMMING, J. Über eine geschlechtsreife Form der als *Tarsonemus* beschriebenen Thiere, Ztschr. f. d. ges. Naturwiss., Halle, 1884 (4), iii, p. 472.

GEBER, E. Entzündliche Processe der Haut durch eine . . . Milbe veranlasst, Wiener med. Presse, 1879, xx.

KARPELLES, L. Eine auf dem Menschen und auf Getreide lebende Milbe, Anzgr. d. k. Akad. d. Wiss., Wien, 1885, xxii, p. 160.

KOLLER, J. Eine Getreidemilbe als Krankheitserregerin, Biol. Centralbl., 1885, iii, p. 127; Pester med.-chir. Presse, 1882, No. 36.

KRAMER. Zu *Tarsonemus uncinatus* Fl., Ztschr. f. d. ges. Naturw., Halle, 1884 (4), iii, p. 671.

LABOULBÈNE, A., and P. MÉGNIN. Mém. sur le *Sphærogyna ventricosa*, Journ. de l'Anat., 1885, xxi, p. 1.

MONIEZ, R. Sur l'habit. norm. dans les tiges d. céréal. d'un paras. accid. de l'homme, Rev. biol. du Nord de la France, 1895, vii, p. 148.

ROBIN, CH., and ROUYER. Erupt. cut. due à l'Acaris du blé, C. R. Soc. Biol., Paris, 1867 (4), iv, p. 178.

WILLCOCKS, F. C. The Predacious Mite *Pediculoides ventricosus*, Agric. Journ., Egypt, Cairo, 1914, iv, No. 1, pp. 17-51.

Nephrophages, &c. (pp. 490 and 491).

ALLMAN, G. Description of a New Genus of Tracheal Arachnidæ, Ann. Mag. Nat. Hist., 1847, xx, p. 47.

BANKS, N. A New Genus of Endoparasitic Acarina, Geneesk. Tijdsch. v. Nederl. Indie, 1901, deel 41, i, p. 334.

CASTELLANI, A. Note on an Acarid-like Parasite found in the Omentum of a Negro, C. f. B., P. and Inf., 1907, i Orig., xliii, p. 372.

GRIJNS, G., and J. DE HAAN. Acarid. als Endoparas., Geneesk. Tijdsch. v. Nederl. Indie, 1901, deel 41, i, p. 176.

HAAN, J. DE. Gibt es beim Menschen endoparasitär lebende Acariden? C. F. B., P. u. Inf., 1906, i Orig., xl, p. 693 [*Carpoglyphus alienus*].

HAAN, J. DE, and G. GRIJNS. Eine neue endoparasitäre Acaride, *Pneumonyssus simicola*, C. f. B., P. u. Inf., 1901 (1), xxx, p. 7.

HARST, VAN DER. Mijten in urine, Pharm. Weekbl., 1903, No. 6.

KRAMER, P. Über *Halarachne halichoeri*, Ztschr. f. d. ges. Naturw., Halle, 1885, lviii, p. 46.

LAMBL, W. Mikrosk. Unters. d. Darm-Excrete, Prager Vierteljschr. f. prakt. Heilkde., 1859, lxi, p. 45.

MAGALHAES, P. S. DE. Um novo Acariano, Progr. medico, 1877, No. 4.

MARPMANN. Über das Vork. v. Milben im Harn, C. f. B., P. u. Inf., 1898 (1), xxv, p. 304.

MÉGNIN, P. Mém. sur les Acar. paras. du tissu cellul. et des bourses aériennn. chez les oiseaux, Journ. de l'Anat. et de la Phys., 1879.

MIYAKE, H., and J. SCRIBA. Vorl. Mitteil. über einen neuen Paras. des Menschen, Berl. klin. Wochenschr., 1893, No. 16, p. 374.

— — *Nephrophages sang.*, ein neuerer menschl. Parasit im Urogenitalapparat, Mitteil. a. d. med. Fakult. d. k. Japan. Univ., iii, p. 1.

NEWSTEAD and TODD in Thompson Yates Lab. Reports, 1906.

NYANDER, J. C. Exanthemata viva, Linnaei amoenitates acad., 1757, v, p. 92, Diss. lxxxii.

OUDEMANS. Over mijten in de urine en in de nieren, Med. Weekbl., 1904, No. 12; Pharm. Weekbl., 1904, p. 269.

SILVA, ARANJO A. P. DA, in Gaz. med. da Bahia, 1877 (2), ii, No. 11; 1878, iii, No. 1.

Tydeus (p. 491).

MONIEZ, R. Hist. natur. du *Tydeus molestus*, Rev. biol. du Nord de la France, 1893-94, vi, p. 419.

Dermanyssus (pp. 492, 493, 703 and 704).

ALT, CH. H. De phthiriasi, Diss. Inaug., Bonn, 1824.

BLANCHARD, R. Nouv. cas de *Dermanyssus gallinæ* dans l'esp. hum., C. R. Soc. Biol., Paris, 1894 (10), i, p. 460.

GEBER, E., in Ziemssens Handb. d. spec. Path. u. Ther., 1884 (2), xiv, p. 394.

HEINICKE, W. Zwei Fälle v. Urticaria, hervorgerufen durch die Vogelmilbe, Münch. med. Wochenschr., 1901, No. 53.

ITZIGSOHN, H. Path. Bagatellen. I. Psora dermanyssica, Arch. f. path. Anat., 1858, xv, p. 166.

JUDÉE. Sur un nouv. paras. de la peau chez l'homme, C. R. Soc. Biol., Paris, 1867 (4), iv, p. 73.

SIMON, G. Die Hautkrankheiten durch anat. Untersuchung erl., 2. Aufl., Berlin, 1851, p. 320.

THEOBALD, F. V. The Parasitic Diseases of Poultry, 1896, p. 49.

WAGNER, A. Über das Vork. v. *Derman. avium* beim Menschen, Inaug. Diss., Greifswald, 1873.

Holothyrus (p. 493).

GERVAIS, P. Quinze espèces d'insect. apt., Ann. Soc. Ent. France, 1842, xi, Bull. p. xiv.

MÉGNIN, P. Un Acarien dangereux de l'île Maurice, C. R. Soc. Biol., Paris, 1897 (10), iv, p. 251.

Leiognathus, Laelaps (p. 493).

MONIEZ, R. *Leiognathus sylviarum*, Rev. biol. Nord de la France, 1893, v, p. 408.

NEUMANN, G. Pseudoparasitisme du *Laelaps stabularis* sur une femme, C. R. Soc. Biol., 1893 (9), v, p. 161.

Liponyssus.

PORTA, A. Dermatosi occasionale nell' uomo dovuta ad un acara (*Liponyssus lobatus*), Zool. Anz., Berlin, 1914, xliv, No. 11, p. 481.

Ixodidæ (pp. 493 to 500, 613, and 704).

ALLEN, W. E. Internal Morphology of the American Cattle Tick, Stud. Zool. Lab., Univ. Nebraska, 1905.

ARAGAO, H. D. B. Notas sobre ixodidas brazileiros, Mem. Inst. Oswaldo Cruz, 1911, iii, pp. 145-195.

— Contribuiçao para a sistematica e biolojia dos ixodidas, Mem. Inst. Oswaldo Cruz, 1912, iv, p. 96.

— Nota sobre algumas Coleçoes de Carrapatos brazileiros, Mem. Inst. Oswaldo Cruz, 1913, v, pp. 261-270.

DÖNITZ. Die Zecken des Rindes als Krankheitsüberträger, Sitzungsb. Ges. nat. Frde., Berlin, 1905, p. 105; 1906, No. 5.
KING, H. H. Ticks of the Sudan, Fourth Rept. Well. Trop. Res. Lab., 1911, pp. 128-130.
KOCH, C. L. Uebers. des Arachnidensystems, Nürnberg, 1847, Hft. iv.
NEUMANN, G. Revision de la famille des Ixodidés, Mém. Soc. Zool. France, x-xii.
— Das Tierreich, Lieferung 26, 1911.
— Notes sur les Ixodidés, Arch. de Paras., vi, viii-xi.
NUTTALL, G. H. F. The Harben Lectures, 1908, Journ. Roy. Inst. Public Health, 1908.
NUTTALL, WARBURTON, COOPER, and ROBINSON. A Monograph of the Ixodoidea.
PAGENSTECHER, H. Beitr. zur Anat. der Milben, Leipzig, 1861, ii.
ROHR, C. J. Estudo sobre Ixodidas do Brazil.
SALMON, D. E., and CH. W. STILES. Cattle Ticks (Ixodoidea) of the United States, Washington, 1902.

Ixodes (pp. 497 to 500 and 704).

BERTKAU, P. Bruchstücke aus der Lebensgeschichte unserer Zecke, Verh. nat. Ver. preuss. Rheinl. u. Westph., 1881; Sitzungsb. p. 145.
BLANCHARD, R. Pénétration de *l'Ixodes ricinus* sous la peau de l'homme, C. R. Soc. Biol., 1891 (3), ix, p. 689.
JOHANNESSEN, A. Acute Polyurie bei einem Kinde nach dem Stiche eines *Ixodes ricinus*, Arch. f. Kinderheilkde., 1885, vi, p. 337.
MÉGNIN, P. Encore un mot sur la biol. des Ixodes, C. R. Soc. Biol., Paris, 1903, lv, p. 175.
— Sur la biol. des tiques ou Ixodes, Journ. de l'anat. et da la phys., 1904, xl, p. 569.
NORDENSKIÖLD, E. Zur Anat. u. Histol. v. *Ixodes reduvius*, Zool. Anz., 1906, xxx, p. 118.

Hyalomma (pp. 501, 502).

RONSISVALLE. Sui fenomeni morb. prod. nel uomo da un Ixodide denomin. *Hyalomma aegyptium*, Bull. Accad. Gioenia sci. nat., 1891, xvii.

Dermacentor (pp. 502 to 505).

COOLEY, R. A. The Spotted Fever Tick (*Dermacentor venustus* Banks) and its Control in the Bitter Valley, Montana, Journ. Eco. Ent., 1915, viii, pp. 47-54.

Argas and *Ornithodoros* (pp. 505 to 510).

AJUTOLO, G. DE. Dell' *Argas reflexus* paras. dell' uomo, Mem. Roy. Accad. sci. Istit. Bologna, 1899 (5), viii.
— Nuovi casi di *Argas reflexus* par. dell' uomo, Rendic. Accad. sci., Bologna, 1898, N.S. ii, p. 222.
ALT, K. Die Taubenzecke als Paras. des Mensch., Münch. med. Wochenschr., 1892, No. 3; C. f. Bakt., 1893, xiv, p. 468.
AUDOUIN. Descript. de l'Egypte, 2e éd., xxii, Zool., p. 426.
BLACKLOCK, B. The Resistance of *Ornithodoros moubata* to various Sheep Dips, Ann. Trop. Med. and Par., 1912, vi, p. 429.

BOSCHULTE. *Argas reflexus* als Paras. des Menschen, Arch. f. path. Anat., 1860, xviii, p. 554; 1879, lxxv, p. 562.
BRANDES, G. *Argas reflexus* als gelegentl. Paras. des Menschen, C. f. B., P. u. Inf., 1897 (1), xxii, p. 747.
DUGÈS, A. Piqûre de Turicata, C. R. Soc. Biol., Paris, 1885 (8), ii, p. 216.
FISCHER DE WALDHEIM, G. Note sur l'Acarus de Perse, Mém. soc. nat., Moscow, 1823, vi, No. 30; Ann sci. nat., 1824, ii, p. 77.
FRITSCH, G. Über die giftige Wirkung des *Argas persicus,* Sitzungsber. Ges. nat. Frde., Berlin, 1875, p. 61.
GERSTÄCKER, A. *Argas reflexus,* ein neuer Paras. des Menschen, Arch. f. path. Anat., 1860, xix, p. 547.
— Gliederth. Ostafrikas von C. v. d. Deckens Reise, 1873, p. 464.
GIBERT, J. M. *L'Argas reflexus* et son paras. chez l'homme, Thèse, Bordeaux, 1896.
GUÉRIN-MÉNEVILLE. Descript. de *l'Argas talaje*, Rev. et Mag. de Zool., 1849, p. 342.
HELLER, C. Zur Anat. d. *Argas persicus,* Sitzungsber. kais. Akad. d. Wiss., Wien; math.-nat. Kl., 1858, xxx, p. 297.
LABOULBÈNE, A., and P. MÉGNIN. Mém. sur les *Argas* de Perse, Journ. de l'Anat., 1882, xviii, p. 317.
MÉGNIN, P. Expér. sur l'action novice des *Argas* de Perse, C. R. Soc. Biol., Paris, 1882, p. 305.
— Les *Argas* du Mexique, Journ. de l'Anat. et da la Phys., 1885, xxi, p. 463.
OKEN, L. Über giftige Milben in Persien, Isis, 1818, p. 1567.
SIMPSON, J. C. Case of Parasite (*Argas mégnini*) in Each Ear, Lancet, 1901, p. 1197.
STRICKLAND, C. Note on a Case of Tick Paralysis in Australia, Parasitology, 1914, xii, No. 4, p. 37.
THOLOZAN, J. D. Des phénom. morb. prod. par la piqûre . . . *Argas* de Perse, C. R. Soc. Biol., Paris, 1882, p. 15.
TODD, J. L. Tick Paralysis, Journ. of Parasitology, 1914, i, pp. 55-64.

Tyroglyphidæ (pp. 511 to 513).

CANESTRINI and KRAMA. Das Tierreich Lieferung, 1899.
DALGETTY, A. B. Water Itch, or Sore Feet of Coolies, Journ. Trop. Med., 1901, iv, p. 73.
FÜRSTENBERG, O. Die Kratzmilben des Menschen und der Thiere, 1861.
LAYOT, A. Etude sur le vanillisme, Rev. d'hyg. et de police sanit., 1883, v, p. 711.
LUDWIG, F. Die Milbenplage der Wohnungen, Leipzig, 1904.
MICHAEL, A. D. British Tyroglyphidæ, 1901 (Roy. Society), i; 1903, ii.
MONIEZ, R. Sur les Tyroglyphes, qui vivent aux dépens. d. mat. alim. ou d. prod. pharm., Rev. biol. Nord France, 1899, vi.
— Parasitisme accid. sur l'homme du *Tyroglyphus farinæ,* C. R. Acad. Sci., Paris, 1899, cviii, p. 1026.
PERRIER, E. Cas de paras. passager du *Glyciphagus domesticus*, C. R. Acad. Sci., Paris, 1896, cxxii, p. 859.
TROUESSART, E. Faux parasit. d'une espèce de Sarcopt. détriticole dans un kyste du testicule chez l'homme, C. R. Soc. Biol., Paris, 1900, lii, p. 742.
— Deuxième note sur *l'Histiogaster spermaticus* et sa prés. dans un kyste du testic. chez l'homme, *ibid.,* p. 893.

TROUESSART, E. Endoparasitisme accid. chez l'homme d'une espèce de Sarcoptide détriticole, Arch. de Paras., 1902, v, p. 449.
— Note compl. sur un Sarcopt. détriticole, *ibid.*, 1906, x, p. 314.

Sarcoptidæ (pp. 516 to 521 and 704 to 708).

ALEXANDER, A. Übertrag. d. Tierkrätze auf Menschen, Arch. f. Dermatol. u. Syphilis, 1900, lii, p. 185.
BERGH, R. Über Borkenkrätze, Arch. f. path. Anat., 1860, xix, p. 1; Vierteljahrschr. f. Dermatol. u. Syphilis, 1874, vi, p. 491.
BOURGUIGNON, H. Rech. sur la contagios. de la gale des anim. à l'homme, Mém. Soc. Biol., Paris, 1851, iii, p. 109; Ann. Sci. Nat., 1855 (4), iii, p. 114.
CANESTRINI, G., and P. KRAMER. Demodicidæ und Sarcoptidæ, Das Tierreich, Berlin, 1899, Lief. 7.
FÜRSTENBERG, M. H. F. Die Krätzmilben des Menschen u. der Thiere, Leipzig, 1861.
GURLT and HERTWIG. Vergl. Unters. üb. d. Haut des Menschen u. üb. d. Krätzmilben, Berlin, 1844.
HERTWIG, C. Über Krätz- u. Räudemilben, Arch. f. Naturgesch., 1835, i, p. 398.
MÉGNIN, P. Mém. sur l'acclim. des acar. psoriques des anim. sur d'autres espèc. anim. et sur l'homme, La France méd., 1876, xxiii, p. 166.
— Sur certains détails anat. que présent. l'espèce *Sarcoptes scabiei* et ses nomb. variat., C. R. Acad. Sci., Paris, 1875, lxxxi, p. 1058.
— Les Acariens parasites, Paris, Encycl. scientif. d. aide-mémoires.
WEYDEMANN. *Sarcoptes vulpis* beim Menschen, C. f. B. u. Par., 1897, xxii, p. 442.

Demodicidæ (pp. 522, 523, 708 and 709).

GUIART, J. La fréq. du Demodex chez l'homme, Bull. Soc. Zool., France, 1902, xxvii, p. 128.
IVERS, K. *Demodex* s. *Acarus folliculorum* u. seine Beziehungen zur Lidrandentzdg., Deutsche med. Wochenschr., 1899, p. 220.
KRAUS, A. Über färbetechn. Method. z. Nachweis d. *Acarus folliculorum*, Arch. f. Dermatol. u. Syphilis, 1901, lviii, p. 351.
LANDOIS, L. Über d. Haarbalgparas. d. Menschen, Greifswalder med. Beitr., 1863, i, p. 17.
LEYDIG, F. Über Haarsackmilben u. Krätzmilben, Arch. f. Naturg., 1859 (1), xxv, p. 338.
MAJOCHI, D. Int. al *Demodex folliculorum* nelle ghiand. meibom., Bologna, 1897; C. f. B., P. u. Inf., xxv, p. 784.
— *Demodex folliculorum* in qualche rara affezione cutanea e speciale reperto del medesimo nei follic. delle ciglia e delle vibrisse, Rend. sess. R. Accad. sci. istit. Bologna, 1899, N.S. iii, 3, p. 90; Bull. sci. med., Bologna (7), x, 5, p. 346.
RAEHLMANN, E. Über Blepharitis acarica, Klin. Mtsbl. f. Augenheilkde., 1899, xxxvii, p. 33.
SIMON, G. Sur les acares vivant dans les follicules pileux de l'homme, Arch. Méd. compar., 1843, i, p. 45.
STCHERBATCHOFF. Le *Demodex folliculorum* dans les follicules ciliaires de l'homme, Thèse, Lausanne, 1903; C. f. B., P. u. Inf., 1904, i, Ref. xxxiv, p. 622.

STIEDA, L. Über d. Vorkom. d. Haarbalgparas. an den Augenlidern, Centralb. f. prakt. Augenheilkde., July, 1890, p. 193.

THUDICHUM, J. S. W. On the *Demodex folliculorum* as the Parasite causing the Mange of Dog and its Transference upon Man, Med. Press and Circ., 1894, p. 103.

ORDER. *Pentastomida* (pp. 523 to 529).

Linguatula rhinaria (pp. 524 to 526).

BENEDEN, P. J. VAN. Rech. sur l'organ. et dével. des Linguatiles, Nouv. Mém. Acad. Belg., 1849, xxiii; Ann. Sci. Nat., 1849 (3), Zool. xi, p. 313.

COLIN, in Bull soc. méd. vét., 1861 (2), v, p. 125; 1863, vii, p. 22; 1864, viii, p. 108.

KOCH, M. Zur Kenntn. des Parasit. d. Pentastomen, Arb. a. d. pathol. Inst., Berlin, 1906.

KULAGIN, N. Zur Naturgesch. d. *Pentastoma denticulatum*, C. f. B., P. u. Inf., 1898 (1), xxiv, p. 489.

LAENGNER, H. Über *Pentastomum denticulatum* beim Menschen, C. f. B., P. u. Inf., 1906, i Orig., xl, p. 368.

LAUDON. Ein kasuistischer Beitrag z. Ätiol. d. Nasenblutens, Berl. klin. Wochenschr., 1878, xv, p. 730.

LEUCKART, R. Bau und Entwickelungsgesch. d. Pentast., Leipzig, 1860.

LOHRMANN, E. Unters. üb. d. anat. Bau d. Pentastomen, Arch. f. Naturgesch., 1889, lv, 1, p. 303.

RÁTZ. ST. V. Von der act. Wanderg. d. *Pentast. denticulatum*, C. f. B. u. Par., 1892, xii, p. 329.

SCHUBART, T. D. Entwickelg. v. *Pentastomum taenioides*, Zeitschr. f. w. Zool., 1852, iv, p. 116.

SHIPLEY, A. E. An Attempt to Revise the Family Linguatulidæ, Arch. de Paras., 1898, i, p. 52.

STILES, C. W. Bau u. Entwickl. von *Pentastomum proboscideum* u. *P. subcylindricum*, Zeitschr. f. w. Zool., 1891, lii, p. 85.

VIRCHOW, R. Helminth. Notiz., I, Arch. f. path. Anat., 1857, xi, p. 81.

WELCH, F. H. The Presence of an Encysted Echinorynchus in Man, Lancet, 1872, ii, p. 703.

ZENKER, F. A. Über einen neuen thier. Paras. d. Menschen, Zeitschr. f. rat. Med., 1854 (2), v, p. 212.

Porocephalus constrictus (pp. 526 to 528).

AITKEN, W. On the Occurrence of *Pentastoma constrictum* in the Human Body as a cause of Painful Disease and Death, Sci. and Pract. of Med., 4th ed., London, 1865.

BILHARZ, TH. Ein Beitr. z. Helminthographia humana, Zeitschr. f. w. Zool., 1852, iv, p. 65.

— Über *Pentastomum constrictum*, *ibid.*, 1856, vii, p. 329.

— Übers. über d. i. Ägypten beobacht. Eingeweidewürmer, Zeitschr. d. Ges. d. Ärzte, Wien, 1858, i, p. 447.

BORDEN and RODHAIM. Contribution à l'étude de *Porocephalus moniliformis*, Anns. Trop. Med. and Par., 1908, ii, p. 303.

CHALMERS. A Case of *Pentastoma constrictum*, Lancet, June 24, 1899; C. f. B., P. u. Inf. (1), xxvi, p. 518.

DIESING, C. M. Vers. einer Monogr. d. Gttg. *Pentastoma*, Annal. d. wien. Mus., 1835, i, p. 1.

FARIA, DE GOMES, and L. TRAVASSOR. Nota sobre a presence de lava de *Linguatula serrata*, Froelich no intestino do homan no Brazil, Mem. Inst. Oswaldo Cruz, 1913, v, p. 123.

GIARD, A. *Pentastomum constrictum*, paras. du foie des nègres, C. R. Soc. Biol., Paris, 1896 (10), iii; C. f. B., P. u. Inf. (1), xxiii, p. 1098.

KIEWIET DE JONGE. Nadere inlichingen over de *Porocephalus moniliformis*, Geneesk. Tijdschr. Nederl. Indie, 1906, xlvi, p. 524.

NEUMANN, G. Sur les Porocéphales du chien et de quelq. mammif., Arch. de Paras., 1899, ii, p. 356.

OUWENS, P. A. *Porocephalus moniliformis* niet alleen tot Afrika, Geneesk. Tijdschr. v. Nederl. Indie, 1906, xlvi, p. 423.

PRUNER. Krankh. d. Orients, Erlangen, 1847, p. 249.

SPENCER, W. B. The Anatomy of *Pentastomum teretiusculum*, Quart. Journ. Micros. Sci., 1890, N.S. xxxiv, pt. 1.

STILES, C. W. Bau und Entwickelungsgeschichte v. *Pentastomum*, Zeit. für wiss. Zool., 1891, lii, p. 85.

THIROUX, M. Un cas de *Pentastomum constrictum* observ. au Sénégal, C. R. Soc. Biol., Paris, 1905, lviii, p. 79. [Firket, who abstracted this paper in Arch. f. Schiffs- u. Tropen-Hyg., 1906, x, p. 295, Anm., mentions that at a meeting in Liége he showed an example of *Pent. constr.* which he had discovered in the liver of a Congo negro.]

(*B*) **Insecta** (pp. 529 to 612 and 709 to 732).

Pediculidæ (pp. 532 to 534, and 709 to 713).

ARTAULT DE VEVEY, ST. Deux cas de pediculose accid. et intermitt. chez l'homme, C. R. Soc. Biol., Paris, 1895, No. 29, p. 684).

BIEBEL, C. G. Insecta epizoa, Leipzig, 1874.

CHOLODKOWSKY, N. Zur Morphologie der Pediculiden, Zool. Anz., 1903, xxvii, p. 120.

— Zur Kenntn. d. Mundwerkz. u. Syst. d. Pediculiden, *ibid.*, 1904, xxviii, p. 368.

ENDERLEIN, G. Läuse-Studien, Zool. Anz., 1904, xxviii, p. 121.

GRABER, V. Anat.-phys. Studien über *Phthirius inguinalis*, Zeitschr. f. wiss. Zool., 1872, xxii, p. 157.

LANDOIS, L. Untersuch. über die am Menschen schmarotz. Pediculinen, *ibid.*, 1864, xiv, p. 1; 1865, xv, pp. 32, 494.

MARZOCCHI, V. Sur le *Phthirius inguinalis*, Archiv. Parasitologie, 1903, pp. 314-317.

PAWLOWSKY, E. Über den Stech- und Saugapparat der Pediculiden, Zeitschr. f. wiss. Insectenbiol., 1906, ii, Heft. 5-7.

PIAGET. Les pédiculines, Leide, 1880, Suppl. 1885.

Acanthiadæ (pp. 534 to 537, and 713).

BACOT, A. W. The Influence of Temperature, Submersion, and Burial on the survival of Eggs and Larvæ of *Cimex lectularius*, Bull. Ent. Res., 1914, v, pt. 2, pp. 111-152.

— Notes on the Development of *Bacillus pestis* in Bugs (*Cimex lectularius*), &c., Journ. Hygiene, 1915, iv, p. 777.

BLACKLOCK, B. On the Resistance of *Cimex lectularius* to various Reagents, Powders, Liquids, and Gases, Ann. Trop. Med and Par., 1912, No. 4, vi, p. 415.

BRUMPT, E. Réduvides de l'Amérique du Nord capable de transmettre le *Trypanosoma cruzi*, Bull. Soc. Path. Exot., Paris, 1914, vii, No. 2, pp. 132-133.

— Un Réduvide du Vénézuela, le *Rhodnius prolixus*, chez lequel évolue *Trypanosoma cruzi*, Bull. Soc. Path. Exot., Paris, 1913, pp. 382-383.

EVERSMANN, E. Quædam insectorum species novæ, Bull. soc. Impér. de Nat., Moscow, 1841, xiv, p. 351.

GIRAULT, A. A. An Account of the Habits of the Common Bed-bug and Bibliography, Psyche, 1905, xii, p. 61; 1906, xiii, p. 42.

— Preliminary Studies of the Biology of the Bed-bug, *Cimex lectularius*, Journ. Econ. Biol., London, 1914, ix, No. 7, pp. 25-45.

JOYEUX, CH. Biologie de *Cimex boneti* (*rotundatus*), Archiv. de Paras., 1913, pp. 140-146.

LANDOIS, L. Anatomie von *Cimex lectularius*, Zeitschr. f. wiss. Zool., 1868, xviii, p. 206.

NEIVA, A. Informaçoes sobre a biologia do *Conorhinus megistus*, Burm., Mem. d. Inst. Oswaldo Cruz, 1910, ii, fas. 11, p. 206.

— Informaçoes sobre a biologia da *Vinchuca-Triatoma infestans*, Klug., Mem. Instit. Oswaldo Cruz, 1913, v, p. 24.

PATTON, W. S. Notes on the Distribution of the Two Species of Bed-bugs, Ind. Med. Gaz., February, 1907, xlii, No. 2.

ROTHSCHILD, N. C. The Tropical Bed-bug, *Clinocoris hemiptera*, Fabr., Bull. Ent. Res., 1913, iv, pt. 4, p. 345.

SIGNORET, V. Notice sur quelq. hemipt. nouv., Ann. soc. entom., France, 1852 (2), x, p. 539.

THOMSON, D. Attempts to find Disease Germs in the European Bed-bug (*Cimex lectularius*) after Feeding Experiments, Ann. Trop. Med. and Par., 1914, viii, p. 19.

Pulicidæ (pp. 545 to 548, 613, 714, and 715).

BACOT, A. W. Observations on the Length of Time Fleas (*Ceratophyllus fasciatus*) carry *Bacillus pestis*, &c., Journ. Hygiene, 1915, iv, p. 770.

BAKER, C. F. Revision of American *Siphonaptera* with a Bibliography of the Group, Proc. U.S. Nat. Mus., xvii.

BERGH, R. Flohlarven als Pseudoparasiten d. Menschen, Monatshefte f. pr. Dermatologie, 1885, iv, p. 209.

BLANCHARD, R. Quelq. mots sur la chique, Bull. Soc. Zool. France, 1889, xiv, p. 95.

— Présence de la chique à Madagascar, Arch. de Paras., 1899, ii, p. 627.

BLANDFOORD, W. H. F. The Chigoe in Asia, Ent. Monthly Mag., 1894 (2), v, p. 228.

CUNHA, DE ALMEIDA. Contribuiçao para o conhecimento dos siphonapteros brazileiros, Mem. Inst. Oswaldo Cruz, 1914, vi, fas. 2, pp. 125-136.

HENNING, G. Zur Geschichte des Sandflohs in Afrika, Naturw. Wchschr. (Potonié), 1904, N.F. iii, p. 310.

HETTNER, A. Die Ausbreitung des Sandflohs in Afrika, Geograph. Zeitschr., 1899, v, p. 522.

HINDLE, E. A Chinese Flea-trap, Proc. Camb. Phil. Soc., 1913, xvii, pt. 3, p. 284.

HIRST, L. F. Identification of Rat-fleas in Colombo, Brit. Med. Journ., January, 1914, p. 85.

JORDAN, K., and N. C. ROTHSCHILD. A Revision of the Non-combed-eyed *Siphonaptera*, Parasitology Supp. Journ. Hygiene, 1908, i, No. 1.

— A Revision of Sarcopsyllidæ, Thompson Yates and Johnston's Lab. Report, 1906, vii, p. 15.

JULLIEN, J. La chique sur la côte occident. d'Afrique, Bull. soc. Zool. France, 1889, xiv, p. 93.

LAMA. *Dermatophilus penetrans*, Giorn. Ital. Mal. Ven. Milan, 1914, xlix, pp. 465-472.

LASS, M. Beitr. z. Kenntn. des histol.-anat. Baues des weibl. Hundeflohs, Ztschr. f. wiss. Zool., 1905, lxxix, p. 73.

ROTHSCHILD, C. N. A Synopsis of the British Siphonaptera, Entom. Mon. Mag., 1915, li, No. 610, pp. 42-112.

ROTHSCHILD, N. C. On Three Species of *Xenopsylla* occurring on Rats in India, Bull. Ent. Res., 1914, v, pt. 1, p. 83.

— A Synopsis of Fleas found on *Mus norvegicus* (*decumanus*), *Mus rattus* (*alexandrinus*), and *Mus musculus*, Bull. Ent. Res., 1910, i, pt. 2.

RUSSELL, H. The Flea, Camb. Univ. Press, 1913.

SCHWELLENGREBEL, N. H. Versuche und Beobachtungen über die Biologie von *Xenopsylla cheopis* in Ost Java, C. f. B., P. u. Inf., Jena, 1914, lxxiv, Nos. 5 and 6, pp. 456-466.

SCHWELLENGREBEL, N. H., and L. OTTEN. Experimentelle Beitrage zur Kenntnis der Uebertragung der Pest durch Flöhe und Läuse, C. f. B., P. u. Inf., 1914, lxxiv, No. 7, p. 592.

STRICKLAND, C. The Biology of *Ceratophyllus fasciatus*, the Common Rat-flea of Great Britain, 42nd Ann. Rept. Loc. Gov. Board, Suppl., App. B, 1913, No. J, pp. 401-412.

TASCHENBERG, O. Die Flöhe . . . monographisch dargestellt, Halle, 1880.

TIRABOSCHI, C. Les Rats, les Souris et leurs parasites cutanés, Arch. de Paras., 1903-04, viii.

TROUSSAINT. Accid. grav. prod. par le *Sarcopsylla penetrans*, Arch. Méd. et Pharm. mil., 1902, xxxix, p. 42.

WELLMAN, F. C. Notes from Angola, Journ. Trop. Med., 1905.

Mosquitoes and other Nematocera (pp. 548 to 603).

ADIE, H. A. Note on the Sex of Mosquito Larvæ, Ann. Trop. Med. and Par., 1912, vi, p. 463.

ANNANDALE, N. Indian Species of *Phlebotomus*, Rec. Ind. Mus., 1910, iv, pp. 2 and 3.

AUSTEN, E. E. Notes on African Blood-sucking Midges (family *Chironomidæ*, sub-family *Ceratopogoninæ*), Bull. Ent. Res., 1912, iii, pp. 99-112.

BALLOU, H. A. Millions and Mosquitoes, Pamphlet No. 55, Imperial Dept. Agri., West Indies, 1908.

BLANCHARD, R. Les moustiques, Hist. nat. et méd., Paris, 1905.

BOLT. Sand-flies and Fever in China, China Med. Journ., Shanghai, 1915, xxix, No. 2, pp. 78-86.

BOYCE, R. Prevalence, Distribution, and Significance of *Stegomyia fasciata* in West Africa, Bull. Ent. Res., May, 1911, ii, pt. 1.

CARTER, H. F. On certain Mosquitoes of the genera *Banksinella*, Theobald, and *Tæniorhynchus*, Arribalzaga, Ann. Trop. Med. and Par., 1913, vii, p. 581.

CHRISTOPHERS, S. R. Contribution to the Study of Colour Markings and other variable characters of *Anophelinæ*, &c., Ann. Trop. Med. and Par., 1913, vii, p. 45.

COQUILLETT, D. W. A Classification of Mosquitoes of North and Middle America, U.S. Dept. Agri., Div. Ent., 1906.

DYAR, H. G. Key to the known Larvæ of the Mosquitoes of the United States, U.S. Dept. Agri., Bur. Ent. Circular 72, 1906.

DYÉ, L. Les parasites des Culicides, Arch. de Paras., 1904, ix, p. 5.

EDWARDS, F. W. On the Culicid Genus *Eretmapodites*, Theobald, Ann. Mag. Nat. Hist., July, 1911, viii, ser. 8, pp. 67-73.

— The African Species of Culex and Allied Genera, Bull. Ent. Res., 1911, ii, pp. 241-268.

— Some New West African Species of *Anopheles*, &c., Bull. Ent. Res., 1911, ii, pt. 2, p. 141.

EYSSELL, A. Die Steckmücken, Handb. d. Tropenkrankh., issued by C. Mense, Leipzig, 1905, ii, p. 44.

FABRICIUS, J. C. Systema antliatorum, Brunsv., 1805-06.

FRANCA, C. *Phlebotomus papatasii* (Scopoli) et fièvre à Pappataci au Portugal, Bull. Soc. Path. Exot., 1913, vi, pp. 123-4.

GALLI-VALERIO, B., and J. ROCHAZ DE JONGH. Beobachtungen über Culiciden, Centralbl. f. Bakt., &c., 1913, xvii, p. 472.

— Beobachtungen über Culiciden und Mittelung über das Vorkommen var. *Phlebotomus papatasii* Scop. im Kanton Waadt, Centralbl. f. Bakt., &c., 1912, lxiii, pp. 222-227.

GILES, G. M. J. A Handbook of Gnats or Mosquitoes, 1st ed., London, 1900; 2nd ed., London, 1902, 17 pl.

— A Revision of the Anophelinæ, London, 1904.

GOUGH, L. H. Preliminary Notes on Egyptian Mosquitoes, Bull. Ent. Res., 1914, v, pt. 2, p 133.

GRASSI, B. Ricerche sui Flebotomi, Memorie della societa italiana della Scienze, 1907, se. 3, xiv.

GREEN, E. E. Insects, Rec. Ind. Mus., 1912, vii, pt. iii, p. 309.

GRÜNBERG, K. Die blutsaug. Dipteren, Jena, 1907.

GUENTHER, K. Culiciden, Zeits. f. wiss. Insektenbiol., 1913, ix, pp. 26-40.

HEADLEE, T. J. The Control of Mosquitoes in a Limited Locality, Journ. Eco. Ent., 1915, viii, No. 1, pp. 40-47.

HOWARD, L. O. Mosquitoes: How they Live, How they Carry Disease, &c., New York, 1901.

— The Yellow Fever Mosquito, U.S. Dept. Agric., Farmers' Bull., 1913, No. 547.

HOWARD, L. O., H. C. DYAR, and F. KNAB. The Mosquitoes of North and Central America and the West Indies, 1912, i and ii; 1915, iii.

HOWLETT, F. M. The Influence of Temperature upon the Biting of Mosquitoes, Parasitology, 1910, iii, No. 4, p. 478.

JAMES, S. P. The Protection of India from Yellow Fever, Indian Journ. of Med. Res., 1913, i, No. 2, pp. 213-217.

— Note on the Practicability of Stegomyia Reduction in Indian Seaports, Ind. Journ. Med. Res., 1913, i, No. 2, pp. 258-262.

JAMES, S. P., and W. G. LISTON. A Monograph of the Anopheles Mosquitoes of India, Calcutta, 1904, 4to, 30 pl.; 2nd ed., 1911.

KING, H. H. Animals Injurious to Man and Animals, Mosquitoes, Fourth Rept. Well. Lab. Trop. Res., 1911, pp. 99-112.

— On the Bionomics of the Sandflies of Tokar, Bull. Ent. Res., 1913, iv, pt. 1, p. 83.

LAHILLE, F. Sobre un Anopheles, una Stegomyia y la Notaçion, de las Nervaduras alares de los Mosquitos, Ann. d. Mus. Naçion. d. Hist. Nat. de Buenos Aires, 1912, xxiii, p. 253-263.

LEICESTER, G. F. The Culicidæ of Malaya, Studies from the Inst. of Med. Res., Federated Malay States, 1908, iii.

LEON, N. Vorl. Mitt. über den Saugrüssel der Anopheliden, Zool. Anz., 1904, xxvii, p. 730.

LISTON, W. G., and T. G. AKULA. A *Stegomyia* Survey of the City and Island of Bombay, Proc. Gen. Mal. Comm., Madras, November, 1912, Simla, 1913, p. 187.

LUDLOW, C. S. Disease-bearing Mosquitoes of North and Central America, the West Indies, and the Philippine Islands, Bull 4, War Dept., Office Surgeon-General, U.S.A., 1914.

— The Philippine Mosquitoes, Psyche, 1911, xviii, No. 4, pp. 125-133.

LUTZ, A. Brazilian Simulidæ, Mem. d. Inst. Oswaldo Cruz, 1910.

— Contribuiçao para o estudo das *Ceratopogoninas hematofagas* encontradas Mem. Inst. Oswaldo Cruz, 1913, v, pp. 45-72.

— Contribuiçao para o estudo das *Ceratopogoninas hematofagas* encontradas no Brazil, Mem. Inst. Oswaldo Cruz, 1912, pp. 1-33.

— Contribuiçao para o conhecimento das Ceratopogoninæ do Brazil, Mem. Inst. Oswaldo Cruz, 1914, v, pp. 81-98.

— Segunda contribuiçao para o conhecimento das especies brazileiras do genus *Simulium*, Mem. do. Inst. Oswaldo Cruz, 1910, ii, p. 213.

LUTZ, A., and A. NEIVA. Contribuiçoes para o biologia des Megarininas, Mem. Inst. Oswaldo Cruz, 1913, v, pp. 129-141.

— Contribuiçoes para o estudo das Megarhininæ, Mem. Inst. Oswaldo Cruz, 1914, pp. 50-56.

— Contribuiçao para o conhecimento das especies do genero *Phlebotomus* existentes no Brazil, Mem. Inst. Oswaldo Cruz, 1912, iv, pp. 84-95.

MACFIE, J. W. S. A Note on the Action of Common Salt on the Larvæ of *Stegomyia fasciata*, Bull. Ent. Res., 1914, iv, pt. 4, pp. 339-344.

MALLOCH, J. R. American Black Flies or Buffalo Gnats, U.S. Dept. Agri., Bur. Ent. Tech. Sci., 1914, No. 26.

MANSION, J. Les Phlebotomes en Corse, Bull. Soc. Path. Exot., Paris, 1913, vi, No. 9, pp. 637-641.

MHASKAR, K. S. *Stegomyia* in Karachi, Proc. Gen. Malaria Com., Madras, 1912, Simla, 1913.

MITCHELL, E. G. Mosquito Life, New York and London, 1907.

NEWSTEAD, R. Papataci Flies (*Phlebotomus*) of the Maltese Islands, Bull. Ent. Res., 1911, ii, pt. i.

— The Papataci Flies (*Phlebotomus*) of the Maltese Islands, Bull. Ent. Res., 1911-12, ii, p. 47.

— Notes on *Phlebotomus* with descriptions of New Species, Bull. Ent. Res., 1912, iii, p. 361.

— Notes on *Phlebotomus* with descriptions of New Species, Bull. Ent. Res., 1914, v, pt. 2, pp. 129-136.

NEWSTEAD, R., and H. F. CARTER. On Some New Species of African Mosquitoes (*Culicidæ*), Ann. Trop. Med. and Par., vii, p. 233.
— — Description of a New Genus and three New Species of Anopheline Mosquito, Ann. Trop. Med. and Par., 1910, iv, p. 377.
— — On a New Genus of *Culicinæ* from the Amazon Region, Ann. Trop. Med. and Par., 1910, iv, p. 553.
NEWSTEAD, R., and H. W. THOMAS. The Mosquitoes of the Amazon Region, Ann. Trop. Med. and Par., 1910, iv, p. 141.
NUTTALL and SHIPLEY. Structure and Biology of *Anopheles*, Journ. of Hygiene, January, April, and October, 1901, and January and April, 1903.
— — Studies in Relation to Malaria; II, Structure and Biology of *Anopheles*, Journ. of Hyg., 1901, i; 1902, ii; 1903, iii.
PERYASSU, A. Os Culicideos do Brazil, Trabalho do Instituto de Manguinhos, 1908.
ROSS, E. H. The Reduction of Domestic Mosquitoes, London, John Murray.
ROUBAUD, E. Quelques mots sur les Phlébotomes de l'Afrique occidentale française, Bull. Soc. Path. Exot., 1913, vi, pp. 126-128.
SCHINER, J. R. Fauna austriaca, Die Fliegen (Diptera), Wien, 1860-64.
SCHWETZ, J. Preliminary Notes on the Mosquitoes of Kabinda, Belgian Congo, Ann. Trop. Med. and Par., 1914, viii, p. 163.
STANTON, A. T. The Anopheles of Malaya, Bull. Ent. Res., 1913, pt. 1, iv, pp. 129-133.
— The Anopheles Mosquitoes of Malaya and their Larvæ, with some Notes on Malaria-carrying Species, Journ. London School Trop. Med., 1912, ii, pt. 1, pp. 3-11.
SUMMERS, S. L. M. A New Species of *Phlebotomus* from South America, Bull. Ent. Res., 1912, iii, p. 209.
TAYLOR, F. H. The Culicidæ of Australia, Trans. Ent. Soc. Lond., March 31, 1914, pp. 683-708.
— A Revision of the Culicidæ in the Macleay Museum, Sydney, Proc. Linn. Soc., N.S. Wales, 1913, xxxviii, pt. 4, pp. 747-760.
— Report of Entomologist, Reprint from Report for Year 1911 of the Australian Inst. Trop. Med., 1913, pts. xiii, xiv, pp. 24.
— Description of Mosquitoes collected in the Northern Territory during the Expedition, 1911, Rept. on Health and Disease in the Northern Territory, Bull. No. 1A, 1912, p. 25.
— Culicidæ of Papua, Trans. Ent. Soc. Lond., 1914, pt. 1, pp. 185-205.
THEOBALD, F. V. A Monograph of the Mosquitoes of the World, 1901-1911, vols. i-v, and atlas and plates.
— New Culicidæ from the Sudan, Ann. Trop. Med. and Par., 1913, vii, p. 591.
— A New Genus and Two New Species of Culicidæ from the Sudan, Fourth Rept. Wellcome Trop. Res. Lab., 1911, Vol. B, Gen. Science, pp. 151-156.
— Three New Culicidæ from the Transvaal, Entomol., March, 1912.
— A New Mosquito from North China, Entomol., June, 1913, p. 179.
— A New Mosquito from Samoa, Entomol., January, 1914, p. 36.
— Culicidæ of the R. Zool. Soc., "Natura Artis Magistra," Amsterdam Overgt. uit het Tijdsch. v. Ent., 1911, liv, pp. 233-240.
— The Distribution of the Yellow Fever Mosquito (*Stegomyia fasciata*, Fabricius) and general notes on its Bionomics, First Int. Cong. d'Ent., 1911, pp. 145-170.

THEOBALD, F. V. A New Species of Culicidæ, Rev. Zool. africaine, 1912, ii, fas. 1.

— Novæ Culicidæ, 1911, pt. i, pp. 35.

— Culicidæ (Percy Sladen Trust Exp. to Indian Ocean in 1905), Trans. Linn. Soc. Lond., 1912 (2nd ser., Zool.), xv, pt. 1, pp. 81-94.

— Culicidæ from New Caledonia and the Loyalty Islands, Nova Cal., Zool., 1913, i-iii, No. 3, p. 163.

— A New Genus and Two New Species of Culicidæ from the Sudan, Fourth Report Wellcome Trop. Lab., 1911, Vol. B, Gen. Sci., pp. 151-156.

TOWNSEND, C. H. T. A *Phlebotomus* the practically certain Carrier of Verruga, Science, 1913, xxxviii, pp. 194-195.

— The Vector of Verruga, *Phlebotomus verrucarum*, sp. nov., Insecuta Inscitiæ Menstruus, Washington, D.C., 1913, i, No. 9, pp. 107-109.

URICH, F. W. Mosquitoes of Trinidad, Proc. Agri. Soc. Trini. and Tobago, 1913, xiii, No. 10, pp. 525-530.

WILLCOCKS, F. C A Preliminary Note on the Prevalence of Mosquitoes in Cairo and its Environs, Ann. Trop. Med. and Par., 1909, v, p. 583.

The House-fly (p. 586).

BAYON, H. Leprosy and House-flies, Ann. Trop. Med. and Par., 1915, ix, pp. 1-90.

BISHOPP, DORE, and PARMAN. Notes on Certain Points of the Economic Importance in the Biology of the House-fly, Journ. Eco. Ent., 1914, viii, pp. 54-71.

FELT, E. P. Methods of Controlling the House-fly and thus Preventing the Dissemination of Disease, New York Med. Journ., April 2, 1910.

HEWITT, C. G. The Biology of the House-fly in relation to Public Health, Journ. Roy. Inst. Pub. Health, October, 1908.

— On the Bionomics of certain Calyptrate Muscidæ and their Economic Significance, with especial reference to Flies inhabiting Houses, Journ. Eco. Biol., 1907, ii, p. 3.

— The Structure, Development, and Bionomics of the House-fly, *Musca domestica*, II and III, Bionomics, &c., and the Relations to Human Disease, Quart. Journ. Micros. Sci., 1908, and December, 1909, pt. 3, liv.

— A Preliminary Account of the Life-history of the Common House-fly (*Musca domestica*, L.), Mems. and Proc. Manchester Lit. and Phil. Soc., 1906-1907, pt. 1, li.

— House-flies and the Public Health, Ottawa Naturalist, May, 1910, xxiv, pp. 31-38.

— Notes on the Pupation of the House-fly (*Musca domestica*) and its mode of Over-wintering, Can. Ent., March, 1915, xlvii, pp. 73-78.

HINDLE, E. The Flight of the House-fly, Proc. Camb. Phil. Soc., 1914, xvii, pt. 4, pp. 310-313.

House-flies, U.S. Dept. Agri., Div. Ent., Circ. No. 71, 1906.

HOWARD, L. O. The House-fly, Disease Carrier, New York, 1911.

HUTCHINSON, R. H. The Migratory Habit of the House-fly Larvæ as indicating a Favourable Remedial Measure, Bull. U.S. Dept. Agri., 1914, No. 14.

JEPSON, F. P. The Breeding of the Common House-fly (*Musca domestica*) during the Winter Months, Journ. Eco. Biol., 1909, iv, pt. 3.

MORRELL, A. W. House-fly Baits and Poisons, Journ. Eco. Ent., 1914, vii, No. 3, pp. 268-273.

NEWSTEAD, R. Preliminary Report on the Habits, Life Cycle, and Breeding-places of the Common House-fly (*Musca domestica*, L.) as observed in the City of Liverpool, &c., Health Committee Rept., City Liverpool, 1907.

— Report on the Habits, Life Cycle, and Breeding-places of the Common House-fly, Liverpool, 1907, Ann. Trop. Med. and Par., February, 1908.

PACKARD, A. S. On the Transformation of the Common House-fly, with Notes on Allied Forms, Proc. Boston Soc. Nat. Hist., 1874, xvi, p. 136.

Reports of the Local Government Board on Public Health, &c. New Series, Nos. 5 and 16, 1909. Preliminary Reports on Flies as Carriers of Infection, and further Preliminary Reports (Paper by Copeman, Jepson, Nuttall, Graham Smith, and Austen), containing Bibliography and Abstracts up to date.

SURFACE, H. A. To keep down House-flies, Zool. Press Bull., Div. Zool., Dept. Agric., Pennsylvania, 1915, No. 313. Recommends ground phosphate rock scattered over manure heaps.

Brachycera, &c. (pp. 600 to 612, and 613 to 615).

ASHLEY-EMILE, L. E. Zambesi ulcer, Journ. Trop. Med., 1905; Arch. f. Schiffs.- u. Tropen-Hyg., 1906, x, p. 164.

AUSTEN, E. E. African Blood-sucking Flies other than Mosquitoes and Tsetse-flies, 1909.

— A Monograph of the Tsetse-flies, 1903.

— Supplementary Notes on Tsetse-flies, Brit. Med. Journ., 1904.

— A Handbook of the Tsetse-flies, 1891.

— Some Dipterous Insects which cause Myiasis in Man, Trans. Soc. Trop. Med. and Hyg., March, 1910, p. 215.

— New African Tabanidæ, Bull. Ent. Res., 1914, iv, pt. 4, pp. 283-300.

BEZZI, M. Etudes systématiques sur les Muscides hématophages du genre Lyperosia, Archiv. Parasit., 1911, xv, pp. 110-143.

— Die Gattungen der blutsaugenden Musciden, Zeitsch. f. Hymenop. u. Dipt., 1907, vii, p. 413.

BLANCHARD, C. Contrib. à l'Etude des Diptères paras., Ann. Soc. Ent. France, 1896, lxv, p. 641.

CARTER, H. F. Descriptions of Three New African Species of the genus Tabanus, Ann. Trop. Med. and Par., 1914, vi, p. 435.

CHEVREL, R. Sur le Myiase des Voies urinaires, Arch. de Paras., 1909, xii, p. 369.

CLUSS, F. Myiasis interna and externa, Inaug.-Diss., Tubingen, 1902.

COCKERILL, J. D. A. A *Dermatobia* in Guatemala, Entomologist, 1914, xlvii, p. 131.

DAVY, J. B. Notes on the Habits of *Glossina fusca*, Bull. Ent. Res., 1910-1911, i, p. 143.

DÖNITZ. Eine neue afrik. Fliege, *Cordylobia murium*, Sitz. Ges. naturf. Frde. Berl., 1905, p. 248.

DUBREUILH, W. Les Diptères cutic. chez l'Homme, Arch. Méd. exp. et d'Anat. path., 1894, vi, p. 328.

ENDERLEIN, G. Die Respirationsorgane der Gastriden, Sitz. k. Akad. d. Wiss., Wien, Math-nat., 1899, Kl. cviii.

FELL, T. E. Notes on Tsetse-flies and on Prophylactic Measures against Sleeping Sickness, &c., Bull. Ent. Res., 1912, iii, p. 227.

FISKE, W. F. The Bionomics of Glossina, Bull. Ent. Res., 1913, iv, pt. 2, p. 95.

FRANCAVIGLIA, M. C. An cora sulla myiasi auricolare, Boll. Sedute Accad. Gioenia, Catania, 1914, No. 31, pp. 15-23.

FULLER, C. The Skin-maggot of Man (*Cordylobia anthropophaga*), Agri. Journ. Union of South Africa, Pretoria, 1914, vii, No. 6, pp. 866-874.

GEDOELST, L. Contrib. à l'Etude des larves cuticoles des muscides africaines. Arch. de Paras., 1905, ix, p. 568.

GILES, G. M. The Anatomy of the Biting Flies of the genus *Stomoxys* and *Glossina*, Journ. Trop. Med., 1906, ix.

GRÜNBERG. Ueber Blutsaugende Musciden, Zool. Anz., 1906, xxx, p. 78.

GRÜNBERG, K. Afrik. Musciden mit parasit. lebenden Larven, Sitz. Ges. Nat. Frde. Berl., 1903, p. 400.

— Die Blutsaugenden Dipteren.

— Ein neuer Fall des Vorkommens. der Larve der Rinderdasselfliege im menschlichen Auge, Sitz. Ges. Nat. Frde. Berl., 1913, 5 and 6, pp. 298-304.

HEWITT, C. G. Observations on the Feeding Habits of the Stable Fly, *Stomoxys calcitrans*, L., Trans. Roy. Soc. Canada, 1914, viii, pp. 37-42.

HUBER, G., and F. L. FLACK. An Unusual Case of Screw-worms in the Nose and Nasal Accessory Sinuses, Journ. Amer. Assoc. Chicago, 1914, lxiii, No. 26, p. 228.

JOSEPH, G. Über Fliegen als Schädlinge und Paras. d. Menschen., Dtsche. Med. Ztg., 1885, i, p. 37, and 1887, iii, pp. 713-725.

JACK, R. W. Observations on the Breeding Haunts of *Glossina morsitans*, Bull. Ent. Res., 1911-1912, ii, p. 357.

KING, H. H. Blood-sucking Flies other than Mosquitoes, Fourth Rept. Well. Trop. Res. Lab., 1911, pp. 112-126.

— Observations on the Occurrence of *Glossina* in the Mongolla Province of the Anglo-Egyptian Sudan, Bull. Ent. Res., 1912, iii, p. 89.

KINGHAM, A. Notes on the Preliminary Stages of *Glossina morsitans*, Bull. Ent. Res., 1911-1912, ii, p. 291..

LE DANTEC and BOYÉ. Note sur une myiase observée chez l'homme en Guinée franç. (Réun. biol. de Bordeaux), Le Caducée, 1905, v, p. 9; Arch. f. Schiffs- u. Tropen-Hyg., 1906, x, p. 71.

LLOYD, L. Notes on *Glossina morsitans* in the Luangwa Valley, N. Rhodesia, Bull. Ent. Res., 1912, iii, p. 233.

LÖW, F. Über Myiasis und ihre Erzeuger, Wien. med. Wchschr., 1882, xxii, p. 247, and xxiii, p. 972.

LOWNE, B. T. Physiology, Morphology, and Development of the Blow-fly, two vols.

LUTZ, A. Tabanidas do Brazil e de alguno Estados visinhos, Mem. Inst. Oswaldo Cruz, 1913, v, pp. 143-190.

— Novas contribuiçoes para o con hecmento das Pangoninas e Chrysopinas do Brazil, Mem. Inst. Oswaldo Cruz, 1911, iii, fas. 1, pp. 65-84.

LUTZ, A., and A. NEIVA. Los Tabanidæ do Estado do Rio de Janeiro, Mem. Inst. Oswaldo Cruz, 1914, vi, pp. 69-80.

MCCONNELL, R. E. Some Observations on the Larva of *Auchmeromyia luteola*, Fabr., Bull. Ent. Res., 1913, iv, pt. 1, p. 29.

— Notes on the Occurrence and Habits of *Glossina fuscipes* in Uganda, Bull. Ent. Res., 1912, iii, p. 55.

MACFIE, J. W. S. Experiments and Observations upon *Glossina palpalis*, Bull. Ent. Res., 1912, iii, p. 61.

MAGALHAES, P. DE. Subsidio ao estudo das Myiases Rio de Janeiro, 1892.

MEIGEN, J. W. Systemat. Beschr. d. bek. Europ. zweiflügel. Insecten, 1818-1838.

MINCHIN, GRAY and TULLOCH. *Glossina palpalis* and its relation to *Trypanosoma gambiense* and other Trypanosomes, Proc. Roy. Soc., London, Ser. B., 1906, lxxviii, p. 4.

MOISER, B. Notes on the Haunts and Habits of *Glossina tachinoides* near Geidam, Bornu Province, N. Nigeria, Bull. Ent. Res., 1912, iii, p. 195.

NEAVE, S. A. Notes on the Blood-sucking Insects of Eastern Tropical Africa, Bull. Ent. Res., 1912, iii, p. 275.

NEIVA, A., and DE FARIA GOMES. Notas sobre um caso de Miiase humana ocasionada por larvas de *Sarcophaga pyophila* n. sp., Mem. Inst. Oswaldo Cruz, 1913, v. pp. 16-23.

NEISH, W. D. The Tabanidæ and Anophelinæ of Jamaica, Rept. Dist. Med. Officer, Spanish Town, Jamaica, 1913.

NEWSTEAD, R. On the Life-history of *Stomoxys calcitrans,* Journ. Eco. Biol., 1906.

— On Three New Species of the genus *Glossina*, Ann. Trop. Med. and Par., 1910, iv, p. 369.

— A New Tsetse-fly from British East Africa, Ann. Trop. Med. and Par., 1912, iv, pt. 4, p. 129.

— A New Tsetse-fly from the Congo Free State, Ann. Trop. Med., 1913, vii, p. 331.

— On the Characteristics of the Newly Discovered Tsetse-fly (*Glossina austenii*), &c., Bull. Ent. Res., 1912, iii, p. 355.

— A Revision of the Tsetse-flies (*Glossinæ*) based on the study of the Male Genital Armature, Bull. Ent. Res., 1911-1912, ii, p. 9.

PARIS, P. Un cas de myiase intestinale, C. R. 41me Session Assoc. française pour l'Avancement des Sciences, 1913, p. 447.

PEIPER, E. Fliegen Larven als gelegentl. Paras. d. Menschen, Berlin, 1900.

POLLARD, J. Notes on the Tsetse-flies in the Muri Province, N. Nigeria, Bull. Ent. Res., 1912, iii, p. 219.

RICHARDO, G. Notes on the *Tabanidæ*, Ann. and Mag. Nat. Hist., January to May, 1910.

RODHAIN, J., C. PONS, VAN DEN BRANDEN, and G. BEQUAERT. Rapport s. l. Travaux d. l. Mission scientifique du Katanga. Annexe, Carte du Katanga, Répartition des Glossines, 1913, Tabanidæ et Glossinæ.

RODHAIN, J., and J. BEQUAERT. Nouvelles observations sur *Auchmeromyia luteola,* Fabr., et *Cordylobia anthropophaga*, Grünb., Revue Zool. africaine, 1913, ii, pt. 2, pp. 145-154.

ROORDA-SMIT, J. A. Die Fliegenkrankheit u. ihre Behandl., Dtsch. Med. Wochenschr., 1906, p. 763.

ROUBAUD, E. Recherches sur les Auchmeromyies, Calliphorines, à larves suceuses de sang de l'Afrique tropicale, Bull. Scient. d. l. France et d. l. Belg., 1913, xlvii, fas. 2, pp. 105-202.

SANDER, L. Die Tsetsen, Leipzig, 1905 (Reprint from Arch. f. Schiffs- u. Tropen-Hyg., 1905, ix).

SAWYER, W. A., and W. B. HERMS. Attempts to Transmit Poliomyelitis by means of the Stable Fly (*Stomoxys calcitrans*), Journ. Amer. Med. Assoc., 1913, lxi, pp. 161-166.

SCHINER, J. R. *Fauna austriaca*, Die Fliegen, 1860-1864.

SCHWERTZ, J. Quelques observations préliminaires sur la morphologie et la biologie de la larve, de la nymphe, et de l'image de l'*Auchmeromyia luteola,* Fabr., Ann. Trop. Med. and Par., Se. T.M., 1914, viii, No. 3, pp. 497-507.

SERGENT, ED. and ET. La "Tamne," myiase humaine des montagnes sahariennes touareg, identique à la "Thimni" des Kabyles, due à *Œstrus oris,* Bull. Soc. Path. Exot. Paris, 1913, vi, No. 7, pp. 487-488.

SPEISER, P. Hippoboscidæ, Wien. ent. Zeitg., 1899, xviii, p. 201.

— Neue Arbeiten über blutsaugende und Krankheiten übertragende Insekten, Zeit. f. wiss. Insektenbiol., 1908, pp. 241, 301, 420, 437.

— Die geographische Verbreitung der *Diptera pupipara* und ihr Phylogenie, Zeit. f. Wiss. Insektenbiol., 1908, pp. 241, 301, 420, 437.

WELLMAN, F. C. Experimental Myiasis in Goats, Journ. Trop. Med., 1906.

WIRSING. Über Myiasis intestinalis, Zeitschr. f. klin. Med., 1906, lx, p. 122.

WOOSNAM, R. B. Report on the Search for a *Glossina* on the Amala River, S. Masai Reserve, E. Africa Protectorate, Bull. Ent. Res., 1911, iv, pt. 4, pp. 271-351.

General Works.

BLANCHARD, R. Traité de Zoologie médicale, Paris, ii, 1886.

BOYCE, R., and F. C. LEWIS. The Effects of Mosquito Larvæ on Drinking Water, Ann. Trop. Med. and Par., 1909, v, p. 591.

BUTLER, E. A. Our Household Insects, 1893.

DOANE, R. W. Insects and Disease.

— Disease-bearing Insects in Samoa, Bull. Ent. Res., 1913, iv, pt. 4, p. 265.

FANTHAM, H. B., and A. PORTER. Some Minute Animal Parasites. 319 pp. and 56 text-figs. London: Methuen and Co., 1914.

GRAHAM-SMITH, G. S. Flies in Relation to Disease (non-Blood-sucking), 2nd ed., Camb. Press.

HINDLE, E. Flies and Disease (Blood-sucking), 1914.

HOWARD, C. W. Insects directly or indirectly Injurious to Man and Animals in Mozambique, East Africa, Bull. Ent. Res., 1912, iii, pp. 211-218.

KING, H. H. Report of the Entomological Section of the Wellcome Tropical Research Laboratories, Fourth Report, Gen. Sci., 1911, vol. B, pp. 95-130.

MÉGNIN, P. Les Parasites et les Maladies Parasitaires chez l'Homme, &c., Paris, 1880.

NEUMANN, G. The Parasites of Domesticated Animals, 1892.

NEWSTEAD, R. Reports on the Twenty-first Expedition of the Liverpool School of Tropical Medicine, Sec. 1, Med. and Econ. Ent., Jamaica, 1908-1909, pt. 1.

— Tick and other Blood-sucking Animals, Ann. Trop. Med. and Par., 1909, iii, p. 421.

NEWSTEAD, R., J. E. DUTTON, and J. L. TODD. Insects and other Arthropoda collected in the Congo Free State, Ann. Trop. Med. and Par., 1907, No. 1, i, pp. 3-114.

NICHOLLS, L., The Transmission of Pathogenic Micro-organisms by Flies in St. Lucia, Bull. Ent. Res., 1912, iii, p. 81.

NUTTALL, G. H. F. On the Rôle of Insects, *Arachnids* and *Myriapoda*, as Carriers in the Spread of Bacterial and Parasitic Diseases, Johns Hopkins Hospital Reports, 1899, viii.

RAILLIET, A. Traité de Zoologie médicale et agricole, Paris.

ROSS, R. The Prevention of Malaria.

ROSS, SIR R., and E. S. EDIE. Some Experiments on Larvicides, Ann. Trop. Med. and Par., 1911, v, No. 3, p. 385.

SERGENT, E. Les Insectes piqueurs-suceurs, Paris.

STEPHENSON, J. Medical Zoology, 1832.

INDEX.

A.

B.

C.

D.

E.

G.

I.

J.

K.

L.

N.

O.

P.

Q.

R.

U.

V.

X.

Y.

Z.

THIS BOOK IS DUE ON THE LAST DATE STAMPED BELOW

BOOKS ... ER
ARE S... K.
RENE...
IMMEDIATE RECALL

DUE FEB 1 9 1976

Feb 18 '76

FEB 11 REC'D

UCD LIBRARY
DUE MAR 3 1976

MAR 23 REC'D

UCD LIBRARY
D. MAY 1 1976

MAY 3 - REC'D