FOURTH REPORT

WELLCOME TROPICAL RESEARCH LABORATORIES

AT THE

GORDON MEMORIAL COLLEGE

KHARTOUM

ANDREW BALFOUR, M.D.
DIRECTOR

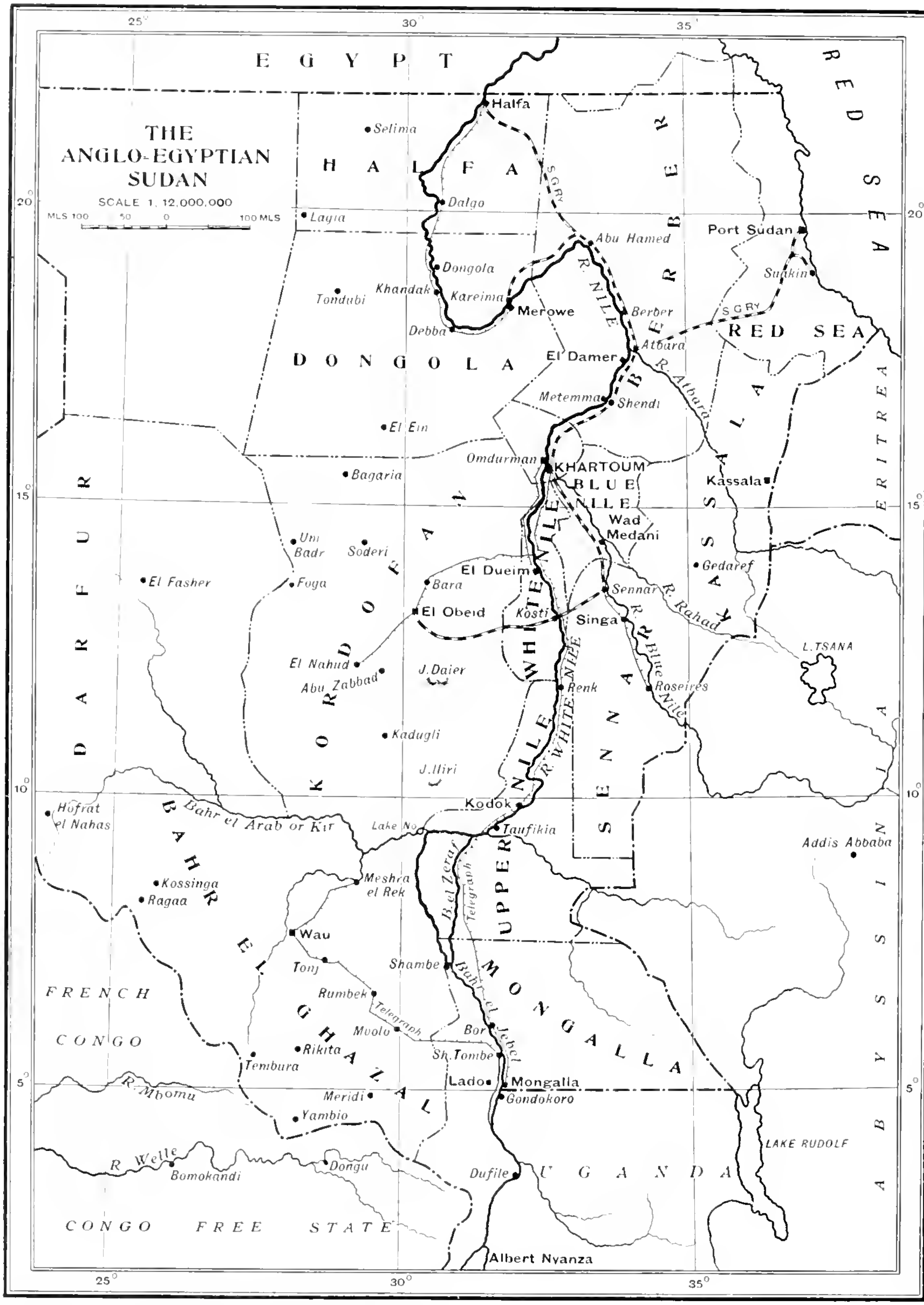

FIG. 1.—MAP OF ANGLO-EGYPTIAN SUDAN SHOWING PROVINCES

FOURTH REPORT

OF THE

WELLCOME TROPICAL RESEARCH LABORATORIES

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GORDON MEMORIAL COLLEGE KHARTOUM

VOLUME B.—General Science

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med.

THE GORDON MEMORIAL COLLEGE AT KHARTOUM

STAFF

OF THE

WELLCOME

TROPICAL RESEARCH LABORATORIES, 1911

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ACKNOWLEDGMENTS

The following have kindly contributed Papers to this Report:—

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PROFESSOR F. WERNER, The University, Vienna

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FIG. 2. FLOATING LABORATORY AND S. W. [illegible]
(Auxiliaries to the Wellcome Tropical Research Laboratories, Khartoum)

INTRODUCTION

A LONGER time than usual has, on this occasion, elapsed between the appearance of Reports. This is due in part to the fact that there have been additions to the Staff, and it was felt desirable that the work of new members should be included, and in part to the increasing difficulty of finding leisure to compile and issue records of this magnitude. Indeed, on the present occasion, it was found necessary to split the Report into two volumes. For a time also we were sorely hampered by the effects of the disastrous fire to which allusion was made in our Third Report, and had to start building up once more, without thoughts of output or future publications. Our difficulties were, however, greatly minimised by Mr. Wellcome's speedy and ample aid, and by the help afforded us by the Director of Education and his Staff.

Sad to say, no sooner was some progress again being made than we lost by death our very capable and energetic laboratory assistant, Mr. E. O. Inglis. He had only been six months in Khartoum, but had already proved himself a man of the right stamp, and his loss was greatly deplored. His place was difficult to fill, but eventually we were fortunate enough to secure Mr. George Buchanan, who, having been trained under Mr. Richard Muir in the pathological laboratory of Edinburgh University, had gained much insight into laboratory methods, and, being an artist of no little skill and a good photographer, has been able to render admirable service. Shortly afterwards a second assistant, in the shape of Mr. A. Marshall, was appointed, as it was impossible for one man to cope with the ever-increasing routine work, museum work, oversight of experimental animals and equipment, and all the manifold duties which fall to the lot of a laboratory assistant, and which are much more onerous in the Tropics than in a temperate climate.

New Assistants

It was, however, evident that additions to the Scientific Staff were absolutely essential, and as a result of an earnest appeal, strongly backed by the Director of Education, two new appointments were made.

Dr. James Thompson, late research student at the Lister Institute, arrived early in 1910, to take up the duties of senior assistant chemist. In addition to routine work it was specially desired that Dr. Thompson should conduct pharmacological research work on the obscure drugs and poisons employed by the natives and on such allied subjects as seemed worthy of special consideration.

At a later period, through the kind offices of Sir William Leishman, F.R.S., the services of Captain W. B. Fry, R.A.M.C., were enlisted as Assistant Bacteriologist and Protozoologist. Unfortunately, Captain Fry had not been long with us, before, as a result of laboratory infection, he contracted Malta Fever and had eventually to return to England on sick leave. This has upset his research work on animal trypanosomiasis, which consequently does not figure so largely in this Report as would otherwise have been the case. Captain Fry's knowledge of some of the newer methods and up-to-date procedures has, however, been of great service.

Increase in the work of the Laboratories

The routine work continues to increase both in variety and magnitude. Since the date of the last Report nearly 1,800 examinations have been conducted in the bacteriological laboratory alone, comprising Wassermann tests, the preparation of bacterial vaccines, reporting on veterinary material, and on all the usual class of specimens which are sent in from hospitals and by practitioners. Certainly more use is now made of such facilities as the laboratories afford, not only in the directions mentioned, but in hygienic work, more especially of course for Khartoum. Thus, a prolonged investigation on the proposed water-supply for this city taxed severely the resources both of the chemical and the bacteriological departments and left but little spare time for research. As will be seen, however, this water enquiry, which turned out to be one of great interest and complexity, soon assumed the nature of a research which led, I believe, to the satisfactory solution of an important and difficult problem.

Water-supply

These are but a few examples of the purposes which the laboratories now serve. The scope of the work and details regarding it will be considered immediately, but here one would chronicle a new development, namely the advent of private workers who, at their own charges, have spent a considerable time in Khartoum carrying out research work in the laboratories and, for the sake of gaining experience in tropical work, kindly assisting the Staff in routine and other work. Thus, during the winter 1908–9, Dr. A. C. Stevenson of the University College Hospital, London, was one of these volunteers and he rendered good service by discovering coccidiosis in Sudanese goats, an observation which enabled the veterinary officers to take measures for stamping out the disease amongst infected herds. Dr. Stevenson also investigated the hæmatozoa and intestinal protozoa of the common toad in Khartoum, and he contributes papers on both these subjects to this Report. He has also kindly supplied the drawings illustrating them. Dr. W. M. Aders, our other free-lance, was here at the same time as Dr. Stevenson. In addition to helping us with his zoological knowledge he studied the subject of hyper-parasitism, and contributes a paper on his researches into the Herpetomonas parasite which he found in *Aspongopus viduatus*, the Sudan melon bug.

Private Workers

Since these gentlemen left, applications have been received from an Italian Scientist, an American Professor and a medical missionary resident in Persia, for permission to study tropical medicine in the laboratories. Unfortunately, we have little spare room at our disposal, but in one of these cases arrangements have been made to grant the request, and Professor E. F. McCampbell of the Ohio State University, Columbus, will, I hope, be our guest and fellow-worker during the winter of 1911–2, both in the main laboratories and in the floating laboratory.

Before proceeding briefly to outline the work accomplished in the different sections, one has to record the fact that, at Mr. Wellcome's request, the distinguishing word "Tropical" has been added to the title of the laboratories, and they will hereafter be known as the Wellcome Tropical Research Laboratories. As mentioned, the laboratory work has so greatly increased, and the number of our outside contributors is on this occasion so numerous, that it has been found advisable to split the Fourth Report into two volumes, the first dealing with medical, the latter with general science. At the time of writing, it is also hoped to bring out a Second Review Supplement more or less on the same lines as that issued as an appendix to our Third Report. We have received a good many letters testifying to the utility of that publication and expressing a hope that another volume would be forthcoming. Hence, both for our own sakes and for workers in the Sudan and in other tropical countries, it seems advisable to make an effort to produce another compilation of this kind. Indeed, it is intended to extend its scope to the whole subject of tropical medicine so that it may be more generally useful. The difficulty, however, will be to keep it within reasonable limits as regards size. Here we only consider the present Volume B, with such comments as may seem desirable.

"Tropical" added to title of the Laboratories

It will be found that its contents range over a considerable variety of subjects, Chemistry, Entomology, Ornithology, certain Arachnida of the Sudan, Protozoology, Geology, Anthropology, Sociology and Sanitary Engineering all claiming attention.

Again we are indebted to extra-mural workers. Mr. A. L. Butler, at my request, kindly furnished a useful practical paper on the grain-eating birds of the Sudan, which, fortunately, thanks to Mr. Wellcome, it has been possible to have illustrated in a manner worthy of the text. Dr. Leiper,[1] for the second time, favours us with an account of Sudanese parasitic worms, and Professor Werner, of Vienna, with a most interesting paper on scorpions and annulated spiders which, with its fine illustrations, cannot fail to be of value. Sir Thomas R. Fraser, of Edinburgh, has very kindly given us a paper on the venom of the Sudan "Spitting-Snake," and Mr. Henry Curtis has written an account of the "Spitting-Snakes" of South Africa, which is illustrated by drawings made by Lady Dorothy Stanley. Mr. Dunn has written an interesting account of ancient gold mining in the Sudan which is illustrated by some photographs kindly given us by Dr. A. M. Elliot (late medical officer of the Om Nabardi Gold Mines), and Mr. F. V. Theobald contributes notes on two new mosquitoes.

Contributors to Volume B

Dr. Aders' paper has been mentioned, and Captain Anderson, whose monograph on medical customs in Kordofan was one of the features of our last Report, has again put pen to paper on our behalf, and contributes a most interesting paper on the Nyam-nyam and Gour people inhabiting the Eastern Bahr-El-Ghazal. The chief anthropological interest is this year supplied by Dr. C. G. Seligmann's paper. He and Mrs. Seligmann, in 1908–9, were given the laboratory steamer for their journey south, and in return Dr. Seligmann has kindly become a contributor, dealing with subjects on which he is a well-known expert.

Finally, Messrs. W. H. McLean and G. E. Hunt, of the Gordon College, who have aided me so greatly in the public health work of the city, have compiled a practical paper on such aspects of tropical sanitary engineering as are likely to appeal to those who have to cater for the sanitary needs of towns in tropical countries, and which should be most useful to Medical Officers of Health, Sanitary Inspectors, Municipal Engineers, Boards of Health and other local Sanitary authorities, at least such as have to work in hot, dry and dusty countries like the Sudan.

Non-medical Members of the Staff

Turning now to the work of non-medical members of the Staff, one finds that Mr. King has been most assiduous in his undertakings. As, at the beginning of his report, he gives an outline of what he has accomplished, where he has been and what he intends to do, I need not enter into details, but content myself with saying that Mr. King is a very valuable asset to the Sudan, and that every facility should be given him to make the most of his keen interest in, and sound knowledge of, his subject.

I need merely refer to his researches on the bionomics of Tabanidae, which are now quoted in all works on this subject, to the Sudan Plant Diseases Ordinance, which owes its existence to his efforts, and to his notes on mosquitoes and mosquito-devouring fish, to indicate what an essential factor this economic entomological work is in the well-being and for the future of the Sudan. A most gratifying feature is the help rendered Mr. King by well-nigh everyone, from Governors of Provinces downwards.

One leaves the most important items to the end as a rule, working, as it were, towards a climax, and hence it is only fitting that this place of honour, so far as Volume B is concerned, should be devoted to a brief consideration of the work of the

[1] Unfortunately the paper by Dr. Leiper was not received in time for publication.

chemical laboratory. Although Dr. Beam has certainly not received that outside aid which should have been fully and cordially extended to him, yet, I think, there are now few in the country who will deny how great a bearing his laborious and painstaking investigations into Sudan products and soils have on the development of the country.

Work of the Chemical Laboratory

He has undoubtedly been hampered and hindered in his work by those who, without proper scientific training, could not appreciate the necessity for scientific methods of collection and procedure, and, I fear, resented advice on these essential points. I believe, however, that the worst is past and that those responsible for the development of commercial products are now likely to co-operate and to recognise how absolutely essential it is to abandon slipshod measures and to proceed on sound scientific lines. This is specially necessary in the case of soil investigations which now bulk so largely. The locality which is being chiefly studied is the Gezira, that vast area lying between the Blue and White Niles, which, if properly handled, may yet bear great crops of wheat and of cotton. There is a scheme afoot to place it under perennial irrigation, and, as the cost of the irrigation work will be very great, it is essential that a sound knowledge of the character of the prevailing types of soil be secured before any reliable opinion can be expressed as to the success or otherwise of such an undertaking. As Dr. Beam says, "attention has been called to the paramount importance of a study of the subsoil as well as of surface conditions, since the question of drainage, resistance to drought and root penetration will depend essentially upon the nature of the substrata. Mechanical analyses of these soils and their subsoils (*i.e.* the determinations of the proportions of gravel, sand, silt and clay) are therefore being made in all cases, and

Analyses of Soils and Subsoils

determinations of the proportion of the essential plant constituents, potash, phosphoric acid and nitrogen as well. These results, taken in conjunction with the observations made in the field, should yield sufficient evidence to enable one to form at least a reasonably accurate judgment as to the results which may be expected from irrigation if the cultivation is carried out on suitable lines."

Soil samples are also being obtained from Dongola and other districts, so that a good general idea may be obtained of the classes of soils met with in areas which are, or are likely to be, cultivated; while the prospect of increasing the yield of certain crops by scientific treatment is shown in a most interesting paper on "Gypsum as a Fertiliser for Sudan Soils." Moreover, after a prolonged and careful study of the question of soil examination, Dr. Beam has devised new, rapid and special methods, which not only greatly facilitate his own work, but appear to place the physical examination of arid soils on a sounder basis than it has hitherto occupied. These are fully described. The gum work, which for reasons explained by Dr. Beam, had perforce been abandoned, is shortly to be resumed with, it is thought, better chance of successful results. Mr. Edie again contributes a paper on the subject, having kindly continued and extended his observations in England. Of special interest are his conclusions, based on Dr. Beam's suggestions, as regards the rôle of ants in gum production, an interesting analogy, possibly, between the transmission of diseases affecting animal and vegetable life respectively.

The Poisonous Ushar plant

Dr. Thompson, besides assisting in the work on soils, water, poisons, commercial products and the various analyses which are always being conducted, took up as a line of research the pharmacology of *Calotropis procera*, the Ushar plant, with a view to isolating the toxic principle or principles which, as previously explained, may occasion poisoning by merissa, the national Sudanese drink, a kind of beer brewed from dura—

(millet). His results are detailed in his paper. In this connection one would gratefully acknowledge the kind help received from Dr. Power and Mr. C. J. S. Thompson of the Wellcome Chemical Research Laboratories, London, who furnished records of the literature on the subject to which we could not otherwise have easily gained access.

Dr. Beam, himself, has succeeded in finding a colour test for the detection of hashish, a most useful discovery the value of which has been confirmed by Professor Schmidt and Mr. Lucas in Cairo, and has been concerned in all kinds of analytical and advisory work, the outcome of questions brought before the Central Economic Board.

Mr. Goodson, who has been elected a Fellow of the Institute of Chemistry, has rendered valuable assistance and has also had charge of the meteorological work for Khartoum, a duty which I am informed he discharges in a most satisfactory manner, but which naturally trespasses somewhat on time which might well be devoted to chemical investigations when there is so much to be done.

The Library

The library increases slowly, for our funds are limited, but our exchange list has attained formidable dimensions and the work of checking, acknowledging and cataloguing reprints and other publications is no light matter considering we do not possess a secretary or librarian.

Distinguished Visitors

The laboratories have been visited by a number of persons interested in their work. I have mentioned Sir David and Lady Bruce. Captain F. P. Mackie, I.M.S., followed them, also on his way from Uganda. Monsieur A. Solvay, of Brussels, came and saw and, as on a previous occasion, most kindly gave us a generous donation which enabled us to purchase a special microscope for the chemical department and to secure some books of which we had need. I only wish more visitors to Khartoum would follow M. Solvay's example. Perhaps they would if they understood the laboratories stand, in some degree, for health, and health means comfort and prosperity and a good many other things which make life worth living. It is Emerson who says, "The first Wealth is Health," a motto which might suitably be inscribed upon our walls and exhibited at intervals to those who control our finances! Lord Kitchener also inspected us and, with his Indian experience, showed himself a keen, though happily a friendly, critic. One has also to record Mr. Wellcome's return to the Sudan. Needless to say we were pleased to see him, and he went fully into all matters pertaining to the laboratories, and, as ever, showed much interest in their development. He had recently been in Panama, studying the Sanitary Department work, and it is remarkable how many of the problems in the Sudan resemble those in the Canal Zone though, of course, on an infinitely smaller scale. There are, however, the same difficulties and disappointments in both places, and one derives a kind of vicarious comfort from such a reflection. At the same time we still retain the support of H.E. the Governor-General, while to Mr. Currie, to whose far-seeing grasp of affairs the establishment of the laboratories was primarily due, we are more than indebted. Under a less sympathetic, a less influential, or, I may add, less determined chief I am quite certain that the development of the laboratories would more than once have received a serious check, not from any hostility towards them but from a lack of knowledge of their needs and a lack of appreciation of all they represent and of Emerson's sound dictum.

In the past, one has always concluded an Introduction by considering the future, and, after eight years of experience, one has now a good idea of what is and will be actually required to keep these laboratories abreast of the times. In our Third Report I spoke

Requirements

of the necessity of a new building, in this I will deal with the Scientific Staff as it should be. Here is what we want, what we have in part obtained, and what I trust will yet be forthcoming:—

Scientific Staff:

Director

Bureau of Microbiology:

Bacteriologist
Pathologist
Veterinary Pathologist
Protozoologist
Helminthologist

Division of Entomology:

Two Economic Entomologists, one especially concerned with medical entomology

Division of Botany:

Botanist
Mycologist

Bureau of Chemistry.

Research Chemist in Charge
Economic Chemist
Agricultural Chemist
Pharmacological Chemist, whose work would include toxicology

In time, no doubt, it would also be well to have an Assistant Director, a Haematologist to carry out serum tests such as Wassermann's reaction, other complement fixation and precipitant tests for blood, and such new developments in this important diagnostic branch of medicine and surgery as may arise. An Anthropologist would also pay his way, especially if his main work was in the direction of sociology.

These then, with the necessary assistants including an artist, with an adequate clerical staff, and more especially with a secretary who could also look after the library, would supply a force which might wage a most successful war with disease in man and animals and plants, which might make the most of such products as the Sudan yields and indicate how they might be improved, which might point out along what lines agriculture should develop, and aid those who will irrigate and till what is now a virgin soil. They will cost money but they will save money, and indirectly they will make money. Money, however, is after all not everything. "The first Wealth is Health," and given health all other things may be added unto us, even in a country like the Sudan with its manifold drawbacks and disadvantages. When I asked Sir David Bruce what he thought should be our annual contingent he straightway replied "ten thousand pounds." We are a very long way off ten thousand pounds, but one is not without hope for the future when one sees how everywhere Science leads the way. We have already grown from small beginnings to a respectable stature, are, I think, secure against extinction, and, so long as we proceed on practical lines which have a bearing on the development and progress of the country, should not fail to receive that support and consideration which the magnitude, scope and importance of the work that now falls to our share amply justifies.

"The first Wealth is Health"

REPORT

OF THE

CHEMICAL SECTION

OF THE

WELLCOME TROPICAL RESEARCH LABORATORIES

BY

WILLIAM BEAM, M.A., M.D., F.I.C., F.C.S.

Research Chemist

The following is a list of the samples received for examination since the issue of the Third Report of these Laboratories in 1908:

Waters	389	Miscellaneous food and other products	31
Gums	52	Pathological chemical examinations	15
Toxicological examinations, drugs, etc....	12	Fuels	13
Soils	358	Clays and earths	30
Fertilisers	13	Limestones and limes ...	28
Oil seeds	17	Other minerals and ores ...	15
Grains and flours	33	Petroleum oils	13
Milk and milk products ...	10	Paints	1
Liquors and beverages ...	18		

Total, 1084

The period covered is from May, 1908, to December 30, 1910. The greater number of these samples were analysed or tested by the ordinary routine methods, but the list also includes samples secured for the purpose of research.

Research on Gum

A very great amount of time and labour was spent on gum research, the earlier results from which were most promising. It is all the more to be regretted, therefore, that one is forced to record, as in previous years, the entire failure of the Woods and Forests Department to effectively co-operate with us in this work. This Department is, however, now in process of reorganisation, and it is expected that we may count upon its aid in the future for the field work connected with research on forest products. Fortunately, too, the laboratories were able to secure for a second year the services of E. S. Edie, B.Sc., Carnegie Research Fellow, who spent the winter of 1908-9 in the forests near Taiara, Kordofan. Mr. Edie's researches were chiefly bacteriological, and his very interesting results appear to confirm those recorded by Greig Smith. The writer was also able to spend a short time in the gum forests of the Blue Nile (Sennar District), and a brief account of the observations there made will also be found below.

Toxicological work

In the course of its work, the chemical laboratory has been confronted with two very important problems, namely, the discovery of reliable tests for hashish and for "*ushar*" (*Calotropis procera*). The latter plant contains a milky juice which is extremely poisonous, and there is considerable evidence to show that it is not infrequently used by the native with criminal intent. It is gratifying to be able to record that what appears to be a reliable test for the former has now been found. As regards "*ushar*," Dr. Thompson has conducted a research on the latex of the plant and brought forward certain colour tests for it which may prove to be of value.

As will be seen from the list of samples tested, a very considerable number of soil examinations has been made in the past two years. At present the laboratories are largely engaged in a study of that section of the Gezira district which it has been proposed to put under perennial irrigation, when funds for the purpose become available. The cost of such irrigation works will be very great, and it is obviously necessary that some knowledge be secured of the character of the prevailing types of soil, before embarking upon a venture of such magnitude.

Soil examinations

Attention has been called, by this section of the laboratories, to the paramount importance of a study of the subsoil as well as the surface conditions, since the questions of drainage, resistance to drought and root penetration will depend largely upon the nature of the substrata. Mechanical analyses of these soils and their subsoils (*i.e.* the determinations of the proportions of sands, silt and clay) are therefore being made, and estimations of the proportions of essential plant constituents as well. These results, taken in conjunction with the observations made in the field, should yield sufficient evidence to enable one to form at least a reasonably accurate judgment as to the results which may be expected from irrigation, if the cultivation is carried out on suitable lines.

We have been fortunate in securing the aid of Mr. S. C. Dunn, Government Geologist, for field work in connection with these investigations, and are greatly indebted to him for the able manner in which he has carried it out in spite of climatic conditions which must be experienced to be appreciated. The first series of 184 samples were collected during the month of May with the thermometer ranging as high as 120° F. in the shade, and almost daily sandstorms.

A Test for Hashish

A reliable chemical test for hashish has long been a desideratum. The material, when pure, is sufficiently easy of identification, by reason both of its appearance and characteristic odour. In the great majority of instances, however, it is encountered in admixture with such substances as cloves, pepper, cinnamon, etc. This is usually the case with the native aphrodisiacs which often contain a small proportion of opium as well. The detection of small quantities of hashish in these mixtures has been extremely difficult and usually impossible. The following simple method has been found to be most satisfactory, and if proper precautions be taken, quite delicate. It depends upon the fact that the resinous matter of hashish strikes a marked purple colour on treatment with potash or soda. The test may be applied as follows: the material suspected to contain hashish is treated with petroleum-ether, the liquid passed through a filter and the ether evaporated to dryness in a small porcelain crucible. In the presence of any considerable amount of hashish a marked amount of tar-like residue is left; but if only a small amount is present there may only be a light yellow stain. To this residue a few drops of alcoholic potash are added, and the mixture evaporated to dryness on the water-bath. In the presence of hashish a rich purple colour is gradually developed. On dilution with water the colour takes on a more bluish cast. It is very permanent.

Details of the test

The purple colour is due to an oxidation product. If the evaporation of the petroleum-ether extract and alkali be conducted in an atmosphere free from oxygen, only a brown colour results.

Any of the ordinary resin solvents, alcohol, ether, acetone, benzene, chloroform, carbon disulphide or petroleum-ether may be applied to the extraction. Petroleum-ether is perhaps the most satisfactory, but it might conceivably be of advantage in special cases to employ one of the others in order to avoid the solution of material with which the hashish is associated.

The richest purple colour is obtained by extraction and evaporation in the cold. If the hashish be completely exhausted by prolonged extraction with warm petroleum-ether, as in a Soxhlet apparatus, the extract may not respond to the test, or only with difficulty. The colour developed by an extract so obtained is reddish, being masked by the brown tint due to the effect of the alkali on the associated extracted matter. There appears to be evidence also that the active body in the extract is gradually destroyed by such treatment.

Extracts of this kind may be made to yield a more characteristic reaction by treating the residue, spread out in a thin layer on porcelain, with strong *aqueous* potash or soda, but the colour may not appear for some hours.

J. A. Goodson, who has carried out much of the investigation in connection with the test, suggests the following method of application, which may be found useful when the hashish is mixed with other highly-coloured bodies. The extraction is made in the usual manner, the petroleum-ether treated with alcoholic alkali and evaporated to dryness. The resin acids are then liberated by the addition of a few drops of dilute acid, brought on to a filter and dissolved by the addition of a small amount of petroleum-ether. The liquid is then underlaid in a test-tube with weak aqueous soda or potash. The purple colour appears at the junction of the two liquids and, if the alkali solution is not too strong, is distributed throughout it. The colour is developed at once, since the resin acids have already been exposed to the air.

Variants of the method, for special circumstances

The test may also be made by the direct addition of the aqueous alkali to the petroleum-ether extract, but in this case the colour may not appear for 36 hours or more. So applied, the test is not delicate.

The ordinary alcoholic extract of *Cannabis indica* of the pharmacopœia does not appear to respond to the above test; this at least was the case with the two samples examined up to the present. The explanation of this may be connected with the fact, mentioned above, that the extract yielded by prolonged exhaustion with the solvent does not strike the purple colour as readily as material obtained by a short extraction in the cold. Then, too, the alcoholic extract of the pharmacopœia is obtained from the entire flowering tops of the plant, and is therefore more complex and more liable to alteration in composition than is hashish, which is chiefly the resinous matter obtained by rubbing the plant tops between the hands, or by some similar method.

[Since the above was written our attention has been called to a note on a similar reaction for "cannabinol" described by Czerkis (*Pharm. Post.* 42, 794-5, through *Chem. Zentr.* 1909, II., 1880, and abstracted in *Chemical Abstracts* of the Amer. Chem. Soc., Vol. 5, No. 4, Feb. 20, 1911). The note made is to the effect that potassium hydroxide produces in alcoholic solutions of cannabinol an intense red colour which disappears on acidifying. The extraordinarily rich purple colour obtained by the method already detailed does not appear to have been obtained.

The method as described has been in use in these laboratories for the past two years.]

Khartoum Water-Supply

In the last Report[1] a note was made on the composition of the waters of the deep wells at Khartoum from which it had been proposed to take the town supply. In it were recorded the results of the bacterioscopic and chemical examinations, which indicated that the water was highly contaminated, and the untreated water was, in consequence, condemned for such purpose. Not only were *B. coli* found in very great numbers, but the water was found to contain notable proportions of iron and manganese, sufficient indeed to give rise to the growth of *crenothrix* and to be objectionable in other ways. Subsequent investigation indicated that it was possible to prevent the contamination of the water. The means by which this was effected are detailed in Dr. Balfour's fuller note on the subject (*vide* Vol. A., *page* 308). It is proposed here simply to give a short account of the chemical composition of the water, before and after the alteration in the wells was made, by which the desired end was attained.

Chemical notes on Khartoum water-supply

The original scheme of the Department of Works comprised the sinking of seven wells. These were all fairly close together—perhaps too close for efficient working. At the present time only three of these wells are in use, Nos. 1, 6 and 7. At the time the earlier tests were made it was not possible for us to obtain the water from each well separately, so that the comparison with the present state of affairs is not as complete as could be desired. Several examinations were made of the water of Well No. 3, the results from one of these being as follows:—

[1] *Third Report, Wellcome Tropical Research Laboratories*, p. 399

Date of Collection, January 1, 1908

		Parts per million
Total solids		265·00
Free ammonia	NH_3	0·55
Albuminoid ammonia	(NH_3)	0·06
Nitrites...	(N)	traces
Nitrates	(N)	0·10
Chlorides	Cl	1·14
Sulphates	(SO_4)	2·06
Carbonates	(CO_3)	143·00
Calcium	(Ca)	64·31
Magnesium	(Mg)	17·64
Sodium	(Na)	7·88
Potassium	(K)	5·74
Iron	(Fe)	1·33
Manganese	(Mn)	0·17

The water was almost quite clear when it emerged from the pipe but became distinctly opalescent after a few minutes exposure to the air, and ultimately deposited a small amount of yellowish-red precipitate. The taste of the water was faintly chalybeate. Its temperature was fairly constant at about 29° C. Physical characters

The points specially to be noted are the high proportion of ammonia, of iron and manganese, and the presence of nitrites. The presence of an excessive amount of ammonia, and of nitrites, is usually an indication of serious pollution; but in the present instance such a conclusion might be erroneous since ammonia is not uncommonly found in deep wells known to be pure, and such ammonia is often, as in the present instance, associated with iron. There could be no doubt, however, as to the objectionable nature of the iron and manganese found, and the prediction made at the time that *crenothrix* would sooner or later appear in the pipes was quickly verified. *Crenothrix* predicted

The mixed waters from Wells Nos. 1, 2, 4, 5 and 6 were next tested, on February 23, after 72 hours' continuous pumping. The water was found to have a distinct odour as it emerged from the pipe and was more turbid than the water from Well No. 3 examined formerly. It contained masses of flocculent matter coloured by iron. The interior of the pipe and the tin in which the water impinged at its exit were markedly coated with a fungoid growth coloured by iron. The proportions of iron and manganese found in this water were:—

	Parts per million
Iron	1·20
Manganese	0·22

After 192 hours' continuous pumping, the water was again tested. It was found to be in practically the same condition. The flocculent masses were examined under the microscope and found to be *Crenothrix polyspora* or closely allied species. Iron and manganese were present as follows:—

	Parts per million
Iron	1·12
Manganese	0·10

The pipes having been cleaned and scraped, another sample was taken on March 1. The odour of the water at its exit had disappeared, but the results of the chemical examination were unaltered.

During my absence on leave in July, 1908, samples from Wells Nos. 2 and 3 were taken by Dr. Todd, Bacteriologist to the Public Health Department, Cairo. These were examined by Mr. Goodson with results as follows:—

		Parts per million	
		Well No. 2	Well No. 3
Total solids ...		291·2	274·8
Free ammonia ..	... (NH_3)	0·379	0·489
Albuminoid ammonia ...	... (NH_3)	0·047	0·012
Oxygen consumed ...	(O)	1·48	2·00
Nitrates...	(N)	0·01	0·02
Nitrites...	(N)	nil	nil
Chlorides	(Cl)	1·72	2·48
Sulphates	(SO_4)	1·64	1·38
Carbonates ..	(CO_3)	134·05	132·84
Calcium... ..	(Ca)	58·98	58·08
Magnesium ...	(Mg)	18·11	19·25
Iron	(Fe)	0·81	0·85
Manganese	(Mn)	0·50	0·33

These showed still higher proportions of manganese than the samples examined before, but the sum of the iron and manganese was much the same.

Two long series of determinations of the manganese were also made during pumping trials on Wells Nos. 3 and 6. These showed the manganese practically constant at 0·3, and 0·55 parts per million, respectively.

Two more complete analyses of Well No. 7 were also made by Mr. Goodson, at Dr. Todd's suggestion, and one of a small surface well, the depth of which was 18 metres only. The results were as follows:—

		Parts per million		
		Well No. 7		Surface Well
Total solids		222·4	220·4	335·60
Free ammonia	(NH_3)	0·622	0·800	0·411
Albuminoid ammonia	(NH_3)	0·017	0·023	0·017
Oxygen consumed	(O)	0·92	0·78	1·60
Nitrates	(N)	0·055	0·040	0·046
Nitrites	(N)	none	none	none
Chlorides	(Cl)	1·33	1·71	0·95
Sulphates	(SO_4)	2·80	4·11	6·25
Carbonates	(CO_3)	112·12	110·00	168·00
Calcium	(Ca)	44·23	42·64	68·14
Magnesium	(Mg)	17·06	17·94	20·04
Iron	(Fe)	0·33	0·13	0·20
Manganese	(Mn)	0·20	0·18	1·11

As pointed out by Dr. Todd, it is evident from the foregoing analyses that the quantities of manganese show considerable differences in the different wells tested—the water from the small surface well containing the highest amount, and that from the deep well (No. 7) the lowest. Thus:—

	Depth	Manganese
Small surface well	18 metres	1·11
Well No. 2	75 ,,	0·50
,, No. 3	75 ,,	0·27–0·33
,, No. 6	75 ,,	0·55
,, No. 7	176 ,,	0·18–0·20

(These figures refer only to the analyses made during the month of July, as the results of analyses made at different seasons might not be comparable).

Dr. Todd further pointed out that the above results showed a certain parallelism with the following results of rough tests for manganese made at his request by Mr. Goodson, of the boring samples of Well No. 7 down to a depth of 80 metres:

Depth of Stratum	Proportion of manganese found	Depth of Stratum	Proportion of manganese found
6 to 15 metres	large	37 to 47 metres	nil
18 to 19 ,,	moderate	47 to 50 ,,	nil
19 to 23 ,,	,,	50 to 52 ,,	moderate
23 to 26 ,,	trace	52 to 54 ,,	,,
26 to 27·5 ,,	fairly large	54 to 56 ,,	small
27·5 to 28·5 ,,	moderate	56 to 61 ,,	nil
28·5 ,,	,,	61 to 62 ,,	moderate
28·5 to 31 ,,	fairly large	62 to 71 ,,	trace
31 to 37 ,,	large	71 to 80 ,,	nil

The analyses as a whole, it was found, seemed to prove that "the best water from a chemical point of view is that of Well No. 7, which is fed mainly from the deeper layers." The recommendations made by Dr. Todd and Mr. Abel, the engineer called in consultation, were, among others, to deepen certain of the wells and to cut off the upper strata by the method detailed by Dr. Balfour in his note on these wells (*loc. cit.*). The wells in use at the present time are Nos. 1, 6 and 7. Many examinations of these have been made in the last year, the most recent results being as follows. They are from Wells Nos. 1, 6 and 7, the others having been abandoned as unnecessary.

	Parts per million		
	Well No. 1	Well No. 6	Well No. 7
Collected ...	Dec. 29, 1910	Nov. 9, 1910	Nov. 9, 1910
Total solids ...	208·00	227·60	195·20
Free ammonia ... (NH_3)	0·50	0·60	0·48
Albuminoid ammonia ... (NH_3)	0·02	none	0·02
Nitrites ... (N)	none	none	none
Nitrates ... (N)	0·01	0·01	0·01
Chlorides ... (Cl)	1·44	2·20	1·90
Sulphates ... (SO_4)	3·79	3·80	3·90
Carbonates ... (CO_3)	109·80	117·60	103·20
Calcium ... (Ca)	44·80	45·60	40·40
Magnesium ... (Mg)	12·28	13·84	12·97
Sodium ... (Na)	5·82	8·18	5·97
Potassium ... (K)	2·21	4·70	5·48
Iron ... (Fe)	0·18	0·32	0·12
Manganese ... (Mn)	0·18	0·16	0·20

Further improvement on storage

The above analyses represent the water not as supplied to the town, but directly it emerges from the air-lift. A further very marked improvement is effected by storage in a large cement-lined reservoir. As a result of the very efficient aeration, due to the use of the air-lift, not only is the iron oxidised and precipitated, but, what was entirely unexpected, the manganese is carried down as well. The precipitation of the iron and manganese probably also aids the direct oxidation of the small amount of organic matter present, the effluent water attaining a remarkable degree of organic purity. The following is a comparison of the water as it emerges from the air-lift pipes with that taken from the tap in the laboratories, *i.e.* after it has been allowed to stand in the reservoir for 48 hours or over.

The water at the time was the product of Wells Nos. 6 and 7.

		From air-lift	From tap in laboratory
Free ammonia ...	(NH_3)	0·54	none
Albuminoid ammonia ...	(NH_3)	0·01	none
Nitrites ...	(N)	none	none
Nitrates ...	(N)	0·01	0·36
Iron ...	(Fe)	0·22	0·05 to 0·80
Manganese ...	(Mn)	0·18	none or trace

The following determinations of iron and manganese in the tap water were made at various times.

Date	Taken from tap at	Iron	Manganese
Jan., 1909	Medical Mess	0·06	none
May, 1909	Military Hospital	0·20	none
Nov., 1909	Dr. Balfour's House	0·45	none
,, 1909	Sudan Club	0·22	none
Oct. 31, 1910	Chemical Laboratory	0·12	none
Nov. 1, 1910	,, ,,	0·80	trace
,, 2, 1910	,, ,,	0·20	0·01
,, 3, 1910	,, ,,	0·50	none
Jan. 4, 1911	,, ,,	0·06	trace
,, 5, 1911	,, ,,	0·05	none

The iron present in the tap water is largely in suspension. It is apparently due to a slight corrosion of the pipes, since the surface water of the reservoir, after only eight hours settling, contains as a rule a smaller amount. There is also the fact that if it were that originally present, it would be associated with a more appreciable proportion of manganese. (*See below*, the analysis of sediment from the reservoir.)

The cause of the corrosion is doubtless, in part at least, galvanic action, the result of the deposition of a small amount of manganese and iron oxide in the pipes. The absence of manganese and presence of iron in the tap water was at first thought to be the result of a slight growth of *crenothrix* in the pipes, but no growth of this kind has been detected since the deepening of the wells and the cutting off of the contaminated water of the surface strata. Corrosion

An analysis, by Dr. Thompson, of the sediment deposited in the storage reservoir gave results as follows :

Loss of ignition		17·46 per cent.
Iron oxide	(Fe_2O_3)	29·40 " "
Manganese protosesquioxide	(Mn_3O_4)	18·07 " "
Alumina ...	(Al_2O_3)	3·97 " "
Lime ...	(CaO)	6·25 " "
Magnesia	(MgO)	2·57 " "
Silica ...	(SiO_2)	21·48 " "
Sulphates ...	(SO_4)	trace
Total		99·30

Plumbo-solvency. The solvent action of the water on lead was tested by means of a section of new lead pipe, about 2 metres long and 1·3 centimetres bore. The water of Well No. 7 only was taken for the test, but as the waters of these wells differ but slightly in composition, the results, I think, may safely be taken as representative of the supply as a whole.

Action on lead

The lead pipe having been fitted with a stop-cock, it was filled with the water which was allowed to remain for twenty-four hours. It was then run off and tested, and the pipe refilled. The tests were carried out in this way for a month. In the beginning, the amount of lead was approximately 0·7 part per million. The amount dissolved gradually diminished, but at the end of the month the proportion found was still considerable, being about 0·44 part per million.

Sobat River Water

In 1908, an attempt was made to carry out an investigation of the composition of the water of the Sobat River, and Mr. Walsh, then of the Sudan Irrigation Service, kindly undertook to collect the samples for the purpose. It was intended to make a series of monthly examinations for an entire year, but Mr. Walsh, by reason of the press of other work, was unable to secure more than nine samples. These were nevertheless well distributed throughout the year and the results probably represent fairly well the usual composition of the water and its variations.

Suitability for irrigation purposes

The results of the examinations are stated in the table on the next page. As will be seen by comparison with those from the Blue Nile and White Nile, which have already been recorded,[1] the Sobat water contains, on the whole, lower proportions of dissolved solids than do any of the branches of the Nile examined up to the present. The proportions of sodium carbonate and potassium carbonate are very markedly lower than is found in the other tributaries of the White Nile or in the White Nile itself, and the Sobat water should therefore be superior to these for irrigation purposes. One may also reasonably expect the soil of the district through which this river flows, and which may be subjected to inundation by it from time to time, to be of better quality than that flooded by the White Nile.

[1] *Third Report, Wellcome Tropical Research Laboratories*, pp. 386 to 395

ANALYSES OF SOBAT RIVER WATER

Date of Collection		Dec. 31, 1907	Jan. 26, 1908	March 2	March 24	May 23	June 21	July 18	Sept. 16	Oct. 29
Suspended matter		25·40	26·60	15·60	30·60	18·60	122·60	49·70	34·80	22·80
Dissolved solids		77·8	78·60	97·20	107·80	96·90	72·00	82·50	70·40	79·80
"Free" ammonia	NH_3	0·023	0·020	not det.	0·038	0·015	0·018	0·015	0·026	0·007
"Albumenoid" ammonia	NH_3	0·274	0·165	not det.	0·143	0·174	0·320	0·323	0·125	0·209
Oxygen consumed in 10 minutes at 100° C.	O	4·07	2·86	2·20	2·01	3·85	5·42	4·68	4·05	4·17
Nitrates	N	0·28	0·22	not det.	0·16	0·466	0·32	0·39	0·12	0·06
Nitrites	N	none	none	none	none	none	none	none	none	none
Chlorides	Cl	0·80	0·96	1·90	1·71	1·90	1·42	1·42	0·78	trace
Sulphates	SO_4	none	none	none	none	none	none	none	none	none
Carbonates	CO_3	26·27	29·60	30·34	29·60	22·12	14·43	14·13	17·43	26·44
Calcium	Ca		11·71	11·08	11·16	7·47	7·57	7·97	9·97	7·17
Magnesium	Mg	—	—	6·21	6·82	4·37	2·84	3·15	4·46	4·73
Potassium	K	4·93	3·15	0·35	0·23	1·53	traces	0·06	2·98	3·70
Sodium	Na	1·41	0·23	7·25	4·73	1·40	0·47	1·46	2·75	3·94
Silica	SiO_2	11·20	10·00	18·40	22·80	not det.	16·60	18·40	7·80	13·00

The Mechanical Analysis of Arid Soils

The mechanical analysis of soils, that is to say the division of their particles into groups according to size, is perhaps of greater importance than any other single determination which the soil analyst is called upon to make. These analyses would undoubtedly be made more frequently than is done at present were the methods suggested more satisfactory and, especially, less laborious. That recommended by Hall,[1] which appears to be the only one practised in Great Britain, is so tedious and often requires so long a time for its completion as to very seriously impair its usefulness. Its application to arid soils offers a still more serious objection in that it entails a treatment with acid, which is not permissible with arid soils, the larger particles of which may be, and usually are, concretions of calcium carbonate. Hilgard's method, depending upon the use of successive currents of water of velocities adjusted to carry particles of the required size, offers several objections, perhaps the least of which is that, requiring special and expensive apparatus, it is, to quote from Hall (*loc. cit.*), suited only to laboratories devoted entirely to soil analysis. Osborne's method, which, like that of Hall, is carried out by a series of sedimentations in beakers, proves in our hands, working with arid soils, to be capable of yielding results of the most varying character. It leaves very much to be desired on the score of ease and rapidity, especially when a number of samples are to be treated at the same time. Indeed, the multiplication of vessels alone renders it quite inapplicable in such cases. The method advocated by the U.S. Bureau of Soils appeared to us to be the most promising. It consists in breaking up the soil agglomerations—puddling the clay—by agitation in a mechanical shaker with water and a few drops of ammonia. The separation of the clay from the other groups of particles is then made by means of a centrifuge.

Various methods of mechanical analysis

Given the appliances suited to the purpose the above method would seem to leave little to be desired on the score either of rapidity or accuracy. Our experience with it, as applied to arid soils, has been most disappointing. It, as do most of the other methods, fails to separate a very considerable proportion of the clay, which goes therefore to swell the silt and other fractions. That the entire amount of clay should be taken into consideration has been abundantly shown by the results of observation on partially water-logged soils, inefficiently drained, and lacking oxygen. Under these conditions sodium carbonate is formed in notable proportion, one of the results being the deflocculation of the clay with its attendant disastrous effect on production.

Importance of ascertaining the total "clay"

In the analytical work carried out recently it has been noted that even when so little as two per cent. of clay remains associated with the residue of silt and sands, the binding effect on the soil is very marked.

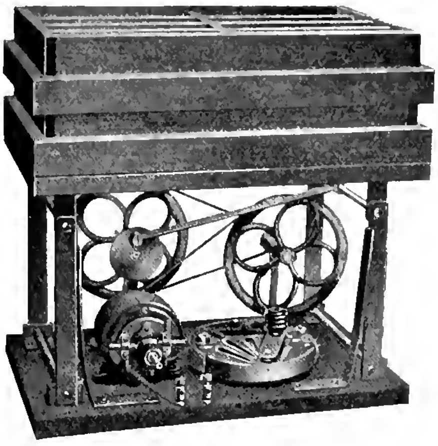
Clay aggregates in arid soils are known to be held together much more firmly than in those of humid regions. There is evidence that this condition is associated with the intense baking which these soils receive during the season of drought. (See below.)

In the tests which were made by the U.S. Bureau of Soils[2] on the effect of length of time of agitation in the mechanical shaker on the proportion of clay found, no marked additional change appeared to take place when the time was increased beyond six hours, except in the case of samples shaken as long as 77 hours. After such prolonged action

[1] *The Soil*, p. 51

[2] *Bureau of Soils Bulletin*, No. 24

there was usually an increase in the amount of clay and this was taken to mean that the soil was being unduly broken down. Six hours was therefore taken as a sufficient length of time to subject the soil to the action of the shaker.



Mechanical "shaker"

The form of electrically-driven mechanical shaker adopted by the U.S. Bureau of Soils is shown in Fig. 3. At the time soil work was begun in these laboratories a machine of this type was not at hand, and the ordinary form of end-over-end rotary shaker was used for the purpose. The following results were obtained on a sample of "cotton soil" known to contain about 54 per cent. of clay. Five grammes of the soil were, in each case, treated with 75 c.c. of water to which ten drops of strong ammonia were added. For the sake of simplicity the proportion of clay only is given, though in many cases complete analyses were made.

Length of shaking in rotary shaker	Clay
6 hours	24·8 per cent.
7 hours	26·1 ,, ,,
14 hours	23·5 ,, ,,
24 hours	29·6 ,, ,,
48 hours	35·1 ,, ,,

Later, a machine of the horizontal type was secured, and a short series of experiments was carried out with it. These were not carried very far since it was soon evident that while the agitation was more violent, the results were not sufficiently improved to render the method practicable. Thus:

Length of shaking	Clay found
30 minutes	25·3 per cent.
1 hour ..	21·4 ,, ,,
2 hours..	26·5 ,, ,,
6 hours...	33·4 ,, ,,

The actual amount of clay present was, as in the former experiments, 54 per cent.

The machine was run at the speed prescribed by the U.S. Bureau of Soils, namely, 100 impulses per minute. By shaking more violently the amount of clay separated in six hours was increased to 38·2, a figure still far below the truth.

As will be seen, even after 48 hours' shaking in the rotary machine, the proportion of clay separated was only about two-thirds the total amount.

No attempt was made to carry the agitation in the horizontal shaker beyond six hours, since it was considered that this length of shaking is as long as can be conveniently carried out, a longer one entailing either two or more periods of shaking, or its continuance during the absence of the analyst, which always introduces an undesirable uncertainty into the determination.

Soils of arid regions usually contain notable proportions of calcium and magnesium compounds, especially calcium carbonate and sulphate. It had already been noted by Briggs, Martin and Pearce[1] that ammonia, when applied to the treatment of such soils, appears rather to flocculate the clay than to break up the flocculations, and its addition in such cases is therefore not desirable. They further note that certain soils (containing an excess of magnesium and calcium carbonate) and which presumably were shaken with water only, were badly flocculated at the beginning of the mechanical analysis; but that after two or three decantations had been made, the tendency to flocculate disappeared and the final separation was made without difficulty. These soils were found to contain as much as 25 and 42 per cent. respectively, of carbonate, calculated as calcium carbonate.

Deflocculation assisted by the presence of sodium carbonate

Although Sudan soils rarely, if ever, contain as much as ten per cent. of carbonates, calcium sulphate is frequently present, more especially in the subsoils, and the two together cause these soils to flocculate persistently in spite of the absence of ammonia. We have found, however, that trouble of this kind usually disappears on the addition of sodium carbonate. As we have abandoned the needlessly laborious and no more accurate method of determining the clay by direct weighing, the presence of sodium carbonate introduces no difficulty. Deflocculation is so effectually aided by the sodium carbonate that only moderate agitation in the mechanical shaker is required, and either of the two forms of machine mentioned above may be applied to the purpose, the one figured on *page* 35 being, however, preferable by reason of its far greater convenience in use.

The use of sodium carbonate in the analysis of these soils is, it appears to us, all the more indicated in view of the fact that it may be formed in the soil as the result of inefficient drainage. The indications furnished by its use in the laboratory are of direct practical bearing aside from the fact that it appears to be the only agent which will enable us to obtain an idea of the true mechanical constitution of the soil, without the use of acids which, for the reason already given, are wholly inadmissible.

A number of experiments was made in order to determine the effect of varying amounts of sodium carbonate. From fifty to one hundred milligrammes to 100 c.c. of water appears to be a suitable proportion. If the amount of sodium carbonate be materially increased, the reverse effect of flocculation results. The yield of clay with the higher proportion of carbonate was nevertheless, in the few experiments made, slightly lower; which is satisfactory in that it goes to show that there is no danger of solvent action on the fine siliceous silt in the soil. The results were as follows:—

Form of shaker	Time of shaking	Sodium carbonate	Clay found
Rotary	6 hours	1 gramme	48·6 per cent.
,,	,, ,,	0·1 ,,	48·9 ,, ,,
Horizontal	,, ,,	1 ,,	47·7 ,, ,,
,,	,, ,,	0·1 ,,	49·1 ,, ,,

[1] U.S. Bureau of Soils, Bulletin 24, *p.* 24

A slightly more effective disintegration of the soil aggregates is had by simple heating with the dilute sodium carbonate solution. The soil tested above gave the results as follows:—

Time of heating	Sodium carbonate	Clay found
15 minutes in steam bath	·2 in 100 c.c. water	50·9 per cent.
30 " " "	" " " "	51·4 " "
5 " boiling	" " " "	51·7 " "
15 " "	" " " "	51·8 " "
35 " "	·1 " " "	51·8 " "

The above results were obtained by the use of the centrifugal machine. If the method of sedimentation in beakers is employed, the boiling method offers the great disadvantage that the number of decantations is very much increased. It is possible that while the clay particles are disintegrated by the boiling, they gradually combine again to a certain extent after the liquid cools.

We have found that by far the most effective agent in bringing about the deflocculation of the clay is an ordinary camel-hair brush. It is employed as follows: The weighed portion of soil is placed in a beaker (or enamelled iron cup) and water cautiously added, sufficient to form a thick paste. The mixture is then stirred with the brush. The clay is rapidly puddled and the mixture becomes so tenacious that a further addition of water is required. This is made very carefully, a few drops at a time, and the puddling continued for from five to ten minutes.

Use of a camel-hair brush in puddling the clay

There appears to be no objection to carrying out the puddling in a beaker. One of these, used for several successive operations, was found not to have lost even a milligramme.

For arid soils, which contain considerable calcium carbonate (and, not infrequently, calcium sulphate) it is essential that all water used should contain sodium carbonate in about the proportion already indicated.

The further treatment of the soil, after the above operation, depends upon the method to be employed. If one of sedimentation, the mixture is made up to a height of say ten centimetres and allowed to stand for a length of time depending upon the size of soil particles which is taken as limiting the clay (*vide infra*). We have adopted what is practically the 8-hour subsidence, which includes, in the clay division, particles up to about 0·002 millimetre. After, usually, the third decantation, the residue, from which most of the water should be removed on the water-bath, is again puddled for about a minute, after which no further puddling is required, the residue being simply mixed with successive portions of water (containing sodium carbonate) and allowed to stand for the specified time until the liquid becomes practically clear at the end of that time.

As already stated, the brush method of puddling has been found to be more effective than any that we have tried. No matter what be the method of analysis adopted, its use at one or more stages of the process is strongly recommended. Its efficiency as compared to that of the rubber pestle recommended by Hall and others is most striking. Using the rubber pestle and employing the Hall method (of acid treatment followed by ammonia) we have frequently had to decant as often as 20 to 30 times before the water came away clear. The analysis carried out in this fashion may take more than a month for its completion. By the aid of the brush and the use of sodium carbonate, the whole or practically the whole of the clay may usually be removed in five decantations.

Great acceleration of analysis by the brush and sodium carbonate method

The following experiments were made in order to determine the rate at which the clay is removed:—

	Clay, per cent. of total present	
	Soil No. 1	Soil No. 2
1st decantation	60·5	76·0
2nd ,,	23·5	12·6
3rd ,,	9·9	5·4
4th ,,	4·1	3·6
5th ,,	2·0	2·4
Total .	100·0	100·0

These results were compared with those of the method by boiling with dilute sodium carbonate solution. It was found that when boiling was adopted, not only was more than double the number of decantations required, but the sum total of the clay removed was 51·5 per cent. as against 54 per cent. by the use of the brush. Examination of the soil particles under the microscope shows the particles of sand and silt to be quite clean when the brush is used, which is not the case with the method by boiling.

Technique for using the brush

As the camel-hair brush picks up and retains a considerable quantity of the soil, care must be taken to remove this by agitation in successive portions of distilled water in a small beaker, the whole of the separated sand being washed out of the beaker after each washing. Usually four or five washings are sufficient. Tapping the bottom of the beaker with the brush submerged in the water, has been found the most efficient method of dislodging the sand.

In order to avoid the frequent washing of the brush, which, while it need only be employed twice in each determination, is nevertheless advantageously applied to bring the clay into suspension after each decantation, it is best to use a separate brush for each soil operated on, and to wash out only once at the end of the process. The brush is conveniently kept in the small beaker in which the operation of washing is carried out at the end.

Any form of camel-hair brush may be applied to the above purpose. We have found the flat form about half an inch broad, bound to a wooden handle by a strip of tin, to be very convenient. Paraffin wax should be applied to the tin junction in order to fill the interstices and prevent the entrance of soil.

The round form of brush may also be used, a glass rod being inserted into the quill, (which is cut rather short) and fastened by wrapping with thin copper wire. The junction should be protected by wax as noted above.

Cleaning of the brush after each puddling is more readily accomplished if the hairs be cut moderately short.

Where a great number of soils are to be operated upon, the labour of the preliminary puddling may be avoided by substituting agitation with water and sodium carbonate in the mechanical shaker, as described above. After the fourth decantation the residue (from which some of the water should be removed on the water-bath) need be puddled by the aid of the brush for about one minute only. The results obtained in this way have been, in our hands, identical with those in which the five or ten minutes preliminary puddling was carried out, but the clay comes away more slowly.

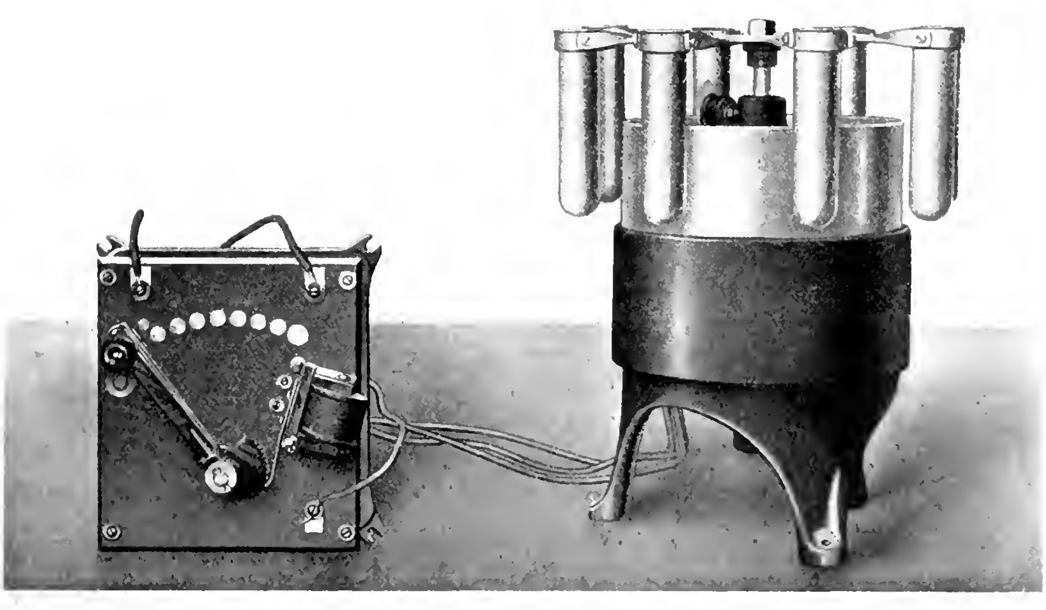
The soil need not usually remain in the shaker more than about an hour, as will be seen from the results of the following experiments with a soil containing about 54 per cent. of clay.

Time of agitation in the mechanical shaker (Water 10 c.c. Na_2CO_3 0·1 gramme. Brush not used)	Clay found
1 hour	47·4 per cent.
3 hours	47·2 ,, ,,
5 ,,	48·8 ,, ,,
6 ,,	49·1 ,, ,,

With the majority of soils little appears to be gained by continuing the operation beyond an hour, since the small amount of clay which remains unaffected at the end of that period is easily brought into suspension by the short puddling mentioned.

Centrifugal Method

While the method of separating the clay, as outlined above, is rapid and generally satisfactory, the operation may be performed still more quickly by means of the



centrifugal machine. Against this must be stated the fact that the centrifugal method entails much more of the operator's attention, though the use of an alarm clock which may

Centrifugal method

be set accurately to the minute will enable him to devote a little time to other work during the whirling. We have found an electric alarm the most reliable for the purpose. One of the forms of centrifuges used in America is shown in Fig. 4. The machines are well known and need no special description. It is desired simply to call attention to the method of controlling the results. It is usually stated that this must be carried out by the use of the microscope. While this is, in a measure, true, it would be useless to expect to obtain results exactly comparable with those from sedimentation, in such a manner. The slightest variation in the size of the particles from the standard which has been adopted would, in many soils, make a marked difference in the results. It must be recollected that the particles are never spherical, so that exact measurement by means of a micrometer is practically impossible, and no two observers could be expected to get precisely the same result. The plan we have adopted is to treat several soils of different character by the sedimentation method and then to determine the length of time of whirling in the centrifuge, run at a known speed, to obtain the same result.

If the soil has been sufficiently puddled at the start we have found that the number of whirlings required is much lessened, almost the entire amount of clay being removed after the sixth decantation. In the machine at hand, 6 minutes has been fixed upon as the period of whirling, the number of revolutions being about 840 per minute. The machine figured runs at a much higher speed and the length of whirling would be materially reduced.

It has been found that after the 6th or 7th whirling, when nearly all the clay has been removed, the remaining soil packs so loosely at the bottom of the tube that the swirling of the liquid, due to the arresting of the machine, causes some of the fine silt to be drawn up into it. As the result of this the water never becomes quite clear, and the end of the clay removal is difficult to judge. This may be avoided by increasing the time of whirling, after the 6th or 7th, to 10 minutes, so that the soil residue packs more closely. The error introduced by the longer whirling at this stage of the process is negligible. The difficulty mentioned would probably not be experienced with machines adapted to higher speed.

Size of the clay particles

The size of the clay particles. Different workers have adopted various limits for the size of the particles taken to represent the group designated "clay." The most common upper limits are ·002 mm. and ·005 mm. Hall[1] employs the first mentioned and separates the clay by 24 hours' subsidence from a column of water $8\frac{1}{2}$ centimetres in height. Kilroe, Seymour and Hallisy[2] employ a method which is attributed to Hall and in which the height taken is 15 centimetres, the particles being stated to have a maximum diameter of ·005 mm. Hilgard[3] describes a method of subsidence of 24 hours' duration, the column of water being 20 centimetres in height "whereby all grain sizes of and above 0·01 mm. diameter are removed from the turbid liquid." Atterberg[4] recommends either the limit ·003 mm. obtained by a 4 hours' subsidence from a column of 10 centimetres, or of ·002 mm. from a column of the same height but with the time of subsidence increased to 8 hours.

It is obvious that the above statements as to the size of the particles are highly discordant. We have made many measurements, all the results of which point to the fact that the figures given by Hilgard and by Kilroe, Seymour and Hallisy and many others, are not even approximately correct. Our measurements agree more nearly with those

[1] *The Soil*, 2nd Ed., p. 51.

[2] *The Geological Features and Soils of the Agricultural Station of the Dept. of Agriculture at Ballyhaise*, 1910.

[3] *Soils*, p. 89.

[4] *Über die Klassifikation der Bodenkörner*, A. Atterberg. Kalmar.

of Hall and of Atterberg, but it is evident that to obtain a separation up to about ·002 mm. it is not necessary to carry the time of subsidence as far as prescribed by Hall. Many of our results were obtained by the use of a column of 20 centimetres height, but we have abandoned this method for the reason that the shortening of the number of decantations was not what was expected. It would appear that the longer the column the more the particles which subside carry others with them. A better result is had by employing two vessels with columns one half the height (10 cm.) the liquid being divided equally beween them; but such a multiplication of vessels does not appear necessary if the soil be properly puddled as described.

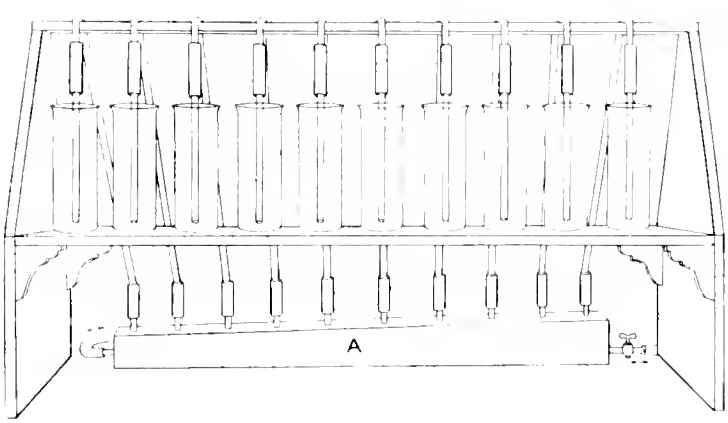
Influence of height of column

An examination of the particles deposited from the 20 centimetre columns proved them to be but very slightly larger than those of the 10 or $8\frac{1}{2}$ centimetre columns, provided always that the time of subsidence be carried to 24 hours. The following figures show how small is the effect of the height of the liquid on the results obtained from the mechanical analysis of Sudan soils. The duration of subsidence was, as stated, 24 hours.

	HEIGHT OF COLUMN OF WATER		
	$8\frac{1}{2}$ cm	10 cm	20 cm
Azaza soil	36·1 per cent.	not determined	38·0 per cent.
Bardobe soil	52·6 ,, ,,	53·1 per cent.	54·2 ,, ,,
Mixture of 10 typical *bardobe* soils	51·0 ,, ,,	not determined	52·4 ,, ,,

Determination of the "Silt"

When a number of soils have to be examined at the same time, we have found the use of the apparatus shown in Fig. 5 to effect a great saving of time and trouble. The residues from the clay determinations (made by difference) are washed into the cylindrical beakers (or museum jars) with distilled water containing the usual small amount of sodium carbonate.[1] After standing for a length of time dependent upon the size of the particles adopted as representing the "silt" division, the liquid is poured away and rejected.



"Silt"

This preliminary treatment should be made with distilled water, since the soil still contains particles in size bordering on those of the clay division. The subsequent operations may, as a rule, be carried out with clear tap water.

[1] Since the heating of the soil residue in the oven usually causes it to cake together, it is advisable to add to it a small amount of water containing sodium carbonate and bring almost or quite to boiling. It is then treated as described above.

The beakers are placed in position and, the vent-cock having been closed, the water tap is turned on very cautiously until the water is seen to appear in the glass tubes. If the level rises equally in all, thus indicating that no air is included, the flow is allowed to continue until the water reaches the bend in the glass tube. At this moment the full force of the water is quickly turned on. If the operation is not carried out as indicated some of the siphons may begin to act too quickly, with the result that their pull on the water may be so great as to prevent entirely the filling of the others. When the beakers are about half filled, the pressure is greatly reduced so that the level of the water rises very slowly. By operating in this fashion even very considerable differences in the diameters of the tubes and beakers will cause no trouble, since the back pressure in those in which the flow is more rapid acts as a check on the incoming water. If the filling is performed with care there will be an almost absolute equality in the level throughout.

Technique of determination of "Silt"

In order to secure the above equality of level the supply tubes should not be too small. Those in the apparatus in use have a bore of 0·5 cm. If the distributing vessel (A) is made as shown, with the top inclined at a slight angle, and the tubes are cut off flush with its under-surface, the inclusion of air with the water in the tubes very rarely takes place. The same result may be attained by substituting for the distributing vessel A, a metallic tube tilted at a slight angle.

During the time the water level is slowly rising in the beakers there is ample opportunity to mix the soil well with the water by stirring with the glass inlet tubes which, as shown in the cut, are connected with the supply tubes by means of flexible rubber tubing.

At the end of the period fixed upon for subsidence of the larger particles, the vent-cock is opened and the supernatant water siphoned off. When this operation has been completed, the water is again turned on (the vent-cock being still open) and a small amount of water is run through in order to wash out the last of the turbid water. The vent-cock is then closed and the entire operation repeated, as described, as often as may be necessary.

The Classification of Soil Particles

The want of uniformity in the system of classification of soil particles no less than the diversity in the methods of separation, is greatly to be deplored. Much of the value of the results is lost by reason of the impossibility of comparison with those of other observers. In a paper presented to the International Agro-geological Congress held at Stockholm in August, 1910, Dr. Atterberg of Kalmar suggested the following limits, with a view to their general adoption:—

Classification by size

Coarse sand (unretentive of moisture)	3	to ·3	*or*	2	to ·2
Fine sand (water-retaining)	·3	to ·03	*or*	·2	to ·02
Silt	·03	to ·003	*or*	·02	to ·002
Clay	·003	to —	*or*	·002	to —

The times of subsidence (in a 10 centimetre column) prescribed for the separation of the two series of silts and clays were:—

Silts		Clays	
·03 mm.	$3\frac{3}{4}$ minutes	·003 mm.	4 hours
·02 mm.	$7\frac{1}{2}$ minutes	·002 mm.	8 hours

In the paper referred to, Dr. Atterberg rather favoured the first series of limits from the point of view of the shortening of the times of subsidence. In a more recent communication, however, he states that against this should be counted the fact that the limit of ·002 mm. for clay has already been rather widely adopted and, further, that the limit of ·2 mm. for the water-retaining sand is more nearly correct than is that of ·3 mm. Our own experience with Sudan soils leads us very greatly to prefer the limits ·02 and ·002 mm., the latter especially, as it differentiates more sharply the soils with which we have to deal. We have therefore adopted these limits, provisionally, with the hope that a general agreement on these lines may be effected. As already noted the figures given are only approximate, the clay being more accurately defined by the time required for its subsidence. Limits of ·02 and ·002 mm. preferred

Résumé of the Method used for the Mechanical Analysis

The following is a short description of the method of mechanical analysis as carried out in these laboratories.

The separation is made, as has been stated, into particles as follows:—

(*a*) *Stones and gravel* above 2 mm.

(*b*) *Fine soil*, less than 2 mm.

The latter is further subdivided into:

Coarse sand (non-retentive of water)	2 mm. to 0·2 mm.
Fine sand (water-retaining) ...	·2 mm. to ·02 mm.
Silt	·02 mm. to ·002 mm.
Clay	·002 mm. and below

The air-dry soil is well mixed, the larger masses being crushed by means of a wooden rolling-pin. One hundred grammes are weighed out on a rough balance and passed through a sieve with round holes, 2 mm. in diameter. The portion, if any, which remains on the sieve is washed with water to separate the adhering sand and soil, dried on the water-bath and weighed. This constitutes the "stones and gravel."

The portion passing the 2 mm. sieve is passed through a sieve with round holes 1 mm. diameter. (The material which passes is taken for the chemical examination and for the further mechanical analysis.) In the above operation the larger masses of soil are treated with the rolling-pin, and also, if not too hard, by rubbing with a cork bung. When most of the soil has been passed through the sieve the remainder is washed on the sieve by a current of water aided by a camel-hair brush, the small quantity of soil washed away being disregarded.

When a number of soils are being examined at the same time, the residues on the sieves are not treated with water at once, but are put aside, in marked beakers, the washings being performed later. In this way the sieves are kept dry during the operations of sifting the soils.

The moisture having been removed by several hours' drying in the air-oven at 110° C., a quantity of the fine dry soil is taken, less than 5 grammes in proportion to the amount of particles between 2 mm. and 1 mm. known to be present in the original soil. This plan of excluding the larger particles is adopted in order more safely to secure an average sample when the small quantity (less than 5 grammes) is weighed out. Resumé of technique

The weighed portion of fine soil is either puddled by the aid of the brush, as described on *page* 37 or, if a number of soils are to be treated at the same time, it is placed in a shaker bottle, 100 c.c. of water containing ·2 gramme of sodium carbonate added, and shaken in the machine, for 2 hours, as described on *page* 35. The soil and water are then transferred to a cylindrical beaker marked at 10 centimetres, distilled water added up to the mark, mixed and allowed to stand for not less than eight hours. In the case of heavy clay soils so much clay is brought into suspension by this method that the first sedimentation is allowed to continue over night in order to ensure that the silt may not be held up by the thick liquid. The subsequent subsidence is of eight hours' duration followed by one over night. In this manner the entire amount of clay may usually be removed in three days. The water used for each operation should contain about one half gramme of sodium carbonate per litre. It sometimes happens that clay is present is such large proportion that the usual volume of water is not sufficient to hold it in suspension for the necessary 8 hours. In the case of flocculation due to this cause, it is necessary either to employ a more capacious beaker, or to divide the turbid liquid between two or more beakers of the usual size (8 centimetres diameter).

Entire amount of clay removed in three days

Flocculation, if it takes place, is more usually due to the presence of soluble salts. This is especially the case with subsoils. It may, as a rule, be avoided by using a smaller proportion of sodium carbonate in order to reduce the total amount of salt present. Two tenths of a gramme per litre may be used for the first two decantations, after which it is advisable to increase to the usual proportion.

If flocculation has occurred, the excess of water, after decantation, should be removed on the water-bath and the soil puddled with the brush. Once the floccules are formed they do not readily break up again in spite of the fact that the salt may have been almost entirely removed by decanting the more or less clear supernatant liquid.

Flocculation due to excess of salts occurs less frequently if the centrifugal method be employed, since it usually takes place very slowly in the presence of the sodium carbonate.

After, usually, the third or fourth sedimentation and decantation, the residue is puddled with the camel-hair brush as described on *page* 37.

When almost the entire amount of clay has been removed, the soil is washed into a weighed beaker of about 200 c.c. capacity, using distilled water (in this case without sodium carbonate). After standing for the usual period (*i.e.* not less than eight hours) or until clear, the water is poured away and the beaker and residue dried by heating in the air-oven for 2 hours at 110 C. From the weight of the soil residue may be calculated the percentage of clay, which is determined by difference. The figure so obtained should be corrected for soluble salts if present in notable quantity. A "correction" for organic matter in the mechanical analysis of a soil is, in the opinion of the writer, neither necessary nor desirable. In any case the amount present in soils even of semi-arid districts, rarely amounts to one per cent. The determination of humus should, of course, be made, but separately, as a part of the chemical analysis. If desired, however, practically the whole of the humus may be removed by using a larger proportion of sodium carbonate in the shaker bottle (·5 to 1 gramme) and, its proportion being determined on another sample by the usual method, the necessary correction may be made.

"Correction" for soluble salts

When it is desired to carry out the separation of the clay more rapidly, the centrifugal machine is used, as already described.

The residue in the beaker, consisting of sands and silt, is treated as detailed on *page* 41. The silt having been removed, the residue is washed back into the original weighed beaker, dried as before and weighed. The silt, like the clay, is determined by difference.

The remaining sand in the beaker is separated into two portions, by means of an appropriate wire sieve.[1] To the portion remaining on the sieve is added that which was retained by the 1 mm. sieve in order to obtain the entire proportion of coarse sand, 2 mm. to ·2 mm. in diameter. The fine sand is determined by difference.

All figures should, obviously, be expressed on the dry soil.

In concluding these notes it is desired to call attention to the fact that while the above method is especially recommended for arid soils, it is equally suitable for those of humid regions. Further, it is held that a method of this kind should invariably be used since otherwise the comparison of humid with arid soils becomes impossible. It must be recollected also that the treatment by acid not only results, at times, in the complete solution of the larger particles, but invariably, in the extraction of material from the finer constituents, so that as a method of "mechanical" analysis it cannot but be considered scientifically unsound.

Soils of the Gezira

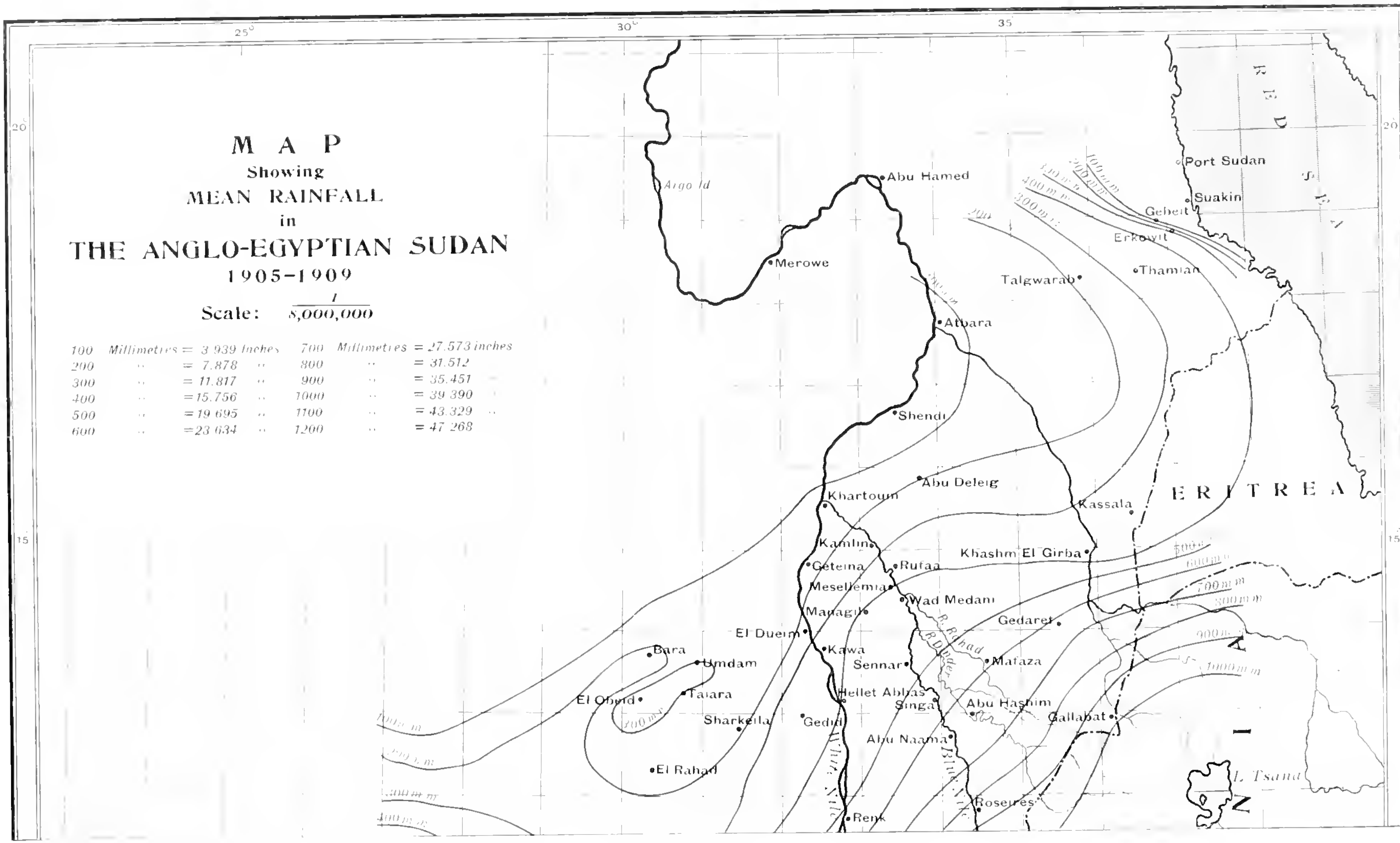
A Preliminary Note

The "Gezira" or "island" is that roughly triangular section of the Sudan which lies between the White Nile and Blue Nile, with Khartoum at its apex, at the junction of these two rivers. It has long been held that the main hope of agricultural development of the Sudan lies in the irrigation of this district. The writer takes a more sanguine view, but, in any case, it appears evident from a study of the rainfall map on *pages* 46 and 47 that the portion south of, say, the 15th parallel, may be capable of profitable development by rainfall cultivation, and there is no little evidence to indicate that even so valuable a product as Egyptian cotton may be successfully grown, as a rain crop, if modern methods of cultivation be applied. Very good crops of dura are now produced, even with the primitive methods of the natives, and it appears likely that wheat may displace this largely when the native cultivator has learned to realise the advantage to be gained. The newly established Gezira railway is already having a marked effect on the output of rain-grown grain from the Gezira, and while this is at present largely dura there is also a certain amount of other grain and of cotton, as well. The latter is grown from native seed and therefore of poor quality, but experiments have been made with Egyptian seed, with most promising results.

Since many appear to be slow to believe in the possibilities of the Gezira from the point of view of rainfall cultivation, a comparison with similar semi-arid districts in other countries may not be out of place. In these districts of low rainfall a method of so-called "dry soil farming" is practised, the distinguishing features of which are (*a*) deep ploughing to ensure the entrance of the rain into the soil, and (*b*) frequent harrowing in order to preserve a loose mulch on the surface and thereby check excessive evaporation. It is obvious that *season* of rainfall in such dry climates is more important than its actual amount.

In the United States (Utah and California), 590 kilogrammes of wheat per acre are stated to have been obtained with a total annual rainfall of about 10 inches. The *average* annual rainfall over the whole of these wheat-producing districts is only about $11\frac{1}{2}$ inches.

[1] The sieve found to pass particles most nearly approximating 0·2 mm. in diameter was of 80 meshes to the linear inch. This will, of course, depend in part upon the size of wire used.



The continuation of this Map to the South is shown on the opposite page

The continuation of this Map to the North is shown on the opposite page

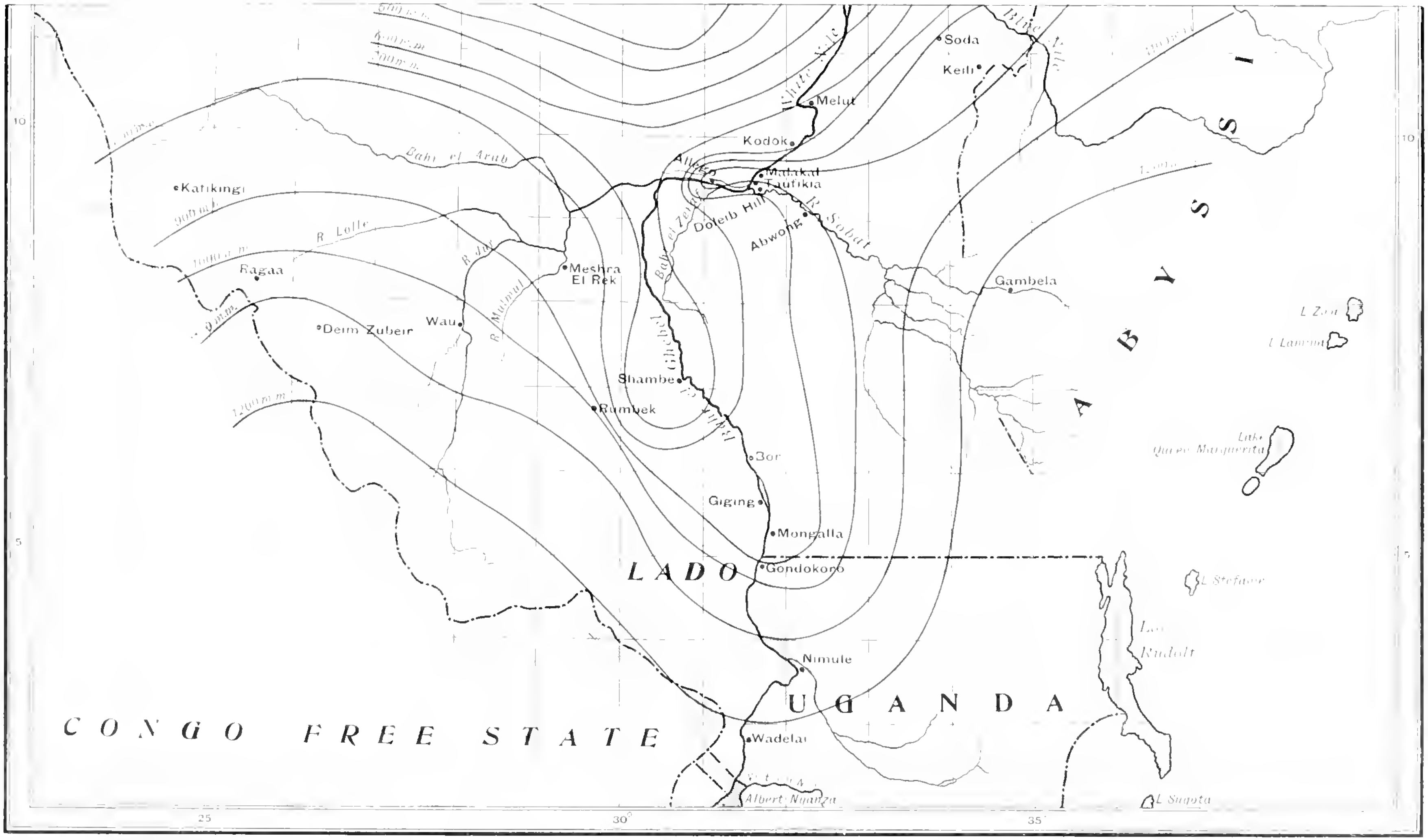


FIG. 6. MAP SHOWING MEAN RAINFALL IN THE ANGLO-EGYPTIAN SUDAN 1905-1909

In the Gezira, at Wad Medani, the rainfall is officially stated to be 400 mm. (about 16 inches). This is slightly greater than the average in the dry farming districts in the United States. Even half-way between Wad Medani and Kamlin, as reference to the map on *pages* 46 and 47 will show, the rainfall is greater than that prevailing in Utah and California where wheat is successfully grown. That the season of rainfall, more especially in the latitude of Wad Medani and south of it, is suitable for cotton, is proved by the fact that it has been extensively grown in the past, in spite of the unscientific methods practised by the natives. Improvement of seed and more modern methods of cultivation would appear to be all that are required to make this enterprise a financial success.

Up to the present but little work has been done on the soils of the Sudan, and especially on those of the Gezira. In 1903 a few samples collected by Sir W. Willcocks[1] were examined by Mr. Hughes, of the Egyptian Department of Agriculture, but no mechanical analyses were made, and, as Mr. Hughes was not supplied with samples of the subsoil, the results, *e.g.* as regards soluble salts, are not only incomplete, but even misleading. Further, the two samples of which more complete chemical examinations were made and which are described by Sir W. Willcocks as "typical Gezira soil," one collected on the Blue Nile and the other on the White Nile side, were taken only 10 miles and 2 miles, respectively, from Khartoum. A comparison with the results in the tables on *page* 54 *et seq.* will show that these soils are not correctly designated as typical of the Gezira generally, since the soils of that district vary greatly, both their mechanical and chemical characters being dependent upon the location—that is to say, upon the climatic conditions, rainfall especially.

At Khartoum, the rainfall is a little over 10 centimetres. At the southern end of the Gezira, it is approximately ten times as great; and while Sudan soils, like those of Egypt, are chiefly river-borne silt of Abyssinian origin, the deposit has suffered very material change in those places in which the rainfall has been more abundant. There is also evidence of change as a result of the alkaline water of the White Nile, some of the soils on this side of the Gezira having their clay in a more puddled condition, and therefore less permeable.

The natives of the Gezira distinguish two main classes of soil. The better of these, from the point of view of suitability for cultivation under ordinary conditions (*i.e.* rainfall cultivation), is termed by them *bardobe*. This is the typical so-called cotton soil, characterised by the deep cracks which form when the soil dries. The other chief variety cracks but little, if at all, on drying. It is called *azaza* and is said to be uncultivable, or, at best, to return inferior yields. Another variety of soil, and the one most esteemed by the native, is termed *fud* or *fuda*. This appears to be merely *bardobe* in a good state of tilth. On drying, it cracks to a less extent than does ordinary *bardobe* soil, and remains friable and permeable. In view of the proposed irrigation of a section of the Gezira a very great number of soils, with subsoils down to four feet, have been collected for us by Mr. S. C. Dunn, the Government Geologist, and examined in the laboratory. A sketch map prepared by Mr. Dunn, showing the points of collection, is found on *page* 51. It is evident from the results of the mechanical analyses that while *azaza* soils are, generally speaking, lighter than *bardobe* the difference in composition is not nearly so great as estimated by the native. The inferior returns under present conditions are due in great part to scanty rainfall. The porous nature of the soil is also a result of this same condition, so that the effect of low rainfall on crop production is doubly felt. *Bardobe* soils,

[1] *The Nile in* 1904, p. 100

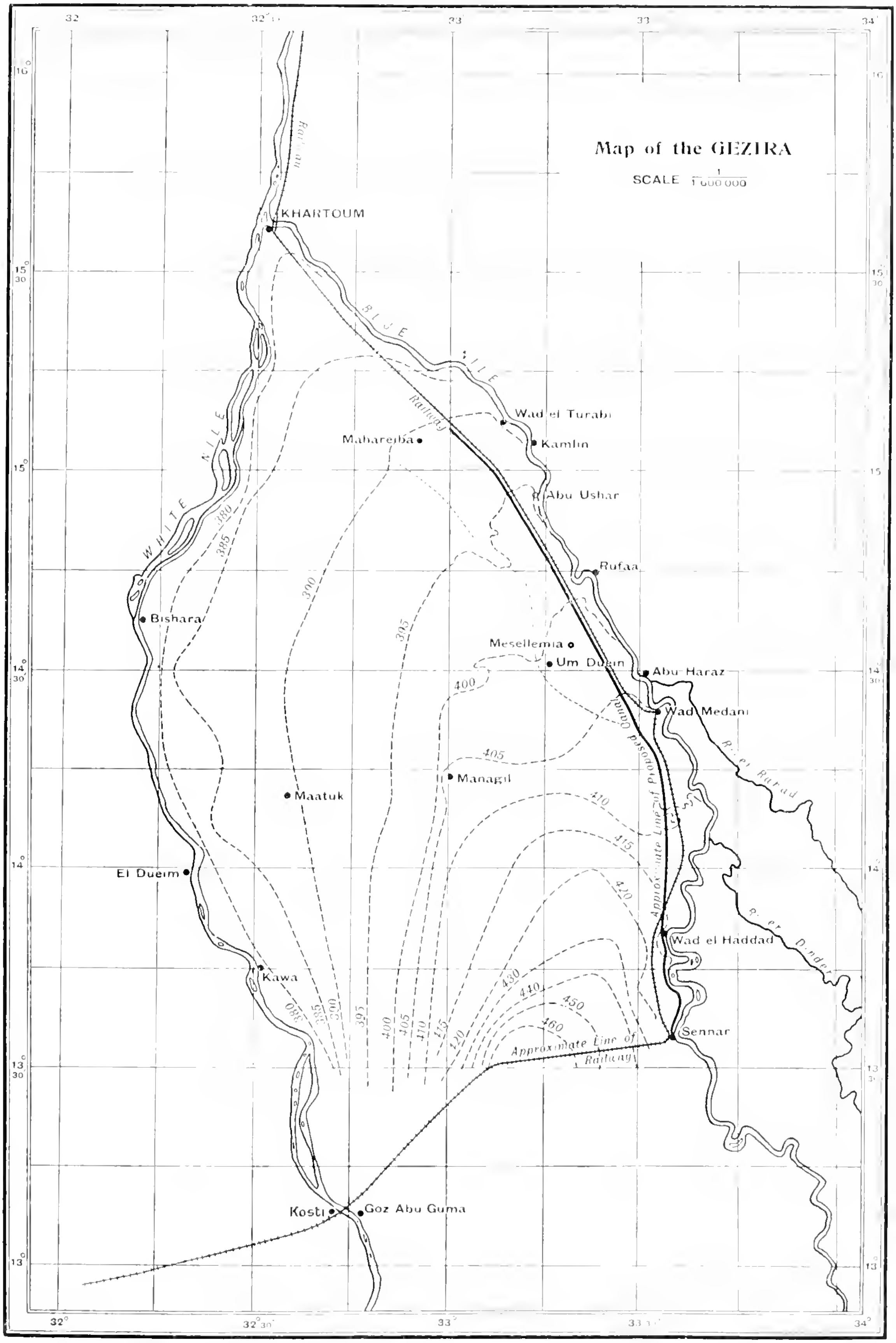


FIG. 7.—MAP OF THE GEZIRA SHOWING APPROXIMATE LINE [illegible] CANAL.
The area coloured green represents that under consideration with a view to irrigation.
Contour lines show height in metres above sea level.
Proposed Canal ———— Railway

from their geographical position, not only receive more moisture, but, by reason of their higher proportion of clay resulting from this condition, are better able to retain the moisture received. *Azaza* soils, here considered very light, would in a country of normal rainfall be held to be rather heavy than otherwise.

Near Khartoum, where the rainfall is only a few inches, the prevailing type of soil is a light *azaza*. This statement does not include the soils directly bordering on the river, which may be subjected to flooding from time to time. These, as a rule, are distinctly heavier. South of Khartoum, as the rainfall increases, the decomposition of the silt and the formation of clay take place to an increasing extent, until, in the neighbourhood of Wad Medani, with an average rainfall of about 16 inches, the proportion of clay amounts to 50 per cent. and even, in some cases, to as much as 60 per cent. Soils in humid regions containing such a high proportion of clay would be considered almost impervious and extremely difficult to work; but the fact that in arid countries even higher proportions may exist in good arable soils has already been pointed out. Thus Means[1] calls attention to a sample from Egypt in which the clay (below ·005 mm.) amounted to about 75 per cent. and the silt (·005 to ·05 mm.) above 12 per cent., making a total of 87 per cent., of heavy material. This "according to the mechanical analysis should be an almost impermeable clay; but in the field the soil was found to be easily drained, perfectly amenable to cultivation and favourable to plant growth." The same remarks apply to Gezira soils and to Sudan soils generally, *provided they are properly drained*. Good drainage is essential to all soils; but the disastrous effect of inefficient drainage on heavy soils has been especially evident in certain lands, improperly worked, near Khartoum, and in the irrigation basins in Dongola Province, in course of construction.

Means (*loc. cit.*) explains the ease with which these essentially heavy soils may be worked by the "cementing action of lime and magnesia and iron compounds which join together the fine grains of silt and clay and form larger aggregates, thus giving the soil a lighter appearance than a mechanical analysis would indicate. The fact," he states, "has been very clearly brought out in mechanical analyses of soils from American desert lands where calcium and magnesium carbonates were abundant. In New Mexico, certain soils were classed in the field as sandy loams, but upon subjecting them to mechanical analysis, when water acts upon the soils for several days, the cementing material was dissolved, the aggregates broken down, and the soil was found to contain enough clay to be classed as a loam or clay loam. The field examinations of Egyptian soils show this cementing process to be developed to a high degree, and soils in the field seem lighter than would be indicated by the mechanical analysis."

The writer was formerly of the same opinion as to the cause of the above effect, but recent experience has shaken his belief in this respect. It has been found, for instance, that the extent to which the clay particles are held together appears to be independent of the amount of earthy carbonates present. It has already been mentioned that the attempt to apply the United States Bureau of Soils method to Sudan soils had not met with success, disintegration of the clay aggregates not being effected by the prescribed agitation with water, and often still less so when ammonia was added. It was found, however, that subsoils often gave results more nearly approximating the truth, and yet the proportion of earthy carbonates in these was not appreciably less—in some cases, in fact, it was even greater. The following are instances of such a condition:—

[1] "The reclamation of alkali lands in Egypt." *Bulletin of U.S. Bureau of Soils* No. 21. *Dept. of Agriculture.*

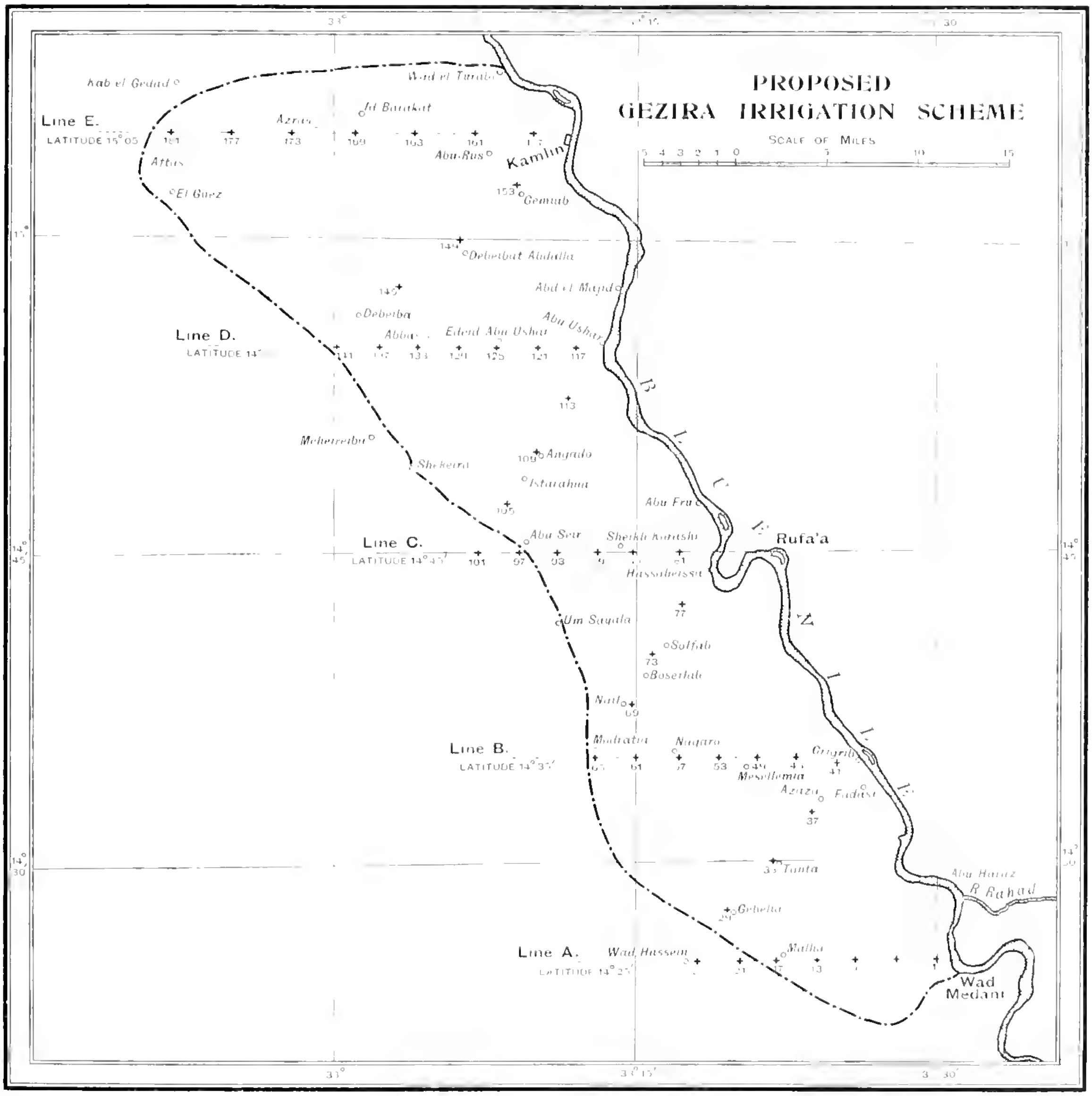


FIG. 8.—MAP SHOWING LINES AT WHICH SAMPLES OF SOIL WERE COLLECTED FOR ANALYSIS

	Clay separated by 7 hours shaking with water	Earthy carbonates expressed as $CaCO_3$
Sample No. 1 (1st foot)	27·3 per cent.	2·36 per cent.
" " 2 (2nd ")	47·0 " "	2·26 " "
" " 3 (3rd ")	45·3 " "	2·57 " "
" " 4 (4th ")	38·9 " "	1·74 " "
" " 5 (1st ")	25·5 " "	1·85 " "
" " 6 (2nd ")	43·9 " "	2·14 " "
" " 7 (3rd ")	17·9 " "	2·17 " "
" " 8 (4th ")	26·7 " "	2·22 " "

The actual amount of clay in the above soils was approximately :—

1st foot	58 per cent.
2nd "	56 " "
3rd "	61 " "
4th "	64 " "

It is not held that the above is proof that cementation of the clay particles by calcium and magnesium carbonates does not occur. It doubtless does occur to a certain extent, but it is felt that some more potent cause is active in the majority of cases. In the regions of no rainfall, *e.g.* Dongola Province, the soils were at first thought to contain practically no clay whatever. Agitation with water, or with water and ammonia, resulted in the bringing of a quantity of material into suspension, but practically the whole of this settled out at the end of a few hours. It was at first assumed that this was due to soluble salts, but the absence of these in the majority of cases was soon proved. It was then concluded that the material present was fine silt, its preservation from decomposition being the result of the total absence of rainfall. Later, these soils were treated with water containing a small amount of sodium carbonate, and were also puddled by the aid of a camel-hair brush as described on *page* 37, with the result that a large amount of clay was separated. The results of the mechanical analyses carried out in this way at once explained the behaviour of the soil in the field.[1] It should be stated that the proportion of calcium carbonate in these soils was usually low—in one case only 0·36 per cent.—so that the explanation of the behaviour of the soil to water by its cementing action does not appear to be tenable.

In the writer's opinion, the intense baking which these heavy soils receive during the hot season plays a very important part, in that it coagulates the clay and renders the soil more permeable and productive. This is in addition to the well-known fact that the

[1] These soils puddle very rapidly when not sufficiently drained

heating of soil even to a moderate degree results in a greater solubility in water of the constituents essential to plant life.

The fact that a treatment so far from drastic as the simple puddling of the soil by means of a soft camel-hair brush, in the presence of an extremely dilute cold solution of sodium carbonate (not sufficient to dissolve the humus), suffices at once to disintegrate the clay aggregates and bring the former into suspension, points rather to the conclusion that the clay has simply been flocculated by the heat and dryness, and that, in the soil, it is usually not held together entirely, or even to any very great extent, by cementing material such as calcium carbonate. It is for this reason that the treatment by puddling in the preparation of the sample for mechanical analysis is held to be a sound one and the substitution of the very small amount of sodium carbonate for the ammonia usually employed, entirely unobjectionable.

There is further evidence that it is not necessary to assume cementation of the clay in the soil aggregates. It has already been noted (*vide page* 14) that when subsoils containing rather high proportions of salts are treated for the mechanical analysis, flocculation of the clay occurs; and that when the excess of salt is removed, these floccules do not readily break up on the addition of water, even in the presence of sodium carbonate. The floccules may appear to do so at first, but if the liquid be allowed to stand for some hours, precipitation of the clay usually recurs.

It is obvious that the intense baking and drying to which arid soils are subjected may cause a similar flocculation of the clay, and the aggregates so formed may be expected to be much more resistant to disintegration than those obtained by precipitation from suspension in water.

Chemical composition of Gezira soils. Extended chemical examinations have as yet only been made of the tract in the Gezira which it has been proposed to irrigate, and which is indicated in the sketch map on *page* 51. The results of examination of individual samples are detailed in the tables on *pages* 56 to 59. The variations in chemical character are more clearly shown in the table of averages on *page* 55, which should be studied in connection with the rainfall map.

As would be expected, the proportion of water-soluble salts in the surface soil, and especially in the subsoils, is greater towards the northern end of the tract where rainfall and consequent leaching are least. The same is true of the proportion of calcium carbonate. Organic matter, as expressed by the content of humus and of nitrogen, is, on the other hand, greater towards the southern end where there has been a greater amount of cultivation and of plant residues left in the soil. Phosphates readily soluble in acid are also less where there has been least rain and where, consequently, rock decomposition has taken place to the least extent. Acid-soluble potash compounds are found to vary but slightly, but in the same direction.

Speaking generally, the soils, both *burdoba* and *azaza*, in this tract may be said to be fairly well supplied with potash and with phosphates. They are, however, like most Egyptian and Sudan soils, markedly deficient in organic matter and in nitrogen, and the results from their cultivation will be largely dependent upon treatment with respect to this deficiency. Rotation with a leguminous crop such as berseem and the ploughing of a fair proportion of the crop into the soil is what is especially indicated. Without such a rotation, rapidly diminishing crops may be predicted with confidence. Since such leguminous crops have not been grown on most Gezira soils, inoculation of the seed first planted should make a very marked difference in the yield. This experiment was tried on a small scale near Khartoum, with results which exceeded all expectations.

Gezira Soils. Averages. Mechanical Analyses

			First foot	Second foot	Third foot	Fourth foot
Line A	Stones, etc., above 2 mm.		3·0	2·1	1·5	0·7
Lat. 14° 25′	*Fine soil below 2 mm.*					
	Coarse sand	2 to ·2 mm.	14·6	12·0	12·2	9·9
	Fine sand	·2 to ·02 mm.	23·4	21·4	22·0	20·7
	Silt	·02 to ·002 mm.	13·0	13·3	14·0	14·6
	Clay	·002 to 0 mm.	49·0	53·3	50·8	54·8
Line B	Stones, etc., above 2 mm.		3·0	1·6	3·1	1·0
Lat. 14° 35′	*Fine soil below 2 mm.*					
	Coarse sand	2 to ·2 mm.	13·5	14·0	12·5	15·2
	Fine sand	·2 to ·02 mm.	19·7	19·9	19·3	16·6
	Silt	·02 to ·002 mm.	14·0	14·2	13·9	13·8
	Clay [1]	·002 to 0 mm.	52·8	51·9	53·8	54·4
Line C	Stones, etc., above 2 mm.		2·5	1·4	1·4	0·9
Lat. 14° 45′	*Fine soil below 2 mm.*					
	Coarse sand	2 to ·2 mm.	16·9	20·9	15·0	14·8
	Fine sand	·2 to ·02 mm.	24·8	21·8	22·8	22·6
	Silt	·02 to ·002 mm.	10·7	10·2	13·0	12·6
	Clay	·002 to 0 mm.	47·6	47·1	49·2	50·0
Line D	Stones, etc., above 2 mm.		2·4	1·4	0·9	1·9
Lat. 14° 55′	*Fine soil below 2 mm.*					
	Coarse sand	2 to ·2 mm.	17·0	18·5	13·6	18·0
	Fine sand	·2 to ·02 mm.	25·6	22·7	23·5	26·3
	Silt	·02 to ·002 mm.	12·2	13·6	14·6	12·6
	Clay	·002 to 0 mm.	45·2	45·2	46·3	43·1
Line E	Stones, etc., above 2 mm.		2·4	1·9	1·7	1·8
Lat. 15° 05′	*Fine soil below 2 mm.*					
	Coarse sand	2 to ·2 mm.	21·1	24·4	20·7	19·4
	Fine sand	·2 to ·02 mm.	25·0	22·1	22·1	21·5
	Silt	·02 to ·002 mm.	12·1	10·0	13·1	14·5
	Clay	·002 to 0 mm.	41·8	44·1	44·1	44·5

[1] Clay separation made by subsidence of 8 hours' duration. If increased to 24 hours the average result would be 2·6 per cent. less clay, the silt being increased in proportion.

Gezira Soils. Averages. Chemical Analyses

			First foot	Second foot	Third foot	Fourth foot
Line A	Potash, soluble in hydrochloric acid[1]	K_2O	0·53			
Lat. 14° 25′	„ insoluble	„	0·57			
	Phosphoric acid[1]	P_2O_5	0·19			
	Humus . ..		0·67			
	Humus nitrogen		0·015			
	Total nitrogen		0·036			
	Carbonates, expressed as calcium carbonate		3·5			
	Water-soluble salts		0·08[2]	0·14	0·33	0·51
Line B	Potash, soluble in hydrochloric acid ..	(K_2O)	0·46			
Lat. 14° 35′	.. insoluble .	..	0·68			
	Phosphoric acid	P_2O_5	0·20			
	Humus .		0·62			
	Humus nitrogen		0·012			
	Total nitrogen .		0·018			
	Carbonates, expressed as calcium carbonate		3·2			
	Water-soluble salts ..		0·08	0·10	0·28	0·60
Line C	Potash, soluble in hydrochloric acid	(K_2O)	0·32			
Lat. 14° 45′	„ insoluble	..	0·74			
	Phosphoric acid	(P_2O_5)	0·15			
	Humus		0·59			
	Humus nitrogen ...		0·013			
	Total nitrogen		0·022			
	Carbonates, expressed as calcium carbonate		3·4			
	Water-soluble salts .		0·10	0·31	0·58	0·49
Line D	Potash, soluble in hydrochloric acid ..	(K_2O)	0·45			
Lat. 14° 55′	.. insoluble	..	0·49			
	Phosphoric acid	(P_2O_5)	0·10			
	Humus		0·52			
	Humus nitrogen		0·013			
	Total nitrogen		0·017			
	Carbonates, expressed as calcium carbonate		4·9			
	Water-soluble salts .		0·10	0·43	0·57	0·54
Line E	Potash, soluble in hydrochloric acid	(K_2O)	0·42			
Lat. 15° 05′	.. insoluble .	..	0·58			
	Phosphoric acid	(P_2O_5)	0·15			
	Humus .		0·51			
	Humus nitrogen		0·011			
	Total nitrogen .		0·020			
	Carbonates, expressed as calcium carbonate		5·7			
	Water-soluble salts .		0·10	0·30	0·57	0·58

[1] 10 hours' extraction with acid of 1·115 Sp. Gr.   [2] Excluding No. 1 which was exceptionally high

GEZIRA SOILS

Surface 12 inches except where otherwise stated *Figures represent per cent. of dry soil*

Point of collection	Lat.	14 25'	14 25'	14 25'	14 25'	14 25'	14 25'	14 25'	14 27'30	14 30'	14 13'30	14 35
	Long.	33 30'	33 28'	33 26'	33 24'	33 22'	33 20'	33 18'	33 19'30"	33 22'30"	33 24'	33 24 45
Sample Number	..	No. 1	No. 5	No. 9	No. 13	No. 17	No. 21	No. 25	No. 29	No. 33	No. 37	No. 41
MECHANICAL ANALYSIS												
Stones and gravel above 2 mm.		3·0	3·4	3·9	3·6	1·9	2·9	2·0	4·4	3·6	2·3	0·9
Analysis of fine soil, below 2 mm.												
Coarse sand, 2 to ·2 mm.		10·2	18·6	11·6	17·2	13·9	15·2	16·1	17·7	18·3	9·5	7·9
Fine .. ·2 to ·02 mm.		16·4	22·2	21·5	23·0	33·3	24·0	22·5	22·0	20·0	24·2	17·1
Silt ·02 to ·002 mm		14·9	12·2	13·9	12·7	12·6	12·2	12·6	12·6	12·1	13·9	14·4
Clay[1] ·002 to 0 mm.		58·5	47·1	53·4	47·1	40·2	48·6	47·8	47·7	49·6	52·4	60·6
CHEMICAL ANALYSIS												
Potash, soluble in hydrochloric acid[2]	(K_2O)	0·43	0·55	0·70	0·31	0·35	0·42	0·99	0·35	0·47	0·50	0·44
,, insol.		—	—	0·52	—	—	0·63	—	—	—	—	0·68
Phosphoric acid	(P_2O_5)	0·24	0·16	0·20	0·13	0·15	0·21	0·26	0·18	0·20	0·19	0·19
Humus		—	—	0·62	—	—	0·72	—	—	—	—	0·62
Humus nitrogen	(N)	—	—	0·01	—	—	0·021	—	—	—	—	0·013
Total nitrogen	(N)	0·055	0·028	0·039	0·027	0·04	0·044	0·024	0·018	0·016	0·018	0·016
Carbonates	$(CaCO_3)$	1·8	3·9	3·9	4·6	3·9	2·4	2·2	2·0	2·90	2·5	2·6
Water soluble salts	1st foot	0·88	0·13	0·08	0·08	0·08	0·08	0·06	0·08	0·08	0·06	0·08
	2nd ..	1·96	0·25	0·09	0·12	0·15	0·14	0·11	0·22	0·11	0·08	0·11
	3rd ..	1·28	0·44	0·15	0·15	0·66	0·45	0·15	0·56	0·22	0·23	0·27
	4th ..	1·25	0·55	0·45	0·76	0·49	0·37	0·60	0·89	0·61	0·54	0·64

[1] Determined by a subsidence of 8 hours. If increased to 24 hours, the average result would be 2·6 per cent. less clay, the silt being increased in proportion.
[2] Ten hours' extraction with acid of 1·115 Sp. Gr.

GEZIRA SOILS—*continued*

Surface 12 inches except where otherwise stated — *Figures represent per cent. of dry soil*

Point of collection	Lat.	14 35	14 35′	14 35	14 35′	14 35	14 35	14 37′30″	14 40′	14 42′30″	14 45	14 45
	Long.	33 23′	33 21′	33 19	33 17′	33 15′	33 13	33 14′30	33 16′	37 17′	33 17′	33 15
Sample Number		No. 45	No. 49	No. 53	No. 57	No. 61	No. 65	No. 69	No. 73	No. 77	No. 81	No. 85
MECHANICAL ANALYSIS												
Stones and gravel above 2 mm.		3·6	3·0	4·9	2·9	2·4	3·1	3·3	2·9	3·4	2·5	3·4
Analysis of fine soil, below 2 mm												
Coarse sand, 2 to ·2 mm.		7·6	11·8	8·9	14·0	12·8	31·0	14·2	23·2	17·6	13·8	16·4
Fine „ ·2 to ·02 mm		18·7	25·9	21·0	18·3	20·9	21·8	25·7	21·7	24·0	19·8	23·1
Silt ·02 to ·002 mm		15·1	12·0	15·0	15·6	12·4	11·0	11·9	10·2	11·6	12·2	11·1
Clay[1] ·002 to 0 mm		58·6	49·3	56·1	53·1	53·9	36·2	48·2	44·9	46·8	54·2	49·5
CHEMICAL ANALYSIS												
Potash, soluble in hydrochloric acid[2]	(K_2O)	0·45	0·55	0·49	0·46	0·51	0·33	0·47	0·47	0·64	0·36	0·45
„ insol. „		—	—	—	—	—	—	0·56	—	—	—	—
Phosphoric acid	(P_2O_5)	0·25	0·14	0·25	0·25	0·20	0·15	0·12	0·13	0·18	0·14	0·19
Humus				—	—	—	—	0·67	—	0·42	—	—
Humus nitrogen	(N)			—	—	—	—	0·012	—	0·013	—	—
Total nitrogen	(N)	0·014	0·019	0·018	0·016	0·016	0·031	0·024	0·037	0·026	0·017	0·030
Carbonates	($CaCO_3$)	1·7	2·5	2·1	2·0	3·2	9·1	6·3	3·3	4·3	3·4	4·0
Water soluble salts	1st foot	0·07	0·06	0·08	0·08	0·08	0·09	0·09	0·16	0·08	0·10	0·09
	2nd „	0·09	0·08	0·08	0·08	0·11	0·17	0·12	0·92	0·16	0·11	0·11
	3rd „	0·46	0·15	0·41	0·17	0·28	0·23	0·63	1·74	0·87	0·35	0·83
	4th „	0·80	0·90	0·54	0·53	0·61	0·22	0·80	1·30	0·25	0·50	0·80

[1] See note on *page* 56

[2] Ten hours' extraction with acid of 1·115 Sp. Gr.

GEZIRA SOILS—*continued*

Surface 12 inches except where otherwise stated — *Figures represent per cent. of dry soil*

Point of collection	Lat.	14 45′	14 45′	14 45′	14 45′	14 47′	14 50′	14 52′30″	14 55′	14 55′	14 55′	14 55′	14 55′
	Long.	33 13′	33 11′	33 9′	33 7′	33 8′30″	33 10′	33 11′30″	33 12′	33 10′	33 8′	33 6′	33 4′
Sample Number		No. 89	No. 93	No. 97	No. 101	No. 105	No. 109	No. 113	No. 117	No. 121	No. 125	No. 129	No. 133
MECHANICAL ANALYSIS													
Stones and gravel above 2 mm		3·4	2·9	2·4	1·0	0·7	6·4	2·8	0·5	1·2	2·1	3·2	2·9
Analysis of fine soil, below 2 mm.													
Coarse sand, 2 to ·2 mm.		19·2	20·0	10·7	21·5	21·8	20·1	22·4	17·9	8·1	19·9	19·4	16·9
Fine sand ·2 to ·02 mm.		24·2	31·1	23·9	27·0	31·4	31·9	29·5	28·3	19·2	24·4	28·6	27·8
Silt ·02 to ·002 mm		10·3	9·3	9·6	11·9	10·4	10·8	10·3	13·9	13·0	12·0	11·3	11·3
Clay [1] ·002 to 0 mm.		16·3	39·6	55·8	39·6	36·4	37·2	37·8	39·9	59·7	44·7	40·7	44·0
CHEMICAL ANALYSIS													
Potash, soluble in hydrochloric acid [2]	(K_2O)	0·36	0·33	0·52	0·25	0·46	0·25	0·30	0·45	0·59	0·30	0·38	0·40
" insol. " " "		—	0·74	—	—	—	0·43	—	—	—	—	0·49	—
Phosphoric acid	(P_2O_5)	0·16	0·14	0·16	0·14	0·14	0·15	0·09	0·13	0·13	0·09	0·09	0·10
Humus		—	0·59	—			0·65	—	—	—	—	0·52	
Humus nitrogen	(N)	—	0·013	—		—	0·014	—	—	—	—	0·013	—
Total nitrogen	(N)	0·031	0·033	0·024	0·021	0·029	0·032	0·021	0·025	0·019	0·012	0·013	0·019
Carbonates	($CaCO_3$)	6·6	3·8	2·4	3·9	2·5	6·9	6·1	2·7	3·4	5·6	6·3	5·2
Water-soluble salts	1st foot	0·13	0·10	0·08	0·10	0·07	0·11	0·09	0·09	0·09	0·10	0·10	0·15
	2nd "	0·79	0·13	0·08	0·68	0·07	0·26	0·72	0·12	0·13	0·57	0·40	1·28
	3rd "	0·67	0·78	0·13	0·64	0·09	0·56	0·78	0·12	0·41	0·54	0·74	1·19
	4th "	0·37	0·34	0·13	0·78	0·11	0·33	0·51	0·12	0·54	0·34	0·74	1·14

[1] See note on *page* 56 [2] Ten hours' extraction with acid of 1·115 Sp. Gr.

Gezira Soils—*continued*

Surface 12 inches except where otherwise stated | *Figures represent per cent. of dry soil*

		No. 137	No. 141	No. 145	No. 149	No. 153	No. 157	No. 161	No. 165	No. 169	No. 173	No. 177	No. 181
Point of collection	Lat.	14 55	14 55′	14 58′	15 0′	15 2′30″	15 5′	15 5′	15 5	15 5′	15 5′	15 5′	15 5
	Long.	33 2′	33 0′	33 3′	33 6′	33 9′	33 10′	33 7′	33 4′	33 1′	33 58′	33 55′	32 52
Sample Number	...	No. 137	No. 141	No. 145	No. 149	No. 153	No. 157	No. 161	No. 165	No. 169	No. 173	No. 177	No. 181
MECHANICAL ANALYSIS													
Stones and gravel above 2 mm		2·9	3·9	1·2	3·3	3·0	2·9	2·6	3·9	4·1	0·5	0·8	2·4
Analysis of fine soil, below 2 mm.													
Coarse sand, 2 to ·2 mm		15·4	21·6	14·3	19·5	20·9	18·3	15·5	25·6	24·5	18·8	23·1	22·0
Fine sand ·2 to ·02 mm		26·9	24·8	28·0	24·8	24·5	29·2	28·1	22·0	24·9	21·2	25·2	24·9
Silt ·02 to ·002 mm		13·6	10·8	14·5	12·7	11·0	13·4	12·8	10·0	12·5	11·6	11·1	13·7
Clay[1] ·002 to 0 mm		44·2	43·8	43·2	43·0	43·6	39·1	43·3	42·4	38·1	48·4	40·6	39·4
CHEMICAL ANALYSIS													
Potash, soluble in hydrochloric acid[2]	(K_2O)	0·57	0·45	0·58	0·60	0·47	0·36	0·51	0·46	0·39	0·53	0·36	0·36
„ insol. „		—	—	—	—	—	—	0·53	—	0·54	—	—	0·66
Phosphoric acid	(P_2O_5)	0·10	0·09	0·10	0·10	0·10	0·12	0·16	0·17	0·13	0·16	0·17	0·16
Humus				—	—	—		0·53	—	0·50	—	—	0·51
Humus nitrogen	(N)							0·010		0·013	—	—	0·010
Total nitrogen	(N)	0·019	0·015	0·018	0·015	0·022	0·021	0·018	0·029	0·018	0·011	0·014	0·026
Carbonates	$(CaCO_3)$	6·6	4·8	4·0	5·4	5·7	4·3	4·5	6·2	7·0	5·4	4·8	7·8
Water-soluble salts	1st foot	0·11	0·08	0·22	0·15	0·34	0·14	0·16	0·11	0·08	0·08	0·04	0·10
	2nd „	0·47	0·08	0·46	0·23	0·43	0·16	0·16	0·69	0·19	0·13	0·54	0·23
	3rd „	0·93	0·18	1·06	0·83	0·91	0·29	0·95	0·70	0·78	0·25	0·55	0·49
	4th „	0·75	0·13	1·13	0·87	1·04	0·26	0·85	0·68	0·87	0·40	0·54	0·46

[1] See note on *page* 56 [2] Ten hours' extraction with acid of 1·115 Sp. Gr.

Gypsum as a Fertiliser for Sudan Soils

The beneficial effect of lime on soil has long been known and its application in one form or another is a common practice, especially in humid regions. In arid regions like those of the Sudan, the removal of the lime originally present as a soil constituent, by the leaching effect of infiltrating rain water, takes place only to a very limited extent, and the soils in such regions are usually so rich in lime that its application as a fertiliser is rarely if ever practised. There is, however, evidence to show that under certain conditions a soil may be benefited by lime even when the analysis indicates that there is already present a proportion much above that usually laid down as amply sufficient. Thus in certain heavy, difficultly permeable, soils, lime, existing as small nodules of calcium carbonate, may be so enveloped by clay as not to be available, and the application of lime in a soluble form may be distinctly beneficial.

The chief beneficial effect of lime, in the form of calcium carbonate, is usually stated to be in connection with the growth of nitrifying organisms. Nitrification, the conversion of the nitrogen of the soil into nitrates directly available for plant food, will not take place except in slightly alkaline solutions such as that furnished by the action of water on calcium carbonate. There are many other effects of lime equally important, and these are shared by other compounds of calcium, more especially calcium sulphates. It is especially with a view to call attention to this latter substance and the possible benefits which may result from its use on Sudan soils that the following notes have been gathered together. It is hoped that they may induce agriculturists in the Sudan to make a trial of gypsum on their lands. If the results obtained are sufficiently favourable, the extensive deposits of gypsum which are known to exist in the Red Sea Province may possibly be worked on such a scale as will enable the material to be secured at comparatively low cost.

Before going into the details of the effects of gypsum in the amelioration of undesirable soil conditions, a glance at the figures in the following table[1] may not be without interest. They show the results of a very great number of fertiliser experiments on cotton soils carried out between 1887 and 1907 and reported in the official bulletins of the United States Department of Agriculture and of the State Experiment Stations. The actual experiments were performed on one tenth or one twentieth acre plots, but the results are uniformly stated in pounds of cotton per acre. The value assigned to the cotton was only 10 cents (2 piastres) per pound, but the present value in Egypt is nearly twice that figure.

Experiments were carried out both with single fertilisers and with mixtures. The table given includes the trials made with single fertilisers alone, since it is only in this series that gypsum figures.

It will be seen that the total area treated with gypsum was 11 acres. Since the trials were made on one tenth and one twentieth acre plots, the number of different experiments carried out with this fertiliser was between 110 and 220. The proportion of cases of success to cases of failure was as ten to one, and the *average* gain per acre over the cost of gypsum was \$18 (about P.T. 360.) or, at the present value of cotton, nearly double that figure. This is six times greater than the average gain from the use of any other form of single fertiliser.

It is fully realised that such a comparison as this is far from scientific; but, as noted by Whitney,[2] owing to the generally inadequate description of the soils in the reports of experiments, it was not found practicable to group and to analyse the data with relation to

[1] Taken from "Fertilizers for Cotton Soils," M. Whitney. *U.S. Dept. of Agriculture, Bureau of Soils, Bulletin* No. 62.

[2] Whitney, *loc. cit.*

RESULTS OF FERTILISER TESTS WITH COTTON SOILS

Kind of Fertiliser used	Total area	Increase to no increase	Range of crop increase	Fertilisers per acre		Average crop increase per acre		Average gain per acre
				Used	Cost			
	Acres	Ratio	Pounds	Pounds	Dollars	Pounds	Dollars	Dollars
Nitrate of soda	73	3·5 : 1	— 60 to 492	160	4.00	64.0	6.40	2.40
Sulphate of ammonia	17	4·7 : 1	— 82 to 234	128	3.97	58.2	5.82	1.85
Acid phosphate	181	9·6 : 1	—108 to 363	286	1.90	69.8	6.98	5.08
Ground bone	14	13·0 : 1	—235 to 283	279	3.63	92.8	9.28	5.65
Rock phosphate	6	1·0 : 1	— 70 to 50	706	3.18	— 4.0	0.40	— 3.58
Floats	25	1·6 : 1	— 96 to 89	201	.80	16.7	1.67	0.80
Basic slag	4	·3 : 1	— 48 to 104	230	1.42	— 1.0	.10	1.52
Boneblack ...	3	3·0 : 0	20 to 290	500	5.50	132.7	13.27	7.77
Muriate of potash	36	3·0 : 1	— 27 to 180	98	2.16	34.5	3.45	1.29
Sulphate of potash	6	·5 : 1	— 30 to 149	112	3.36	21.2	2.12	— 1.24
Kainit	161	3·9 : 1	—108 to 201	292	1.75	32.3	3.23	1.48
Wood ashes	3	2·0 : 1	— 18 to 206	1,667	4.17	68.0	6.80	2.63
Cotton-seed-hull ashes	12	1·0 : 1	— 47 to 250	271	4.61	41.6	4.16	— .45
Lime	3	2·0 : 1	42 to 127	1,333	4.00	33.3	3.33	— .67
Marl	3	2·0 : 1	— 20 to 64	900	.23	19.0	1.90	1.67
Salt	1	—	— 8	200	.80	— 8.0	— .80	— .88
Gypsum	11	10·0 : 1	— 27 to 360	195	.78	197.4	19.74	18.96
Total ...	559	4·1 : 1			2.33	54.0	5.40	3.07

the chemical and physical differences in the soils. The results are nevertheless interesting and suggestive. Whether anything like the same benefit will accrue from the application of gypsum to Sudan soils, can only be determined by trials on a practical scale; but it may be mentioned in passing that a number of pot cultures in the laboratory, with heavy soils, showed marked improvement to result from the addition of moderate amounts of gypsum.

The following is a brief account of the various effects which have been noted as resulting from the application of gypsum to soils, and which may account for the increased yields which have been recorded in the table given on *page* 61.

(*a*) The harmful action of sodium carbonate on soils and on plant life is well known. It appears to be the most injurious mineral ingredient found in otherwise good arable soils. Its action is both direct, on the plant, and indirect, on the soil. On the plant it acts by corroding the root, crown or stem and in some cases the latter is girdled, the bark being completely destroyed. This effect is especially liable to take place when the salt accumulates near the surface as the result of evaporation of the soil water. The effect on the soil is no less injurious, a proportion less even than one tenth per cent being sufficient to destroy the tilth of the soil and to render it unproductive. The effect is due to the deflocculation (puddling) of the clay, with the result that the soil becomes almost or quite impermeable to water.

In cases like the above, gypsum acts as a veritable specific. The impermeability of the soil renders the simple washing out of the salt impossible; but the addition of a small amount of gypsum to the soil water suffices to convert the sodium carbonate into comparatively harmless sodium sulphate, the clay being coagulated and rendered permeable at the same time.

The fact that too little attention has commonly been paid to the drainage of irrigated lands is a truism. When this lack of drainage results in the stagnation of the soil water—*i.e.* insufficient aeration—sodium carbonate is almost invariably formed. Treatment with gypsum should be the first step in the correction of such a condition.

(*b*) The harmful effects of ordinary salt—in fact of practically all soluble salts, even those employed as fertilisers—when present in any but very small proportions, are only too well known. The case of one of these, sodium carbonate, has just been discussed, and its destruction by the use of gypsum noted. The effect of gypsum in this case is usually explained by a consideration of the chemical change which takes place when these two bodies are brought together. It has, however, been discovered that the inhibition of the injurious action extends to other salts as well, a fact all the more remarkable as no adequate explanation can as yet be given for it. In an investigation[1] of the effect of alkali soils on vegetation carried out in 1902 by Kearney and Cameron, of the United States Dept. of Agriculture, a very important fact was recorded in connection with calcium sulphate. It was found that while certain very small proportions of salts, such as common salt, sodium sulphate, magnesium chloride and sulphate, were distinctly injurious to plant life, in the presence of calcium sulphate these proportions may be greatly, in some cases even enormously, exceeded, without apparent injury. Thus, under the conditions mentioned, the maxima of concentration of the salts endurable by the plant were increased as follows:—

Magnesium sulphate	480 times
,, chloride	80 ,,
Sodium sulphate	66 ,,
,, chloride	10 ,,

[1] "Some mutual relations between alkali soils and vegetation." Bulletin No. 71, 1902

In other words, if, in ordinary soil, one part of magnesium sulphate was found to be sufficient to prevent plant growth, in the presence of calcium sulphate the proportion of magnesium sulphate could be increased to 180 parts before the same poisonous effect was manifest.

The experiments mentioned were carried out with wheat seedlings. The results obtained in 1902 have been confirmed by later investigations. Kearney and Harter in a bulletin[1] which appeared in 1907 have detailed the results obtained with four varieties of dura, two of oats and two species of cotton (the Jannovitch Egyptian and an American variety). The results establish the fact that different genera and species differ greatly in their power of resistance to the salts of so-called alkali soils, and that in the presence of salts of calcium, especially calcium sulphate, these differences are much less pronounced. They, however, still exist to such a degree as to leave no escape from the conclusion that some species and varieties of these plants are better adapted than others to grow in soils containing a relatively large amount of these salts.

The extent to which gypsum neutralises the poisonous effect of salts, thus increasing the resistance of the plant to the same, varies with the nature of the salt. In the case of sodium chloride the resistance of the plant was increased as follows:—

Lupine (white)	5 to 10 times
Wheat	5 to 10 ,,
Dura	about 10 ,,
Oats	,, 9 ,,
Cotton (*G. barbadense*) ...	,, 32 ,,
Beet	,, 8 ,,

These experiments were carried out with solutions saturated with gypsum. It was found, further, that when the latter was present even in very small amount, its effect was still marked. Thus, when present to the extent of only one sixteenth part of that required for saturation, the neutralising effect was more than one half that observed for the concentrated solution. It may be stated here that very little calcium sulphate is required to form a saturated solution in pure water—approximately two parts in one thousand parts of water.

The experiments detailed above were all on a small scale, in the laboratory. A very interesting series of field experiments on a larger scale was made at the Experiment Station of the Hawaiian Sugar Planters' Association.[2] These were directed to the determination of the effect of salt in the irrigation water of sugar plantations and the extent to which neutralisation might be effected by the addition of calcium carbonate (in the form of ground coral) and of gypsum. Very large amounts of salt were used in those experiments (200 grains per gallon of irrigation water, amounting in all to over 30 tons of salt per acre) so that the effect on the yield of cane was very marked.

It was found that when gypsum or ground coral were employed, the effect of the salt was to a certain extent neutralised, the yield of sugar being increased by about 16 per cent. The quality of the juice was also slightly improved, the sugar being associated with less impurity.

(*c*) The importance of maintaining a good "tilth"—that loose friable condition of the soil in which the clay exists, not in the puddled state, but agglomerated into small aggregates, thus permitting the free access of moisture and air—is so well known as to

[1] Bulletin No. 113. Bureau of Plant Industry, U.S. Dept. of Agriculture.

[2] Report of the work of the Experiment Station of the Hawaiian Sugar Planters' Association, Division of Agriculture and Chemistry, Bulletin No. 11.

require no special discussion here. A fact which is, however, very generally overlooked in the Sudan, is that the *penetrability to roots should extend as far below the surface as possible.* Gypsum, like other soluble lime compounds, has a marked effect in loosening heavy clayey soil. Being more readily soluble than, *e.g.*, calcium carbonate, it is more quickly removed in the drainage water and the effect is, therefore, less lasting. At the same time it must be remembered that once the soil is made more penetrable and the roots have reached a greater depth, the fact of their presence, and the introduction of more organic matter into the soil, renders the penetrability easier to maintain.

The effect of clay in lessening the cohesion of heavy soils was clearly shown by the results of trials made recently in this laboratory. Several soils were made into bricks, in the one case with pure water, and in the other with water containing gypsum. The clay in the soil was, of course, partially puddled in the operation. After these bricks had thoroughly dried, their transverse breaking strain was determined. In three out of four cases the breaking strain of the bricks which contained gypsum was very markedly less than that of those made from the untreated soil. It is evident, therefore, that a plant root would usually find a gypsum-treated soil more readily penetrable than the original soil.

(*d*) Gypsum shares the effect, exhibited by certain other soluble compounds, of rendering the potash of the soil constituents more available. The gypsum, being comparatively soluble, easily penetrates the soil and acts upon the potassium compounds, especially the hydrosilicates (zeolites) formed as the result of rock decomposition under atmospheric influences. The result of this action is a partial substitution of calcium for potassium, the latter being set free in soluble form, available as plant food.

(*e*) It has already been mentioned that lime (or magnesia), in the form of carbonate, is essential to nitrification, and that these act by neutralising the nitric acid as fast as it is formed, thus preventing its accumulation and the consequent inhibition of the growth of the nitrifying micro-organisms. Calcium sulphate has been found to have a remarkably stimulating effect on the growth and multiplication of these bacteria. In this respect it has been stated by Pichard[1] to be more effective than any other substance known. Taking the effect of gypsum as the maximum, he found that, other things being equal, the amounts of nitrates formed were as shown in the table below—

Gypsum	100
Sodium sulphate	47·9
Potassium sulphate.	35·8
Calcium carbonate	13·3
Magnesium carbonate .. .	12·5

Hilgard has noted that the above results are confirmed by his observations on the soils of California. The explanation of the increased nitrification in the presence of gypsum appears to be due to the fact that the latter acts as a food for the micro-organism.

The importance of this effect of gypsum in the treatment of many Sudan soils may be very great. There is considerable evidence to show that certain of them are, from one cause or another, markedly deficient in nitrifying power. The application to these of gypsum is well worthy of a trial from this point of view alone.

(*f*) The partial exhaustion of soils by the continuous removal of the same variety of crop, without rotation, cannot be explained simply as the result of abstraction of plant food. Several causes are probably at work and there is evidence to show that among

[1] Quoted in *Soils* by Hilgard

them may probably be included the accumulation of products excreted by the plant, these (like all excretory products) being poisonous to the organism producing them.

The beneficial effects of fertilisers has been thought by some to be due, in part at least, to their direct action on these harmful excretory products. It is not impossible that gypsum may have an action of this kind. Be this as it may, the sterility of some soils has been shown by Shreiner and Shorey of the United States Department of Agriculture to be connected with the presence of certain organic compounds among which is, *e.g.*, dihydroxy-stearic acid. An interesting point in this connection is that while some of the combinations of this acid with bases are as harmful as the acid itself, the potassium and *calcium* salts are apparently without injurious action. Soils containing this or similar bodies might therefore, it appears to the writer, reasonably be expected to be made more productive by the application of gypsum as a fertiliser.

(*g*) Lastly, gypsum has long been known to act favourably in promoting the growth of leguminous crops, notably the clovers. The rationale of its action in this case appears not to be fully understood. It may be due to effects not yet discovered or to a combination of those already detailed.

Amount to be applied.—The usual dose of gypsum is about 200 pounds to the acre. In special cases, where there is a notable proportion of sodium carbonate present and the soil well puddled in consequence, 500 pounds or even more may have to be employed.

It should be remembered that lime either as such or in the form of gypsum is not a plant food in the ordinary sense but that it acts rather as a "tonic." It would not be good practice to continually fertilise with gypsum since the effect might be to impoverish the soil too rapidly. The gypsum should, in most cases, simply be added to aid in bringing the soil into good working condition, and its maintenance in this state can be effected only by having regard to the requirements of each special case.

Gum Research

The disadvantages under which the laboratories have been labouring in connection with research on gum products have already been mentioned. Many lines of investigation have had to be abandoned for lack of efficient aid in the field work. Some advances have nevertheless been made, and it may not be without interest to state, briefly, some of the points which appear to have been established, as well as to indicate the lines along which investigation should be directed in future work.

Origin of gum. Mr. Edie's researches, both those detailed in the Third Report, and those carried out during the winter of 1908-9 (*vide page* 73), appear to confirm the earlier work of Greig Smith, which indicated that gum production is the result of the activity of a specific micro-organism. The mode of infection probably varies in different cases, but there is evidence to show that ants, and possibly other insects, frequently act as carriers. During the course of some experimental tappings of *talh* trees (*Acacia seyal*) in the Sennar Province, the freshly exuded sap was observed to attract streams of ants to the cut surface, and it seemed extremely likely that this fact was directly connected with the infection of the tree by the gum-producing microbe.

Microbial origin of gum

The attention of Mr. E. S. Edie, who was at this time at work on *hashab* trees (*A. senegal*) in the Kordofan forests, was called to this point, and his observations (*vide page* 81) appeared to amply confirm the conclusion arrived at. Such a view would explain the results which were obtained from the attempted inoculations of *hashâb* trees in 1907.[1] The experiments made at that time were as follows:—Tapping was performed by making a series of gashes with an axe, no bark being stripped off, and (as it was thought that the chances of efficient inoculation might thus be lessened) an attempt was made to ensure the entrance of the microbe by rubbing a moist rag over the bark, in which the microbe was presumed to reside, and subsequently into the cut.

"Tapping" experiments

A series of trees tapped in the usual native fashion, by stripping the bark, were also treated in the same manner for comparison. The number of trees operated on in each case was twenty-five. The following table exhibits the results obtained:—

Method of tapping	Treatment	Yield of gum per tree per season
Ordinary	No attempt to inoculate	0·9 rotl
,, ...	Attempted inoculation	0·55 ,,
Short gashes	No attempt to inoculate	0·28 ,,
,, ...	Attempted inoculation	0·14 ,,

When the results were reported it was suggested that possibly the lower yields were due to the fact that in place of increasing the extent of infection, the procedure adopted had, on the contrary, lessened it, since the sap exuded was, in great part, removed by the wet cloth. If we accept the view that ants are the chief carriers of infection the results become still more comprehensible. A portion of the sap having been removed (and the amount exuded is usually very small) there was no longer sufficient present to attract the insects, in the usual number, before the cut had healed.

Another point which is of interest in this connection is the effect of cold at the time of tapping. No further experiments have been made since those already reported on, but these appear to show conclusively that cold at the time of tapping has a marked retarding effect on gum production. Should the weather remain cold for several successive days after tapping, the operation may even be entirely fruitless. It seems reasonable to conclude from this that the growth of the microbe is inhibited by the low temperature, and that the wound heals before the tree has become sufficiently infected.

It should be stated here that the exact determination of the quantitative effect of any given condition on gum production is far from easy by reason of the difficulty in securing a reliable standard for comparison, *i.e.* a tree of the same age and size, perfectly sound, to the sap of which the microbes are unable to gain access. Small cracks or fissures at one point or another are almost sure to be found during the dry season, and a certain indeterminate amount of infection appears to be inevitable.

Methods of tapping

Methods of tapping. The native method of tapping *hashâb* trees is to remove a strip of the bark, from 2 to 3 feet in length and 1 to 3 inches broad, according to the size of the branch operated upon. Trials have been made to improve upon this method by removing shorter strips, or by simply gashing the tree, but up to the present, the native method appears to yield the best results.

Tapping of gum trees is only a comparatively recent practice in Kordofan, and is said to date from about 30 years ago. Previous to this, only such gum was collected as was found exuding from natural fissures in the bark. Tapping by the present method was found to increase the yield to something like five times the former amount.

[1] *Vide Third Report, Wellcome Tropical Research Laboratories*, p. 422

Varieties of hashab gum. The gum found exuding naturally is called by the natives "wady" gum and is usually held by them to be stronger than that resulting from tapping. This is not borne out by the result of examination. Indeed, wady gum is, on the whole, of inferior quality, since it is usually darker in colour than the gum of tapped trees. Varieties of *Hashâb* gum

After tapping, the first collection of gum is usually made at the end of several weeks, more or less, depending in part at least upon the temperature, which has a marked influence upon the rate of exudation. There are usually seven or eight collections in the season, which terminates when the rains begin to fall.

The gum of the earliest exudation is usually not completely soluble. On treatment with water, a glairy, mucus-like liquid results, from which there separates, after a time, a greater or less amount of true solution. This effect is usually less marked in weak solutions. Fortunately it has been found that storage of the gum for a short period is sufficient to correct this defect, the gum becoming completely soluble in solutions even of the highest concentration. Senegal gum has been found to behave in a similar manner.

The change which takes place in the gum on storage has not yet been worked out, but it is doubtless connected with the presence of certain enzymes[1] which have been found to be present.

Hashâb (*A. senegal*) gum is found to be a mixture of two markedly different varieties, one hard, and the other soft. These may be separated by exposing the mixed gum to the sun. The harder variety remains glass-like and transparent, whereas the softer becomes more or less rapidly covered with innumerable small fissures which make it appear almost quite white. This bleaching of the gum is more apparent than real, and if the gum is originally appreciably coloured it will remain so in the interior. A certain amount of true bleaching does, nevertheless, take place, but it is not very marked. The solution of this variety of gum is less viscous than that of the harder variety.

The usual range of viscosity of 20 per cent. solutions of the two varieties is as follows, the figures expressing degrees of retardation in the torsion viscosimeter.[2]

Hard gum	60 to 70 degrees
Soft gum	28 to 33 ,,

The two gums exhibit no apparent differences as regards their proportion of ash and acidity.

The origin of the hard gum, that is to say, the special conditions which determine its formation, has not yet been determined. A great deal of work has been attempted with this end in view, but the investigation had to be abandoned for a time for the reasons stated above.

If tested shortly after exudation, gum of the six or more successive collections in a given season exhibits a more or less regular decrease in apparent viscosity strength of solutions. This is not due to a higher proportion of the hard, transparent, strong gum in the earlier collection but to the presence of the less soluble, constantly changing variety to which reference has already been made. If the gum is stored for some months before testing, the change to complete solubility will usually be found to have taken place, and all the collections will exhibit approximately the same viscosity strength.

The typical hard, strong, gum suffers but little change in viscosity strength, on storing.

Effect of coppicing. A considerable proportion of *hashâb* gum is derived from coppiced trees. As such gum might show marked difference in quality or quantity from that Effect of coppicing

[1] *Vide* F. Reinitzer, *Zeit. f. Physiolog. Chem.* 1909, p. 352

[2] *Vide Second Report, Wellcome Tropical Research Laboratories*, p. 232

exuded by ordinary trees, the Forestry Department was urged to furnish us with samples of the two, collected at the same time, and from the same district, for purposes of comparison. This request has not been complied with, but a sample from a single coppiced tree, kindly collected for us by Mr. E. S. Edie, was found to weigh only about one-half of that exuded by an ordinary tree of about the same size. As only a single tree has been tested the result must be taken merely as suggestive. The chemical examination of the two gums yielded results as follows:—

	Gum from coppiced tree	Gum from ordinary tree
Moisture, per cent.	8·29	8·41
Ash, per cent.	2·40	2·67
Acidity (mmgs. KHO required to neutralise one gramme) ...	3·57	3·38
Viscosity of 20% solution (degrees of retardation in torsion viscosimeter)	19·0	17·1

There is no marked difference in quality between the two gums, but both were exceptionally weak as regards the viscosity of their solutions.

As has been noted in previous Reports, *hashab* gum is only formed when the tree is reduced in vitality, usually as a result of the dryness of the soil. It might be expected, therefore, that in the case of coppiced trees the greater root development in proportion to the size of the tree would result in increased vitality during the period of drought, and consequently in lessened gum production. The single instance mentioned above would appear to bear out this assumption, but many collections will have to be made and examined before a reliable conclusion to this effect may be drawn.

Talh gum

Talh gum. This gum, which is the product of two varieties of *Acacia seyal*, is of much less importance, commercially, than that of *A. senegal*, to which it is inferior in several respects; the solution of the gum is less viscous than that of the hard variety of *hashab* gum, and further, on standing exposed to the air, it becomes dark in colour, usually depositing a brownish-black precipitate. The gum is also more acid than is *hashab* gum.

A gum of much better quality may be had by selecting only the colourless pieces. These yield a solution less acid and having little or no tendency to darken on exposure to air. Colourless *talh* gum is found only in very small proportion in the product as ordinarily collected.

Tapping of *talh* trees

Tapping of talh trees. *Talh* trees are not tapped by the native gum collectors. At our request an experimental tapping of these trees was carried out by Mr. S. A. Wood, Inspector of the Woods and Forests Dept., with a view to determine whether the quality or quantity of the gum was naturally improved. From the report made by this official it appeared that the quantity of gum exuded could be very considerably increased in this way; and, from the sample of such gum sent us, it appeared also that the quality was even more markedly improved. In the Third Report of the Laboratories, *page* 436, is found a comparison of the results of examination of this sample with that of ordinary gum collected in the same district from untapped trees. Later investigations disclosed the fact that for some unaccountable reason the sample furnished as gum from tapped trees had been picked, all the darker particles being rejected. The comparison of results referred to above was, therefore, rendered not only useless but misleading.

A second attempt was made to determine the effect of tapping *talh* trees but the forestry official to whom the work of tapping and collection was confided again failed to carry out the work in a satisfactory manner, and the results were useless except to confirm the conclusion that the sample first furnished was not reliable.

A third attempt was made, the operations of tapping being carried out under the supervision of the writer. The trials made and their results are detailed below.

Red *Talh* Trees. *Tapped November 18.*

Red *talh* trees

SERIES A. Ten trees tapped by a clean cut with a sharp spoke-shave, removing both bark and liber. The strips removed were about 10 × 1½ inches. They were taken from the trunk alone, since the branches were too high to be accessible.

Nov. 24. No appearance of gum.

Dec. 18. No appearance of gum.

The cut appeared to have healed when observed on Nov. 24.

SERIES B. Strips, of outer bark only, removed by means of the spoke-shave. Five trees operated upon.

Nov. 24. No appearance of gum.

Dec. 18. No appearance of gum.

SERIES C. Simple horizontal gashes, to the number of about six on each tree, made with a small native axe. Six trees operated upon.

Nov. 24. Gum just beginning to exude.

Dec. 18. All the trees but one (C 1) showed exudation of a small amount of gum at each gash. The gum was dark coloured except in the case of tree (C 5) which had apparently been less affected by fire.

SERIES D. Two horizontal clean cuts, so made as to remove a wedge-shaped piece of the bark and liber, and exposing the wood. Six trees operated upon.

Nov. 24. Gum beginning to appear.

Dec. 18. Nos. 1, 2 and 3 showed a slight exudation, No. 4 a large blob of gum of rather dark colour. No. 5 tree, markedly less affected by fire, yielded no gum.

SERIES E. Six trees treated as in D, but the bark adjoining the cut bruised by blows with blunt end of the axe.

Nov. 24. Gum beginning to appear in most cases, but of dark colour.

Dec. 18. In four cases gum was found to be exuding in fair quantity but rather dark in colour, especially where it had passed through the cracks in the bruises.

Two of the trees, which were larger and less affected by fire, showed no exudation at all.

SERIES F. Simple vertical gashes made by blows of a small sharp axe. Six trees operated upon.

Nov. 24. Gum beginning to exude in some cases.

Dec. 18. Two trees showed practically no result from the tapping. One of them was almost completely shaded by a large tree with heavy foliage. The remaining four trees showed gum either at some or at all of the gashes.

Tapping experiments

SERIES G. Bark and liber removed and an auger hole made in the denuded wood. In this case the removal of the bark was effected by making a horizontal cut and loosening the bark beneath it by bruising slightly with the blunt end of the axe. In this way a strip of the bark may be pulled off by hand, an operation which is otherwise sometimes effected with difficulty. Six trees operated upon.

Nov. 24. No appearance of gum.

Experiments *continued*

Dec. 18. In the case of one fairly large sound tree, no gum was found at the point of tapping. In all the other cases there exuded a fair, and usually quite considerable, amount of gum which was dark in colour, especially in the case of the trees most injured by fire.

SERIES H. An auger hole, about ¼-inch in diameter, made through the bark and into the wood. Six trees treated.

Nov. 24. Slight exudation of gum, from between the bark and the wood. None from the wood itself.

Dec. 18. A small quantity of gum—usually of dark colour—exuding from most of the holes.

SERIES J. Holes made by "pecking" with a sharp-pointed axe. Six trees operated upon.

Nov. 24. Gum beginning to exude at each point.

Dec. 18. In five out of the six trees, gum of fair colour was found exuding from nearly all the "pecks." In one case, when the exposed roots of a large tree had been much affected by fire, but the rest of the tree practically uninjured, there was an extremely large amount of gum yielded at one of the "pecks."

SERIES K., L. AND M. These trees were tapped by removing the bark and liber in the manner detailed for Series G, and the cut surface was treated with strong antiseptics in order to determine whether such treatment would prevent inoculation and gum production.

SERIES K. A solution of corrosive sublimate rubbed into the freshly denuded surface and the neighbouring bark. Three trees operated on.

Nov. 24. Gum appearing in greater quantity than in the previously detailed experiments.

Dec. 18. Considerable exudation of gum, of rather lighter colour than the average yielded in the former series of experiments.

SERIES L. Diluted formalin applied, under the same conditions, to three trees.

(*Note.* The roots of these trees had been considerably injured by fire.)

As in the case of Series K, all three of the trees exuded a large amount of gum. In one case there was not less than a pound, partly hanging from the tree and partly lying on the ground.

SERIES M. Three trees taken. The treatment in this case was with a solution of sodium metabisulphite. The results yielded were in the main similar to those in the case of experiments K and L. One of the trees yielded practically no gum, but the remaining two yielded much larger amounts than in the case of simple tapping without the use of chemicals.

The gum, in all three cases of chemical treatment, was evidently exuded much more quickly than is usually the case, and it was spread over the tree to such an extent that it could not be removed without great loss.

White *talh* trees

White *Talh* Trees

These trees were tapped on November 19 and the observations made on December 17.

SERIES A. Ten trees. Simple tapping by removing a strip about 8 inches long, including both bark and liber. The removal of the bark was effected as in Series G of the Red *Talh* trees.

When examined on December 17 most of these trees, fairly sound, showed little or no appearance of gum. Several trees which had obviously been injured by fire exuded a fair amount of gum of dark colour.

SERIES B. Eight trees, tapped as above, but, in addition, an auger hole made into the denuded wood.

In most cases no gum was found exuding from between the bark and the wood, and in no case was any trace of gum found exuding from the hole in the wood itself.

SERIES C. Six trees treated by boring holes with an auger, through the bark and into the wood.

In the case only of one tree was gum found exuding, and from one only of the several auger holes in it.

SERIES D. Five trees treated by removing a wedge-shaped piece of the bark and liber, and bruising the adjoining bark by blows of the blunt end of a small axe.

Three of these trees yielded no gum at the point of tapping. The remaining two yielded a fair amount, but very dark in colour, especially where it exuded from the cracks in the bruised bark.

No further reliable observations were made on the above experimental tappings. It was intended when they were instituted that observations be made periodically—once every two or three weeks—in order to watch the course of the exudations. It appears, however, that the forest officer in charge of the district did not visit them until three months after the date mentioned above, when he reported the practical absence of gum from any of the trees except those which had been chemically treated. We were therefore left somewhat in the dark in this connection; but, in view of the fact that the apparently sound trees, both of *White Talh* and of *Red Talh*, did not yield gum when tapped in the ordinary way, there seems to be strong evidence that, at least in the immediate district in which these experiments were performed, the conditions were not naturally favourable for gum production. Taken altogether the results appear to justify the following conclusions:—

(*a*) In the district in question sound *white talh* and *red talh* trees—*i.e.* trees which have not been injured by fire or which have not suffered marked mechanical injury—are not susceptible to the action of the gum-producing microbe, and will not, therefore, yield gum on simple tapping in October and November. It appears evident that at this time the ground is still sufficiently moist, from the lately fallen rains, to keep the trees in a resistant condition. Conclusions

Such trees would probably yield gum if tapped at the end of February or, better, in March, when the weather is hot again and the soil contains less moisture. On the other hand, the soil itself appears to be of rather good texture and fairly rich, which, again, is unfavourable for gum production under ordinary conditions.

(*b*) Trees which have been injured by fire are more susceptible and yield gum fairly readily; but such gum is very frequently coloured to an objectionable degree. Even in the case of these fire-injured trees, it would seem preferable to perform the tapping as late as possible after the rains, so that the exudation may not be checked by the colder weather of December, January and February.

(*c*) Tapping by cuts with a sharp instrument, such as a spoke-shave, will probably be least effective, since such cuts appear to heal too quickly. This method, has, however, not yet been tested on trees known to be in a low state of vitality, and therefore most suitable for gum production.

(*d*) Bruising of the bark around a cut allows freer outlet to the gum and increases its production; but the resulting gum, especially if it exudes through cracks in the bruised bark, is coloured to an objectionable degree.

(*e*) If found feasible it would appear preferable to tap lightly, but in a considerable number of places, on each tree, in order that the gum may form separate tears, instead of running down the trunk in a thin layer. It is probable that this latter condition would be less likely to obtain if the tree were tapped, as suggested, towards the end of the dry season, when the gum might be expected to exude in a less liquid condition. Such gum might form tears less contaminated by bark and more easy of collection.

(*f*) As regards the marked effect of the application of chemical agents to the freshly tapped surface, it seems reasonable to conclude that these act, not by inciting gum formation, but rather as irritants, stimulating the flow of gum-containing sap to the part. In other words, it seems likely that the gum already existed in the sap, the trees having previously become infected by the entrance of the microbe at other points. This conclusion is supported by the fact that, of a further lot of twenty trees, treated in the same way by the forest officer, a few failed to respond.

The above results, obtained in Sennar, were communicated to Mr. E. S. Edie, who was working at the same time on similar lines in Kordofan, but on the *hashab* tree. As will be seen from his report (*page* 73), Mr. Edie's observations led him to the same conclusions.

To conclude these notes, the fact that in the neighbourhood of Saoleil, only such trees as had been injured by fire yielded gum readily on tapping, is a point of obvious importance. As already noted, it still remains to be determined whether the sounder trees could be made productive if tapped towards the end of the hot dry season. If not, we would be compelled to rely upon injured trees for gum production, and, in this case, a method of reducing vitality more under control than a chance forest fire, is obviously desirable. Girdling some of the roots of the tree, or, more simply, partial girdling of the trunk near its base would seem to be a promising method. Objection may be raised that it is not advisable to carry the injury to such an extent, but since these trees are at present put to no use and have cost the Government no inconsiderable sum for fire protection, such an objection does not appeal to one as sound.

The method, if found to answer, might be advantageously used to secure at the same time a cheap wood fuel which is even more desirable than an increased output of *talh* gum. The trees might be utilised for gum as long as the work appeared profitable, after which they could be felled for use as fuel.

Experiments on Gum Production in Kordofan

BY

E. S. Edie, M.A., B.Sc., Carnegie Research Fellow, 1908-9

On being awarded a renewal of the Carnegie Fellowship held by me during 1907-8, I discussed with Dr. Balfour and Dr. Beam the best way in which I might be able to throw some more light on the subject of gum production, the principal questions at issue being the causes affecting the amount of gum exuded and the quality of the gum. It was decided that the best way would be for me to study the problems in one of the gum-producing districts, instead of having to get material sent to Khartoum to be worked up there.

I arrived at Taiara, the principal centre of the gum industry in Kordofan, in the first week of November, 1908, and was fortunate enough to find that two gum gardens suitable for experimental work had been partly cleared of grass and fenced in by the Woods and Forests Department in the previous season. One garden consisted entirely of young *hashâb (Acacia senegal)* trees which had never been tapped. These were all in a good state of health and free from accidental injuries. The other garden contained principally large trees, probably none being less than ten years old.

Selection of site for experiment

Twenty trees in each of these gardens had been tapped in the ordinary manner before my arrival at Taiara, about October 15. It will be of interest to consider the gum produced by these trees before entering into the question of the influence of artificial conditions on the yield of gum.

Gum from twenty small trees.—These trees, tapped for the first time, were among the largest of those in the first-mentioned garden, being probably from five to seven years old, judging from comparison with trees of known age elsewhere. On the whole they were considerably smaller than the average trees tapped by the natives in their own gardens. In order to show the fluctuations in the yield of gum throughout the season, it will be useful to give the complete figures for these trees, and afterwards to give a similar table in the case of the large trees.

It will be seen that the collections, after the first, were made at intervals of about 16 days.

On looking at the table on the next page, one is immediately struck with the enormous variation in yield of the individual trees. From an examination of the latter I think that the variations could not be entirely accounted for by differences in the size of the trees or the extent of the tapping. Tree No. 10, for example, was one of the largest of these trees, and was as well tapped as any, but yet it only yielded a very small amount of gum. The trees from which only a small amount of gum was obtained may not have been so well infected as the others.

Variation in yield of individual trees

Of special interest is the amount of gum obtained at the last collection. From the way in which the exudation was gradually falling off, one would have expected very little gum at this time, instead of which not only was there a considerably greater total yield on this occasion than on the one immediately preceding, but several trees actually gave more gum at the last than at any previous collection. The reason for this is probably as follows:—Between March 29 and April 8 about an inch and a quarter of rain fell, as a result of which many of the smaller trees came into leaf, and the renewed exudation was probably caused by the sudden increase in the amount of sap from which the gum is produced. The increase was principally in the first ten trees, which were, on the whole, smaller than the rest. The amount of rain at this time was probably not sufficient to affect the larger trees as they did not come into leaf as a consequence. This increase, after the first rains, is of greater interest, as it is nearly always stated that the exudation of gum stops when the rain begins. It may quite probably be that more or less gum is produced until the edges of the wounds caused by tapping are entirely healed up. There was no sudden change of temperature for any prolonged period, nor any other exceptional circumstance of any kind to account for this increased yield. The average yield from these young trees is 900 grammes, considerably higher than is usually supposed to be the case. From the amount exuded by individual trees, however, it will readily be seen how difficult it is to reach definite conclusions from experiments with a few trees only, even though these may be to all appearances under similar conditions of health, age, etc.

Increase in gum after the first rains

YIELD OF GUM FROM SMALL TREES DURING SEASON 1908-9 (IN GRAMMES

Tree No.	Dec. 17 1908	Jan. 2 1909	Jan. 19	Feb. 3	Feb. 17	Mar. 4	Mar. 19	Apr. 4	Apr 22	Total
1	31	55	53	30	36	50	28	18	37	338
2	50	47	50	27	3	33	7	39	81	337
3	64	42	37	0	10	22	8	44	38	265
4	144	179	190	151	129	169	103	25	42	1132
5	351	239	153	19	27	52	37	38	18	934
6	98	16	32	27	10	6	0	11	29	229
7	186	137	130	97	11	101	56	10	22	750
8	36	55	61	14	24	63	74	45	86	458
9	33	25	35	3	5	34	28	25	82	270
10	59	28	23	0	0	34	16	5	23	188
11	308	214	244	195	206	196	174	39	16	1592
12	131	125	90	50	29	15	3	18	21	482
13	524	385	278	187	53	110	26	17	14	1594
14	770	536	536	388	226	242	81	51	26	2856
15	145	159	178	135	90	144	73	21	7	952
16	524	395	390	245	65	125	17	9	43	1813
17	498	318	269	238	48	227	84	32	47	1761
18	94	79	67	34	14	46	4	0	16	354
19	133	133	96	100	16	90	26	13	38	645
20	238	198	166	117	125	119	24	41	39	1067
Total...	4417	3365	3078	2057	1127	1878	869	501	725	18017

This garden was much more densely covered with trees than any ordinary garden which I saw belonging to the natives, which leads one to the conclusion that the amount of gum produced in the country could easily be very much increased without even the necessity of opening up new areas which are not at present developed at all. Mr. Bisset, of the Woods and Forests Department, has shown that clearing the grass away carefully has a marked beneficial effect in increasing the number of trees by allowing them to obtain a good hold in the first year or two of their life, where they would otherwise simply be killed off. I have seen fair-sized tears of gum, an inch and more in diameter, produced by trees three years old, but the natives do not appear to tap their trees until the latter are about six years old. Of course, by tapping the trees at an earlier age, there may be a considerable risk of prematurely shortening the gum-producing life of the trees.

Prospect of benefit from increasing the number of trees on a given area

Gum from twenty large trees.—These trees varied considerably more in size than the small trees described above, and were not all equally well preserved. From the general appearance of the trees, however, I should say that they represented an average garden. The following table shows the yield of gum from these trees throughout the season:—

Tree No.	Dec. 18 1908	Jan. 2 1909	Jan. 20	Feb. 4	Feb. 18	Mar. 4	Mar. 20	Apr. 5	Apr. 23	Total
1	351	322	375	231	327	344	138	104	57	2249
2	241	193	177	99	47	3	2	15	8	790
3	243	156	171	118	112	43	31	135	72	1081
4	614	258	176	97	43	37	6	32	27	1290
5	239	311	434	350	301	417	268	147	68	2565
6	173	99	74	40	32	30	13	81	47	589
7	174	141	104	67	60	36	15	41	29	667
8	450	458	553	459	349	411	224	226	138	3268
9	437	509	705	822	1041	1212	936	677	415	6754
10	817	829	892	812	890	888	557	336	107	6128
11	304	336	341	260	146	141	29	124	51	1732
12	363	228	131	45	29	11	0	2	6	820
13	952	835	920	606	520	379	135	54	11	4412
14	38	82	140	165	173	248	147	108	42	1143
15	342	109	93	73	91	65	24	66	23	886
16	80	276	218	281	335	493	126	206	95	2410
17	299	236	251	198	157	175	90	141	56	1603
18	177	261	339	339	282	188	107	40	3	1736
19	308	138	279	145	111	64	24	37	19	1125
20	128	102	54	24	19	10	3	31	8	379
Total..	6735	5884	6427	5231	5065	5225	3175	2603	1282	41627

The average yield of gum from these trees for the season is over two kilogrammes, which again is much higher than the general estimate. Trees Nos. 9, 10 and 13 are remarkable for the exceptionally high yield, and the continued increase in exudation throughout nearly the whole season noticed in No. 9 is very interesting. Individual trees vary enormously in this garden also, not only in their total yield of gum, but also in the relative amounts produced at the beginning and towards the latter half of the season. For these differences, as in the case of the younger trees, there was no apparent cause, trees which gave only a small amount of gum being in many cases as large and, so far as one could see, as healthy as others from which a very much larger amount was obtained.

Production from large trees unaffected by early rains

It will be seen that the rain at the beginning of April was followed by no increase in the amount of gum exuded by these large trees. Probably the rain was not sufficient to cause any increased flow of sap, and no new leaves appeared in consequence of it. It might be of interest to tap a few trees about the middle of the rainy season, when they are in full leaf, with a view to seeing if any gum was exuded before the wounds had time to heal up.

Dr. Beam has pointed out in the Third Report of these Laboratories that it is usually considered inadvisable to tap trees on a cold day, and has given the results of some experiments confirming this. It does not seem to be the case, however, that the exudation of gum has a tendency to increase as the season advances and the days become warmer.

Temperature records

Near the end of December Mr. Bisset was kind enough to send me a maximum and minimum thermometer, readings of which I took every day, and it may be of interest to state briefly the variations in temperature for the four succeeding months. A convenient method of doing this, without tabulating the whole figures, will be by giving the absolute and also the average maximum and minimum temperatures during each interval between the collections of gum. This is sufficient to give a fair idea of the weather for each period, as apart from differences of temperature, the conditions remained the same the whole time with the exception of about ten days at the beginning of April when the weather was rather cloudy.

TEMPERATURE AT TAIARA, JANUARY TO APRIL, 1909

Period	Max.	Min.	Average Max.	Average Min.
January 2 to January 19	97·5° F.	45° F.	86° F.	54° F.
January 20 to February 3	96·5° F.	51° F.	90° F.	58° F.
February 4 to February 17	103° F.	48·5° F.	94° F.	60° F.
February 18 to March 4	104·5° F.	57·5° F.	96° F.	63° F.
March 5 to March 19	110° F.	59° F.	102° F.	64° F.
March 20 to April 4	109° F.	63° F.	104° F.	71° F.
April 5 to April 22	109° F.	65·5° F.	106° F.	71° F.

There was thus a gradual but regular increase in the temperature during these four months, but in spite of this the amount of gum produced declined nearly as steadily. The explanation of this lies probably in the fact that there was a continuous decrease in the amount of sap available for the production of gum.

Dr. Beam has mentioned the fact that the natives are first of all agriculturists, and therefore do not trouble to tap their gum trees until they have secured their crops. If these trees described above be taken as a fair average, however, it would probably pay the owners of gum gardens to take the trouble of tapping them as soon as possible after the rains, an operation which need not take up very much of their time, and in that way it is reasonable to suppose that a considerably larger amount of gum per tree would be obtained, while the money value of the gum from an acre of well stocked gum garden would well repay any extra labour spent in clearing the ground or sowing seed where necessary. The question of increasing the amount of gum produced in a district is comparatively simple, as the factors on which the yield of gum depends are to a considerable extent under control, such as increasing the number of trees and removing those which are too old to produce gum. In view of this it becomes a much more important point to be able to increase the proportion of hard, strong gum which fetches a much higher price than that of lower grades. Unfortunately, the factors which underlie the production of this hard gum are but little understood. Dr. Beam has made a special study of this problem, but failed to find any of this hard, strong gum in a series of collections made in several gardens at Taiara. This may have been due to lack of favourable conditions of temperature and rainfall, wrong season of tapping, or other causes mentioned by Dr. Beam in his article on this subject in the Third Report of these Laboratories. I examined the gum from these two sets of trees above-mentioned, but also failed to find any of this strong gum.

Desirability of producing a hard and strong gum

The following table shows the viscosity and acidity of the gum from the two sets of trees, so far as determined:

GUM FROM SMALL TREES

Date of Testing			Viscosity of 20 % solution (grammes of sugar in 100 c.c.)	Acidity (milligrammes of KOH)
1st collection,		January 21	62·1	2·58
2nd	,,	January 30	61·4	2·98
3rd	,,	February 14	66·7	2·80
4th	,,	February 26	65·3	3·17
5th	,,	March 18	62·5	2·60
6th	,,	April 2	61·6	2·95

GUM FROM LARGE TREES

Date of Testing			Viscosity of 20 % solution (grammes of sugar in 100 c.c.)	Acidity (milligrammes of KOH)
1st collection,		January 21	61·5	2·24
2nd	,,	January 30	61·7	2·60
3rd	,,	February 16	65·8	2·58
4th	,,	February 28	62·3	2·80
5th	,,	March 18	61·8	2·43
6th	,,	April 2	62·4	2·64

An attempt was made at first to test the samples immediately after collection, but the tears of gum were then so tough that they could not be pounded up, and consequently it was not possible to obtain a fair sample. The mixed gum from each collection was therefore allowed to dry in the air for several weeks, and a fair sample of sufficient size taken for examination as soon as it was found to be dry enough to powder. The

Technique for determination of acidity and viscosity

gum then usually contained about 10 per cent. of moisture. The acidity was determined by titrating a weighed amount (about 3 grammes) with decinormal sodium hydrate, using phenol-phthalein as an indicator. The results are expressed as milligrammes of potassium hydrate required to neutralise one gramme of gum. The acidity was always a little higher in the case of the gum from the small trees, but this is unimportant.

The viscosity was determined by using Ostwald's viscosimeter as described by Dr. Beam in the Third Report of these Laboratories. The solutions used contained 20 grammes of dry gum in 100 c.c., allowance being made for the percentage of moisture in the particular sample under examination. The determinations of viscosity were made at 32 C., and the results are expressed in terms of the amount of pure cane-sugar in 100 c.c. required to give the same viscosity. The gum of the third collection from the 20 small trees was slightly ropy when first tested, but in the course of another month it had become completely soluble. All the other samples tested gave a homogeneous solution. The gum in all cases compared favourably with good commercial samples, giving an almost white powder, and a 20 per cent. solution had usually a very pale straw colour.

As a rule, the gum from the small trees had a higher viscosity than that of the same collection from the large trees, but this was not invariably the case. I tested the gum of the earlier collections at intervals during the season, and found a gradual falling off in the viscosity, this being most marked in the gums of the third and fourth collections. On being kept in the sun for a short time a large proportion of all the gum took on the "bleached" appearance of the commercial grade of gum which is exposed to the sun in large quantities at Omdurman. As Dr. Beam has previously remarked, this is not a real bleaching, the appearance being due to the presence of a very large number of minute cracks and fissures on the surface of the tears. This does not occur in the case of the hard, strong gum of high viscosity. Dr. Beam mentioned in his last report that this strong high-grade gum was said to occur more in the collections made very early in the season, about November or December. In the year 1908, however, there was no gum brought into Taiara in the former month, and only a small quantity in December. I was given to understand also that this was the usual condition of affairs there. It may be that in other districts of Kordofan the collection of gum begins at an earlier date, and Dr. Beam, I believe, arranged for a series of collections to be made in different parts with a view to determining whether the presence of hard, strong gum depended on local conditions, such as soil, height and water level in the ground, etc.

"Bleached" appearance due to cracks and fissures of surface

The Effects of Treatment of *Hashab* Trees on the Yield of Gum

In the *Third Report of the Wellcome Tropical Research Laboratories, Khartoum, page* 422, Dr. Beam gives the results of experiments carried out by him in which he tried the effect of rubbing a moist rag over the bark and then into a cut which was made in the tree instead of the bark being removed. This was done in view of Greig Smith's work on the production of gum by bacteria, the object being to facilitate the entrance of the bacteria to the wound. The result was a complete surprise, however, the yield of gum being considerably less in the case of the trees thus treated than in the control trees. Dr. Beam concluded from this that the rubbing had washed away much of the sap containing the bacteria and therefore rendered infection less complete. This would probably be the effect of such treatment in those cases where only a few bacteria were already present in the tree, and in other cases, as Dr. Beam has also pointed out, the effect would be to wash away the sweet sap, after which there would be less attraction for the ants and flies which carry the infection. At the same time it must be remembered that trees vary enormously

Paradoxical result of attempts to infect the site of tapping in their yield of gum under ordinary circumstances, even though to all appearance they are under similar conditions of health and size, and though they are sufficiently infected to produce a considerable quantity of gum.

With a view to supplementing Dr. Beam's experiments in this direction I treated a number of trees both before and after tapping with a number of solutions, and observed the effect of this on the exudation of gum. The trees chosen for this purpose were young trees never previously tapped, in the garden already described. They were nearly uniform in size, neither the smallest nor the largest being used. To make the results more comparable also, the trees were not tapped heavily, as would be the case if a large yield of gum was desired, but a strip of bark about 30 inches long by an inch and a half wide was removed in each case.

Experiments with antiseptics

It was thought that treatment of the wound with strong antiseptics such as formalin and mercuric chloride would, by killing the bacteria, prevent the exudation of gum. At Dr. Beam's suggestion I also treated the bark of a number of trees with the same solutions before tapping, with a view to finding whether killing the bacteria on the outside of, or near the surface of, the bark would have the effect of preventing the formation of any gum.

Method of Treatment	Dec. 28 1908	Jan. 22 1909	Feb. 13	March 6	March 22	April 13	Total
Control trees ..	57	83	156	118	95	62	571
Bark treated—							
(*a*) with 10% Formalin	72	106	139	142	121	78	658
(*b*) with 1% Mercuric Chloride	65	98	117	108	84	91	563
(*c*) 5% Potassium Carbonate...	69	102	97	123	128	82	601
(*d*) 5% Acetic Acid ..	58	72	165	127	111	74	607
Wound treated—							
(*a*) 10% Formalin ...	107	218	341	345	293	187	1491
(*b*) 1% Mercuric Chloride ...	41	52	38	31	44	23	229
(*c*) 3% Hydrochloric Acid	112	153	237	228	265	140	1135
(*d*) 5% Acetic Acid	76	95	130	132	147	86	666
(*e*) 5% Potassium Carbonate	93	116	147	153	101	89	699
(*f*) 3% Cane-sugar .	84	73	109	127	96	114	603

In testing the effect of each solution used, six trees were employed. In those cases where the tree was to receive preliminary treatment, the bark where tapping was to take place was thoroughly rubbed with cotton wool saturated with the solution used, on each of the three days preceding the tapping. In the other cases the wounded surface was rubbed with the solution immediately before tapping and also on the two succeeding days. It was hoped that the whole wound would thus be thoroughly impregnated with the substance in question.

The trees of which the bark had previously been treated were tapped on November 19 and the others on the next day, the temperature on both of these days being about the same, and not too low.

The principal results of these experiments are shown in the table on the previous page, the dates being those on which the different collections of gum were made, while the figures represent the total yield of gum (in grammes) from the set of six trees in each case.

The control trees were not treated in any way either before or after tapping. The formalin solution was made by diluting one volume of "Formalin" (40 per cent.) with three volumes of water. The hydrochloric acid contained one volume of the strong acid to ten of water. The sugar solution was used as it was thought that the bacteria might increase in number much faster if the wounded branch was treated with a suitable medium for their growth.

Increase of sap as response to irritation

The first effect noticed was that exudation of gum began much more quickly from the trees which had been treated after tapping. This is probably due to the fact that these solutions acted as irritants, causing an increased flow of sap to the wounded part. The gum already present in the sap was there exuded within the first week after the trees were tapped, and then the production of gum went on more slowly. The treatment of the bark before tapping cannot be held to have had much effect on the yield of gum. This was probably due to the fact that even strong antiseptics such as formalin and mercuric chloride failed to kill the bacteria in the inner layers of the bark, and they also had little action on the tissues of the tree when merely rubbed on the outside of the bark. The most interesting results are seen in the after-effects of the treatment. Contrary to expectation, the yield of gum was not increased by rubbing the wound with a solution of sugar. There were, most probably, sufficient bacteria in these trees at the beginning of the experiment, or the sap itself was quite suitable as a medium without the addition of any extra constituents. Probably, also, the mere question of sufficient infection has not alone to be considered, as the sap ceases to flow in some trees much sooner than in others, speaking at least from the much longer time which some trees keep their leaves.

Mercuric Chloride proved to inhibit gum-production

It will be noticed that treatment with mercuric chloride almost entirely prevented the further production of gum. This is specially interesting in view of the bacterial origin of gum. When the solution had dried up, the tissues would still remain impregnated with the antiseptic, in consequence of which any bacteria brought to that part would immediately be killed, and would therefore be unable to produce any gum in spite of the lessened resistance of the tissues to bacterial action through wounding Later in the season I tapped a number of trees on two branches, treating one branch only with mercuric chloride. As a result the branches thus treated exuded no more gum, while the control branches kept on doing so. The trees treated with formalin after tapping continued to give a much larger yield of gum than the control trees. In this case, while the formalin would at first kill any bacteria present, this solution would soon entirely evaporate, and fresh bacteria would be brought to the spot in the sap. The increased flow of sap to an injured branch probably continues until the injury is repaired, which would account for the large yield of gum after formalin treatment. This would account for the increase after treatment with hydrochloric acid. The other solutions used would probably have less effect in injuring the branches, and therefore the flow of sap to these parts would not be markedly increased, thus to some extent explaining the fact that the exudation of gum was not greatly affected in those cases.

Formalin leads to an increase

It must be remembered that the explanations given above of the action of formalin, etc., are largely tentative, owing to the difficulty of being certain that all the trees under observation were exactly comparable at first, and that the flow of sap would have been the same in each set of trees under ordinary conditions.

Dr. Beam has dealt fully with the question of the yield of gum when trees are tapped in various ways. At his suggestion I tapped several by making a series of cuts with an axe, these cuts being arranged spirally around the tree from the ground upwards, and also along the branches. Only a piece of bark about eight inches long by an inch and a half wide was removed. These trees, however, did not exude any more gum than a similar set tapped in the ordinary way at the same time.

Production of Gum by Bacteria

As mentioned in the *Third Report of the Wellcome Tropical Research Laboratories, Khartoum*, the question of the bacterial origin of gums was first investigated by Greig Smith in Australia. I described briefly in that Report a few experiments carried out in Khartoum with a view to confirming Greig Smith's conclusions in the case of *Hashab* gum. Being unable, in the time at my disposal in Khartoum, however, to reach conclusive results, I took the opportunity of pursuing the matter further at Taiara. The procedure was the same as already described, twigs from which gum was exuding being passed through the flame in order to kill any bacteria accidentally adhering to the outside of the bark, and from these cultures were made in tubes of glucose gelatine. After about 24 hours' cultivation at 37° C. the growths were plated on media containing cane-sugar, asparagin, potassium citrate and agar. No potato extract was used in these media, as was done in the earlier experiments. A large number of twigs was treated in this manner at different times of the season, and in every case the predominant bacterium showed the same habit of growth and the bipolar staining of the bacterium which I had already isolated in my experiments in Khartoum. In a number of cases, particularly where the gum had been exuding from a small puncture in the bark only, the original plate culture showed this bacterium with no contamination, while in the other cases, by sub-cultivation on the same medium, a pure culture was readily obtained. From these and my previous experiments, it seems justifiable to assume that this bacterium is always present in gum-bearing branches of *hashab* trees. I also succeeded in isolating it free from contamination from branches showing no wound, and from which no gum was exuding. It seems improbable, however, that any trees in a gum-producing district are absolutely free from gum, as it was noticed especially towards the latter half of the season that nearly all the trees, even those which had never been tapped, were exuding a small amount of gum. This was very often in the form of thin rods or spirals of gum, and an examination of the spot showed the presence of a slight wound, caused in many cases by the accidental breaking of a small twig, or again, by the borings of small beetles or other insects. With respect to this latter point it may again be stated that Zimmermann connects the formation of gum in the case of *Acacia decurrens* with the borings of Ambrosia beetles, mentioning also that in all cases of gum production the essential point is, in the first place, some injury to the tree.

Bacteriological technique, and discovery of the probable bacterial cause

On tapping the trees in the early part of the season I noticed that within a few hours a large number of ants were usually to be seen swarming over the wounded surface of the branches, attracted, no doubt, by the sweetness of the sap. Dr. Beam also called my attention to the fact that he had observed the presence of large numbers of ants after tapping some trees in connection with a series of experiments carried out by him up the Blue Nile. Besides the ants, flies of several kinds were observed on the wounded surfaces soon after the trees had been tapped.

Presence of ants when trees have been tapped, and their possible rôle as carriers

These facts at once suggested a means by which this particular bacterium might readily be transmitted from one tree which had been tapped to another, or, indeed, a wound of any kind might serve as a point from which ants or other insects could pick up infection, or on the other hand bacteria conveyed by insects to a wounded surface could readily obtain a hold in the tissues of the tree at that point. It was important, therefore, to

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find whether such an infection was thus capable of being conveyed from tree to tree under ordinary circumstances. Some flies were caught after being seen apparently feeding on the recently tapped surface of a branch. These were killed and introduced into sterile test-tubes, a few c.c. of sterile water being then added. After being left thus for a few hours, a loopful of the water was introduced into sterile tubes of gelatine media containing sugar. These were then cultivated at 37° C. for a day. In some cases the flies were put direct into the tubes of gelatine. In all cases, cultures were made from the gelatine on plates of saccharose agar, as was done with the gum-bearing branches. Among the colonies obtained from the flies in this way was a number showing the same appearance as those produced by the bipolar staining organism already isolated. A further examination of these colonies revealed the presence of this organism, which showed all the properties of that obtained from the twigs. An examination of some ants obtained from tapped branches also showed the presence of this bacterium. The method of transmission from tree to tree is probably simply mechanical, the legs and wings of the insects picking up small quantities of sap containing the organisms, some of which are conveyed to the exposed surface of the next branch on which the insect alights.

Recovery of implicated organism from flies and ants

Having proved the invariable presence of these bacteria in gum-bearing branches, and having also found a ready means for their transmission from one tree to another, the question of the production of gum from the sap of the tree by these organisms had next to be investigated. The best way to do this seemed at first sight to be by growing the organisms in the sterilised sap of the *hashâb* tree itself. It was found impracticable to obtain this in any quantity by pressure, so the following method was adopted. One or two young trees from which no gum was exuding were cut down and the branches chopped into lengths of about two inches. These pieces were bruised, put in a steriliser with water, and boiled for a short time. The water was then poured off and the extraction repeated, the two extracts being mixed and concentrated. The resulting liquid represented a somewhat diluted sap, but on filtering off the dirt, bark, etc., it was found also to contain a considerable quantity of gum. This liquid was therefore unsuitable as a medium for testing the gum-producing powers of the bacteria, as it would have been very difficult with the means at my disposal to estimate with any degree of accuracy the proportion of gum present before and after the experiment. An artificial medium was therefore used, which had been found suitable for the cultivation of the bacteria in tubes and on plates. This contained 4 per cent. levulose, 1 per cent. glycerine, 0·1 per cent. asparagin, and 0·1 per cent. potassium citrate in water. I preferred using a liquid medium to a solid one containing agar in addition to these constituents, as in the latter case there is a danger of some agar getting scraped off when removing the slime produced by the bacteria, and this may give, on hydrolysis, products resembling those derived from gum.

Production of a gum-like substance "in vitro" by action of bacteria

The above medium, after being sterilised, was inoculated from a pure culture of the bacterium and kept at 37° C. for about a month. The growth was then stopped by heating the flask in the steriliser for half-an-hour. The liquid was then concentrated to half its original volume over a small flame, a few drops of dilute sulphuric acid being added towards the end in order to precipitate any substances of a protein nature which might have been formed by the bacteria. The liquid was then filtered, and to the clear filtrate, on cooling, was added three times its volume of alcohol. The whole was well stirred up and allowed to settle, after which the supernatant liquid was poured off, the remainder being filtered and the precipitate washed with 75 per cent. alcohol. This precipitate was redissolved in a little water, brought down again with a large excess of alcohol, filtered off, washed with alcohol and dried.

Properties of the gum-like bacterial product

The final product was nearly white and resembled gum in appearance. From the method of its separation described above it will be seen that this substance also resembled gum in being soluble in water and insoluble in 75 per cent. alcohol. Levulose is readily soluble even in alcohol of a much higher strength, and any of this sugar which had been unchanged by the bacteria would remain in solution when the product of bacterial action was precipitated at first. The same is true of the other constituents of the original medium, and, in addition to this, the amount of asparagin and potassium citrate used was so small that the new substance could only be accounted for by having been derived from the levulose, and perhaps to some extent from the glycerine, any products of a protein nature being removed in the treatment of the original solution with acid and afterwards with alcohol.

The bacterial product did not reduce Fehling's solution, but on boiling a solution of the former in five per cent. sulphuric acid for twenty minutes and then neutralising this, a good reduction took place, showing another point of resemblance between this bacterial product and the gums exuded from tapped trees. Some of the ordinary gum tests were also tried, such as coagulation with basic lead acetate and ferric chloride, and these gave positive results. From the examination of this bacterial substance, therefore, we must assume that these bacteria, when grown in an artificial medium of suitable composition, produce, among other things, a substance of the same nature as the gum of the tree from which they have originally been isolated. The formation of gum from the sugars of the sap is thus, as Greig Smith pointed out, the result of pathological conditions. In the first place, exudation of gum does not take place from *Hasháb* trees in those districts where the rainfall is high compared with that met with in the gum-producing districts of Kordofan. In the latter case the tree as a whole is in a state of reduced vitality, and the tissues are therefore more susceptible to the effects of abnormal injuries. In those districts where the proportion of moisture in the soil is relatively high, the injury produced when the tree is tapped is repaired before the bacteria present have time to produce any appreciable amount of gum. The wounding of the tree through tapping causes a local weakness in the tissues next to the bark, and the cells of the tree are then unable to prevent the rapid increase of, and increased transformation of the sap by, the bacteria. This appears to go on until sufficient new bark has grown over the wound to form a protection for the exposed surface. In the case of a tree which was quite free from bacteria, it has already been shown how infection can readily be carried by means of ants or flies.

Effect of mechanical injury to the trees

Since my return from Taiara, I have confirmed my work there, both in obtaining pure cultures of this bacterium from gum-bearing branches of *hasháb* trees, and also in producing a substance of the nature of a gum by cultivating the bacteria on artificial media containing sugar as the principal constituent. I regret, however, that I have been unable up to the present to investigate the properties of these bacteria at all fully. They grow equally well on glucose and levulose media, but not so well on maltose and other sugars, and they do not appear to form a very adhesive slime. Greig Smith found his bacteria to produce slime more readily in presence of tannin, but the *hasháb* bacteria do not grow at all well in media containing tannin.

Acting on a suggestion made by Dr. Beam, I obtained, through the kindness of Mr. Tippetts, Inspector at Taiara, some gum-bearing branches of *talh* trees from Sherkeila, and made cultures from small portions of these in the manner already described. It is of great interest to note that by far the largest number of colonies obtained in this case also were those of the same bipolar bacteria isolated from *hasháb* branches. In this connection it is well to recall the fact that Greig Smith

Isolation of the characteristic bacteria from *Talh* trees states that the bacteria found responsible for gum-flux in *Acacia binervata* also caused production of gum (of a different kind) when made to infect peach trees. In other instances, also, he found that one species of bacterium could produce gum in the tissues of different species of trees.

In cases of this kind the differences in the chemical nature of the gums are probably due to the presence of different sugars or other constituents in the sap of the various trees.

In concluding this report, I wish again to express my thanks to Dr. Balfour and Dr. Beam for suggestions and advice which they have kindly given me in connection with my work.

Preliminary Notes on the Chemistry of the Latex of *Calotropis procera*

BY

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This investigation was undertaken, primarily, with the object of discovering a test which could be relied on in cases of suspected poisoning. *Calotropis procera*, a shrub belonging to the Nat. Ord. *Asclepiadaceæ*, is a common weed throughout the Sudan, and under the name of "ushar" is well known to the natives as a poisonous plant. When wounded, all parts of the plant exude considerable quantities of an acrid milky juice, possessing a nauseating odour, in some degree reminiscent of rhubarb. The leaves are used in the preparation of "merissa," the native beer, and it is possible that the presence of an excessive quantity, whether there by criminal intent or not, might account for cases of apparent poisoning, which had been investigated in these laboratories with negative results. In India, under the popular name of "madar," or "ákh," *Calotropis procera* has long been famous as a remedy in a variety of ailments, the milky juice, root-bark, and flowers being in use. A detailed description of the plant and its medicinal uses is to be found in the *Pharmacographia Indica*, Vol. II., *pages* 428–437. The attached photographs (Figs. 9 and 10) give a good idea of the plant, the first showing leaf, flower and seed-pod, and the second the entire plant.

Previous work on the subject

While considerable work has been done on the chemistry of the root bark,[1] the literature at my disposal records no similar examination of the latex, nor has communication with several sources revealed that any such examination has been made. In this connection, one is greatly indebted to Dr. Power and Mr. C. J. S. Thompson of the Wellcome Chemical Research Laboratories, London, for their kindness in furnishing valuable extracts of the literature on the subject.

So long ago as 1867, in consequence of the numerous cases of infanticide by the milky juice, Dr. McReddie, Medical Officer of Hurdur, India, suggested that an investigation should be made with a view to the detection of this poison by chemical analysis, but no record that his suggestion was acted on is to hand.

Dr. Duncan[2] (1829) made a chemical examination of the root-bark, and concluded that its medicinal activity was due to an extractive matter which he termed "*mudarine*." The authors of the *Pharmacographia Indica*,[3] repeating the work of Duncan, failed to obtain anything corresponding to his *mudarine*, but, instead, an acrid resin, with which was associated a bitter principle, probably the active constituent of the plant. Drs. Warden and Waddel,[4] after a lengthy research, concluded that a yellow, bitter resin, occurring to the extent of 0·093 per cent., was the active principle.

The resins and bitter principle described by these various investigators being in all probability derived from the dried latex present in the root-bark, a thorough examination of

[1] *Pharmacographia Indica*, Vol. II., pp. 428–437

[2] Duncan, *Edinburgh Medical and Surgical Journal*, 1829, XXXII., 65

[3] *Pharmacographia Indica*, Vol. II., pp. 428–437

[4] Warden and Waddel, *Pharmaceutical Journal*, 1885, pp. 165–170

the latex itself may be expected to furnish valuable evidence as to the precise nature of the toxic principles of the plant. It is worthy of note that experiments carried out in India[1] indicate that, while the fresh leaves are extremely acrid, producing severe vomiting accompanied by much pain and distress, the cooked leaves are innocuous, and the writer has observed goats and sheep eating withered parts of the plant, while the natives affirm that they will not touch the fresh plant.

Uses of the juice for making an intoxicating liquor

The milky juice of *C. procera* is undoubtedly used in the preparation of an intoxicating liquor, both in India and in Central Africa, but it is impossible to gather whether the juice itself is directly fermented or is simply used as a ferment or bitter. Sir G. Birdwood (*Bomb. Prod.*, 208) says, "the intoxicating liquor *bar* is prepared from it by the tribes of the Western Ghâts," and Lisboa, in *Useful Plants of Bombay*, asserts that the tribes of Central Africa prepare from it their *giya*.

A Colour Reaction for the Latex of Calotropis Procera

When the latex is diluted with four volumes of water, and a few drops of acetic acid added, and the liquid boiled, coagulation readily takes place, and by straining off the coagulated gutta-percha and filtering, a clear, pale yellow liquid, of decidedly acid reaction to litmus, is obtained. To this liquid, and to the residue left on its evaporation, were applied the customary reagents giving colour reactions. Those having strong sulphuric acid as a basis—Erdmann's, Frohde's, Buckingham's, Mandelin's, etc.—were found to give, with the liquid, green to blue colorations; of the many others tried, none gave any reaction worthy of note. When sulphuric acid, diluted with one half its volume of water to prevent charring, is carefully added to the liquid, a greenish-blue ring is formed, and, on carefully mixing the liquids, a bluish-green solution results. The addition of traces of oxidising agents causes a change of colour to a deep Prussian blue. Ferric chloride has been found the most suitable oxidiser, the blue colour produced in its presence being comparatively stable, lasting for two or three hours, and then changing slowly to a dark brownish-purple. The more energetic action of such oxidisers as hydrogen peroxide, nitric acid, chromic acid, and sodium persulphate, even when these are present only in minute traces, results in a quick change of the blue colour to dark green, then greenish-brown and finally deep yellow. In the presence of nitrates the blue colour rapidly changes, owing to the formation of nitric acid, while the presence of nitrites prevents its production, the deep yellow colour being at once developed.

Details of the reaction

The reagent found to give the most satisfactory results is prepared by diluting sulphuric acid with one half its volume of water, and adding sufficient ferric chloride to impart a faint yellow colour to the liquid. A mere trace of ferric chloride is not sufficient to develop the blue colour; on the other hand, excess is to be avoided, as any marked yellow colour of the reagent would interfere. The reagent is added carefully in equal volume to the liquid to be tested; a deep blue ring forms at the junction of the liquids, and, on mixing, a deep Prussian blue colour is developed. A decided blue colour is given by the reagent to 1 c.c. of a liquid containing one part of latex in 250 parts. Sulphuric acid alone gives no coloration when added to a latex solution of this strength, but the subsequent addition of a drop of ferric chloride solution brings up the blue colour.

The substance which gives rise to the blue colour on the addition of sulphuric acid and an oxidising agent, appears to be present in the latex in very minute quantity, and has not yet been isolated. The following facts regarding its properties have, however,

[1] Harvey, *Report on Medico-legal Returns, Bengal Presidency*, 1870–1872.

Fi... *Calotrop...* ...a HOWING LEAF FLOWER AND SEED-POD

FIG. 10. *Calotropis procera* SHOWIN... ENTIRE PLAN...

been established. It is not removed from its solution by ether, chloroform, or petroleum-ether, but is completely precipitated by basic lead acetate in the presence of ammonia, the lead salt being soluble in excess of lead acetate.[1] Neutral lead acetate, in the presence of acetic acid, does not precipitate the substance, nor does basic lead acetate when added to a solution faintly acid with acetic acid (the free acetic acid is, of course, neutralised by a portion of the basic lead acetate). After reduction with zinc and sulphuric acid, its solution gives no coloration with sulphuric acid; on reoxidation, the blue colour is produced. The substance may be removed from its solution by boiling with animal charcoal, and is dialysable.

Application of the test in cases of suspected poisoning

As regards the application of the test to cases of suspected poisoning, it is, of course, essential that a solution of the latex free from substances which would give colorations with the reagent, and so obscure the reaction, be obtained. Several experiments have been carried out, which have led to the adoption of the following method. The stomach contents, and, where emesis has occurred, the vomit, are digested in water slightly acidulated with acetic acid. To the strained liquid is added slight excess of neutral lead acetate, to precipitate albuminous matter, and the liquid filtered. The filtrate is carefully treated with basic lead acetate until no further precipitation results, and, after filtration, the liquid is made distinctly ammoniacal. The resultant precipitate is filtered off, carefully washed, and decomposed with dilute sulphuric acid. The liquid is filtered from lead sulphate, and the reagent applied to the filtrate, which may be concentrated if necessary.

Experiments have shown that, by following this method, 0·5 c.c. of the latex may be readily detected when mixed with stomach contents. In most cases it will be found that the treatment with basic lead acetate and ammonia may be omitted, and the reagent applied direct to the filtrate from the neutral lead acetate, after freeing it from lead by the addition of dilute sulphuric acid. In cases where the volume of liquid to be tested is considerable, the treatment with ammoniacal basic lead acetate is advisable, since concentration of the liquid is thereby rendered unnecessary, the resultant precipitate being decomposed by the addition of a small volume of dilute sulphuric acid. The addition of the latex to *merissa* (the native beer made from millet) is easily demonstrated by applying the reagent direct to the filtered liquid. Should the latter be coloured, the preliminary treatment with lead acetate, indicated above, would be necessary.

Addition of latex to native beer is easily detected by the reagent

Latex, which has been thoroughly dried by exposure in an open vessel, is found to respond to the test after digestion with water. The concentration of dilute latex solutions by boiling does not affect the production of the blue colour by the reagent, nor does digestion of the latex with pepsin and dilute hydrochloric acid.

The action of the stomach juices on the latex being of primary importance as regards the value of the test in cases of suspected poisoning, the following experiment was carried out. An artificial gastric juice was prepared by digesting the fresh stomach of a sheep in water, and adding to the strained liquid sufficient hydrochloric acid to give it an acidity of 0·2 per cent. hydrochloric acid. To 100 c.c. of this liquid was added 10 c.c. latex, and the liquid incubated at 37° C. Portions of 25 c.c. each were removed at intervals of 24 hours and the test applied. The treatment with lead acetate, etc., previously described, was employed, a control test being applied to the gastric juice itself. From the liquid, to which latex had been added, positive reactions were obtained in each case, while the gastric juice itself gave no coloration with the reagent.

[1] When this lead compound [cf. Table A, seq.] is decomposed by sulphuretted hydrogen or dilute sulphuric acid, a strong solution of the colourable substance of the latex, to which test reagents may be advantageously applied, is obtained.

The possibility that plant juices, other than those of *C. procera*, may give a similar reaction, has not been overlooked, and special attention has been devoted to the examination of foodstuffs in common use among the natives, and which might, therefore, be present in the stomach contents of suspected cases. The test has been applied to between twenty and thirty varieties of *dura*, which is the staple food in the Sudan, and to as many common vegetables and fruits. The foodstuffs were crushed, macerated for several hours in 0·2 per cent. hydrochloric acid, and the reagent added to the strained and filtered liquids. The pale-coloured varieties of *dura* gave no ring or coloration on shaking. In the case of the red varieties, however, a pink ring was developed, and a deep crimson solution obtained on shaking. A strong extract of a red variety of *dura*, to which a small amount of latex had been added, gave with the reagent a purple coloration, as was to be expected. Further examination of the *dura* extract showed that the red colouring matter is entirely removed by basic lead acetate when added to a faintly acid solution. Since the colourable substance of the latex is not so precipitated, the presence of red *dura* in no way interferes with the test, as several trials on red *dura* extracts to which small quantities of latex had been added, have proved.

Examination of foodstuffs to exclude possibility of confusion

Of the other foodstuffs examined, none was found to give the deep Prussian blue colour produced by the latex. The majority gave pale yellow or greenish-yellow rings, and pale yellow colorations on shaking. Two, the cucumber and sweet potato (Arabic, *bambé*) give pale blue rings, and pale blue colorations. The pumpkin (Arabic, *gara*) gives a purplish-blue colour, and the vegetable marrow a yellowish-green. This latter colour was found to mask the colour given by the latex when the reagent was added to a mixture of a very small quantity of latex and a large quantity of vegetable marrow, a green tint being imparted to the blue. With the latex in larger proportion, the green tint was not seen.

The foodstuff extracts were also treated with lead acetate, etc., as previously described (*vide page* 88), and the reagent applied to the decomposed ammoniacal basic lead acetate precipitates. Some differences in the colour reactions given were observed. The cucumber gave a pale blue colour, which changed slowly to pale pink, and the pale blue colour given by the sweet potato was rapidly discharged. The vegetable marrow gave no ring or immediate coloration, but a strawberry-pink colour developed on standing. The pumpkin gave a pale heliotrope colour, becoming more pronounced, and then fading. In all cases the colour faded comparatively quickly; a solution of latex similarly treated gives a Prussian blue colour, which does not fade until after some considerable time. In carrying out these tests the liquids were not cooled after shaking, and the fading of the colours in the case of the vegetables may be due to the heat developed. It is worthy of note, however, that the blue colour of the latex does not readily fade under these conditions.

It is to be borne in mind that the degree of dilution of the latex, when no interfering body is present, determines whether the blue coloration can be correctly described as Prussian blue. Dilutions of 1 in 5 to 1 in 25 give an unmistakable Prussian blue, 1 in 50 gives a pale Prussian blue, while 1 in 250 gives what could be described as a pale blue, although of exactly the same tint as a much diluted solution of Prussian blue.

Effects of dilution on the Prussian blue coloration

The depth, purity and permanence of the blue colour given by the latex are quite distinctive, but a confirmatory reaction has been discovered which eliminates any risk of mistaking these foodstuff colours for the colour of the latex, and also enables the latex to be detected with certainty when mixed with these foodstuffs.

A very striking colour-reaction, which, so far as is at present known, is characteristic of the latex, is given by sulphuric acid containing a trace of formaldehyde. The reagent found to give the best results consists of a mixture of 75 c.c. concentrated sulphuric acid and 25 c.c. water, to which is added a drop of 40 per cent. formaldehyde solution. When this reagent is added (not too carefully, so as to allow slight mixing) to the coagulated latex, or to the decomposed ammoniacal basic lead acetate precipitate (d) Table A, a grass-green ring or band is developed. Almost immediately a strawberry-pink band begins to form below the green, gradually deepening, and, after allowing to stand for a short time, super-imposed bands of colour are seen in the following order, from below upwards: pale strawberry-pink, deep strawberry-pink, purple (narrow ring), grass-green, chrome-yellow. On now cooling in ice, and carefully shaking, a bright olive-green solution, of decided depth and permanence of colour, is obtained.

A confirmatory test

This reagent has been applied to the four foodstuffs, which give colorations with the sulphuric acid reagent simulating in some degree the blue colour given by the latex. Both strong water extracts, and similar extracts treated with lead acetate, etc. (*vide* Table A seq.) were tested, and in no single case was any coloration produced. The formalin-sulphuric acid reagent thus furnishes a certain means of distinguishing the latex from these foodstuffs, and of detecting it in their presence.

The application of this reagent as a test is being extended to other foodstuffs.

The solution of the colour-yielding substance of the latex obtained by decomposing the ammoniacal basic lead acetate precipitate with sulphuric acid (*vide* footnote, *page* 88) has also been submitted to the action of reagents in the following manner. After making faintly alkaline with ammonia, small portions were evaporated on crucible lids to dryness. To the dried residues were added a number of the customary colour reagents; the most striking colour reactions obtained are given below.

(*a*) Sulphuric acid: yellow, changing to orange and finally to rose-pink.

(*b*) Frohde's reagent: bright greenish-blue, changing at once to grass-green, then slowly to mahogany-brown and finally olive-green.

(*c*) Sulphuric acid and ferric chloride: electric blue, changing at once to green then brown and finally dark olive-green.

(*d*) Sulphuric acid and trace of formalin: purplish, then rose-pink.

Speaking generally, sulphuric acid with oxidising agents gives blue and green colours, while, with reducing agents, sulphuric acid develops yellow and pink colorations.

Analysis of the latex

The latex of *C. procera* is distinctly acid in reaction; the acidity to phenol-phthalein of eight samples, expressed in terms of acetic acid, was found to vary from 0·13 gramme to 0·23 gramme per 100 c.c. One sample, collected from several plants, showed an acidity of 0·46 per cent. These differences are probably due to the age of the plants. Steam distillation of the latex showed this acidity to be fixed.

A sample of latex, collected from several plants, gave the following figures on analysis:

Acidity, as acetic acid	0·15 gramme per 100 c.c.
Total solid matter	13·0 per cent.
Ash	2·4 per cent.

The ash consisted chiefly of magnesium, calcium, sulphates, and phosphates, and was distinctly alkaline. The magnesium was present in far larger quantity than the calcium.

Exhaustion of the latex, by Adam's fat-extraction method, with alcohol, petroleum-ether, and acetone in succession, yielded a considerable extract to the alcohol, and comparatively little to petroleum-ether and acetone. The petroleum-ether extract was varnish-like, almost colourless, and acrid in taste. The alcoholic extract was only partly soluble in cold water, but soluble in hot. This solution gives a deep blue colour with the diluted sulphuric acid reagent. If water be added to the alcoholic solution previous to evaporation of the alcohol, a bright yellow, acrid resin is obtained.

On reducing the coagulated latex with zinc dust and acetic acid, a liquid is obtained, which, after removal of the zinc by sulphuretted hydrogen, gives no coloration with sulphuric acid, unless previously reoxidised. Concentration of this liquid leaves an amorphous brownish residue, and a considerable crop of silky needle-like crystals of calcium sulphate. Extraction of the liquid with solvents revealed no organic substance of a crystalline nature.

The following tables give in summary form the results of the experiments carried out to gain some information as to the character of the substance in the latex to which the blue coloration, produced by sulphuric acid and an oxidising agent, is due. From 100 c.c. to 200 c.c. of the latex were taken for each experiment, so that concentrated solutions were obtained. Summary of results.

TABLE A

LATEX

Added 4 volumes of water and a few drops of acetic acid, and heated on the water-bath to coagulation. Strained and filtered.

GUTTA-PERCHA, and associated resinous bodies, etc.	FILTRATE. ‡ Added slight excess of neutral lead acetate, and filtered.			
	HEAVY WHITE PRECIPITATE. Washed well with water and decomposed with dilute sulphuric acid. Solution °	FILTRATE (a).‡ Added slight excess of basic lead acetate, and filtered.		
		PRECIPITATE. Washed well with water and decomposed with dilute sulphuric acid. Solution °	FILTRATE (b).‡ Added excess of ammonia bulky yellowish-white precipitate. Filtered.	
			PRECIPITATE (d). Washed, and decomposed with dilute sulphuric acid. Solution ‡	FILTRATE (e) °

‡ indicates positive reaction with reagent
° ,, negative ,, ,,

TABLE B

LATEX

Added 4 volumes of water, and a few drops of acetic acid, and coagulated. Strained and filtered.

GUTTA-PERCHA, and associated resinous bodies, etc.	FILTRATE.‡ Digested on the water-bath for several hours with animal charcoal, and filtered.	
	CHARCOAL RESIDUE (a). Washed with cold water, dried over sulphuric acid, and extracted thoroughly with absolute alcohol. Alcoholic solution.‡	FILTRATE ° (b).

‡ indicates positive reaction with reagent
° ,, negative ,, ,,

The time at disposal has not permitted of any thorough investigation, but the following observations have been made. The acid liquid [(a) in Table A] left after the removal of the lead salt was treated with ammonia until no further precipitation took place. After filtration, the alkaline liquid was boiled until free from ammonia, and the lead removed by sulphuretted hydrogen. The liquid was freed from sulphuretted hydrogen by a current of air, filtered, and concentrated. This concentrated liquid gave amorphous precipitates with tannic and picric acids, mercuric chloride, iodine, Meyer's reagent, and phosphomolybdic acid, and with basic lead acetate, the latter being soluble in excess. The tannic acid precipitate was soluble on boiling, reappearing when the solution was cooled, a reaction characteristic of the proteids. The examination of this liquid is proceeding.

Further examination

The lead compound [(d) Table A] produced by the addition of ammonia and basic lead acetate to the filtrate from neutral lead acetate was washed, suspended in water, and decomposed by sulphuretted hydrogen. After filtration, and removal of excess sulphuretted hydrogen by a current of air, the solution was concentrated on the water-bath. This concentrated solution gave a deep blue coloration with the sulphuric acid reagent. Attempts to obtain from it anything of a crystalline nature were unsuccessful; on evaporation to dryness a brown amorphous residue was obtained.

The charcoal residue [(a) Table B], previously washed with water, and dried over sulphuric acid, was extracted with absolute alcohol, and the alcoholic solution evaporated to dryness. A small quantity of a brown, gummy, and somewhat resinous residue, acrid to the taste, and only partially soluble in cold water, was left. This was dissolved in hot water, cooled and extracted with ether. The aqueous liquid, which was distinctly acid to litmus, did not reduce Fehling's solution, even after hydrolysis, but gave voluminous precipitates with tannic acid, picric acid, mercuric chloride, iodine, potassium-bismuthic-iodide, and phosphomolybdic acid, and a deep blue colour with the sulphuric acid reagent. The precipitates were amorphous, and the picric acid precipitate was soluble on boiling, re-forming on cooling. The ethereal liquid left a small quantity of a resin-like substance on evaporation.

On making the aqueous liquid alkaline with ammonia and extracting with ether, a white amorphous residue, sparingly soluble in ether, insoluble in cold water, but readily soluble in alcohol and chloroform, was obtained. This substance has not yet been further examined.

The filtrate from the animal charcoal [(b) Table B] was evaporated on the water-bath to a syrupy consistency, and allowed to evaporate slowly over sulphuric acid. A large quantity of crystalline salts was deposited, extremely soluble in water, but insoluble in alcohol. On evaporating the syrupy liquid to dryness, a yellow, crumbly, sugar-like mass remained, which charred on heating in a dry tube, with the formation of an amorphous sublimate, soluble in cold water, and strongly acid to litmus. The charred residue was alkaline, and consisted chiefly of magnesium oxide.

Toxicity of the Latex

Toxicity
Animal experiments

Experiments have been carried out to determine the toxicity of the latex by subcutaneous injection and by feeding. Rabbits were the only animals used in these experiments. With regard to subcutaneous inoculation, one rabbit was inoculated with a quantity of the decomposed ammonium hydrate precipitate [(d) Table A] corresponding to 0·2 c.c. latex. Another rabbit was inoculated with the filtrate from the basic lead acetate precipitate [(e) Table A] corresponding also to 0·2 c.c. latex. A third rabbit received an inoculation corresponding to 0·5 c.c. latex of the filtrate (b) Table B from animal charcoal, while a fourth was inoculated with 0·5 c.c. of the water solution of the alcoholic extract (Table B). In all cases the animals remained quite well, and showed no symptoms of illness.

Feeding experiment

With regard to the feeding experiments, the fresh latex was slowly dropped from a pipette into the mouth of the animal. In the first experiments, doses of 0·05 c.c. and 0·3 c.c. were given, but these produced no effect. Larger doses were then tried, 1 c.c. (2) 1·5 c.c. (1) and 2 c.c. (2) being given. The rabbits receiving the 1 c.c. doses showed no symptoms. One of the rabbits receiving the 2 c.c. quantity showed, almost immediately, paresis of the hind legs and died in 20 minutes. Post mortem examination showed slight congestion of the mucous membrane of the stomach, but no other pathological change. The stomach contents were tested for the presence of the latex, and gave a positive result.

The other rabbit receiving 2 c.c., and the one receiving 1·5 c.c., showed no symptoms during the time they were under observation (viz., six hours) but died during the night. A rabbit receiving 2 c.c. of latex which had been digested in boiling water for half-an-hour also died. Post mortem examination showed no pathological change in the organs; the contents of the intestines were, however, semi-liquid. The stomach contents were tested for the presence of the latex, with a positive result where the 2 c.c. fresh latex had been given, and negative results in the case of the 1·5 c.c. fresh latex and 2 c.c. boiled latex.

A rabbit fed with 2 c.c. of fresh latex, from which the gutta-percha had been removed by coagulation, remained well.

So far as can be judged from the experiments yet carried out, the fresh latex of *C. procera* is toxic to rabbits when given by the mouth in doses greater than 1 c.c. per kilo body-weight. In smaller doses it produces no toxic symptoms whatever.

Conclusions

The fact that 2 c.c. of boiled latex proved toxic, while 2 c.c. of latex from which the gutta-percha had been removed, was non-toxic, indicates that the toxic bodies are in all probability the resins or other bodies associated with the gutta-percha, but further experiments are necessary before any definite conclusions can be arrived at.

I desire to acknowledge my indebtedness to Captain R. G. Archibald, R.A.M.C., and Lieutenant W. E. Marshall, R.A.M.C., for their assistance in the toxicological experiments.

[*Editor's note.*—The continuation of the above research by Dr. Thompson was unfortunately prevented by his illness and retirement from these laboratories. The extent to which the colour tests mentioned may be relied upon in cases of suspected poisoning remains, therefore, to be determined. Attention should especially be called to the fact that the production of a violet colour on the addition of sulphuric acid containing a small amount of iron constitutes Hehner's test for formaldehyde in milk and that the colour described above as "strawberry" is yielded by sulphuric acid, formalin and peptone. The last named is a common constituent of stomach contents so that the possibility of error from this source must be borne in mind. In the presence of proteids and of vegetable matters it may be found that a reaction simulating that of the above confirmatory test might be produced, or again that the colour due to these might mask that of the latex. These points are now under investigation. In any case, the reactions described are useful presumptive indications of the presence of *ushar* latex.]

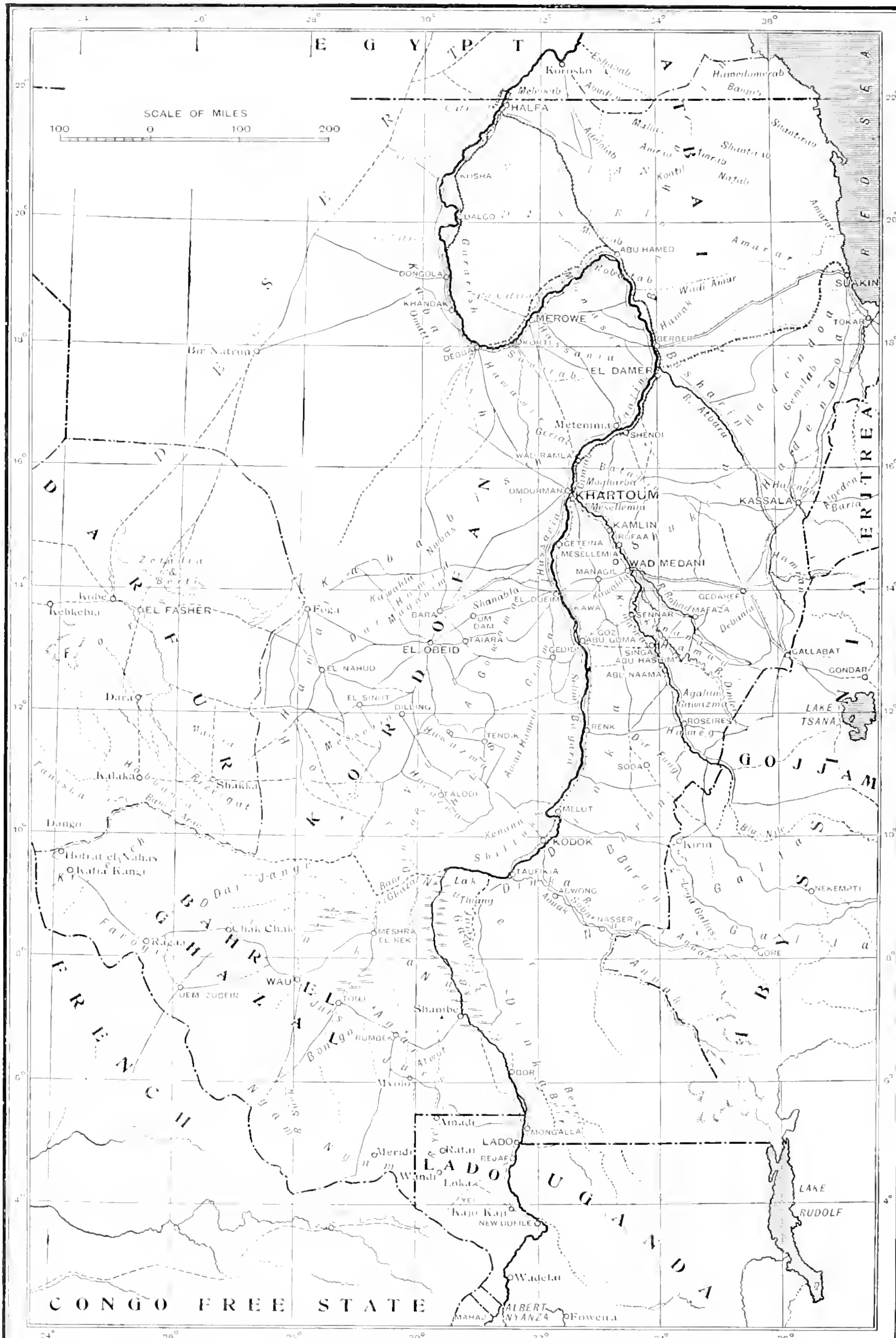

FIG. 11.—MAP OF ANGLO-EGYPTIAN SUDAN

REPORT

OF THE

ENTOMOLOGICAL SECTION

OF THE

WELLCOME TROPICAL RESEARCH LABORATORIES

BY

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Introduction

This report deals with work accomplished since February 14, 1909, on which date I arrived at Halfa on my way back from leave. Thence I proceeded to Zeidab to spend a week in investigating the causes of an outbreak of malaria among the natives on and in the neighbourhood of the estate belonging to the Sudan Plantation Syndicate, Ltd. On April 17, I left Khartoum for Gondokoro, on the s.s. *Culex* with the floating laboratory in tow, and from there worked down stream as carefully as time would permit, collecting blood-sucking insects and ticks and endeavouring to obtain some knowledge of their life histories, arriving in Khartoum on July 19. Eighteen days later, I started for Khor Arbat, Red Sea Province, to obtain living specimens of the fish *Cyprinodon dispar* which it was hoped would prove of value in the control of mosquitoes by devouring their larvæ, and, on September 19, went to Zeidab to place these fish in a gudwal on the estate of the Sudan Plantation Syndicate, Ltd.

On October 19, I proceeded to England on leave, and three days after my return, on January 23, 1910, started for Dongola Province to investigate an attack of cutworms—larvæ of *Agrotis ypsilon*, Rott.—on the basin cultivations at Nuri and Gureir. On my way back, at the end of February, I stopped at Berber in consequence of a plague of "Asal fly"—*Aphis sorghi*, Theob.—on seluka dura, and at El-Damer for the purpose of overhauling the spraying machines, etc., stored there for use against locusts. On February 27, I again went to Berber and from there to Zeidab, and on April 5, started for Khor Arbat to obtain more *Cyprinodon dispar*, returning to Khartoum ten days later.

On April 28, I left for Dongola Province with a view to ascertaining whether it would be possible to lessen the numbers of "Nimitti"—*Simulium griseicollis*, Becker—which render life a burden in the northern half of that Province during the winter months, and was away from Khartoum until May 30. From that date, except for four days spent in Berber in the month of July, I remained in Khartoum until August 25, when I left for England, on leave, to return on November 27. The last month of the year has been spent in writing up this report, in preparing an exhibit of blood-sucking insects and ticks for the International Exhibition of Hygiene held at Dresden in 1911, and in making ready for an expedition to the Bahr-El-Ghazal Province to study the insect pests of that part of the Sudan.[1]

Insect pests on crops

With the exception of "Asal fly" on dura in Berber and Khartoum Provinces, and cutworms on the basin cultivations in Dongola Province, there have been no serious outbreaks of insect pests on crops during the past two years. The dura stem-borer, like the poor, is always with us, and some investigations have been carried out on its life history with a view to finding some simple method of controlling it. It is, undoubtedly, responsible for a considerable loss to native cultivators, but, though many of them realise this, it is difficult to persuade them to persevere in any measure likely to yield good results. The average native appears to be of the opinion that a plague of caterpillars or of some other insect is sent by "Rabonah" and that in all probability "Rabonah" will eventually take it away. In the meantime, he hopes that the Government will grant him a remission of his taxes. The Director, Agriculture and Forests Department, has had translated into Arabic and distributed among native cultivators a paper in which are described the life-cycles of three of the more common insect pests of agriculture—viz., the melon fruit-fly—*Dacus sp.*, the melon plant bug—*Aspongopus viduatus*, Fab., and the cotton stem-boring beetle—*Sphenoptera neglecta*, Klug. It is hoped that by this means the native will be induced to take a more intelligent interest in the foes and friends of his crops.

Of the grant of £E 700, allotted to be spent in the carrying out of trials to ascertain the value of poisons in the control of locusts in this country, just over £E 500 remains, owing to the non-occurrence of locusts in Berber, the province in which it was intended to make the experiments. This has, in one sense, been very disappointing, as it was hoped to demonstrate the value of the methods employed by the South African Locust Bureau and to induce the Governors of Provinces to adopt these methods throughout the districts in which locusts are in the habit of doing damage. However, as the old adage has it, "everything comes to him who waits," and it is improbable that locusts will prove the exception to the rule. "It is an ill wind that blows nobody good" is another proverb which would not be out of place in this connection.

Measures to prevent introduction of injurious insects

The need of some regulation to prevent the introduction of injurious insects on nursery stock imported from other countries was referred to in my last report. A fumigation chamber has now been erected at Halfa, similar to the one at Port Sudan, and an ordinance enforcing the inspection and fumigation of nursery stock, at the port of entry, has recently been published. A copy of this ordinance is appended. The need for such an ordinance was emphasised by the discovery at Darmali of a scale insect—one of the "mussel" scales, but the specimens were too damaged on arrival at Khartoum for determination to be possible—on a young fig tree, recently imported from Egypt. This fig tree has since died from the attacks of *Sinoxylon sudanicum* and the scale insect perished with it, but had this boring beetle not been present the scale insect would undoubtedly have spread to the other fig trees growing in the immediate vicinity.

Perhaps the more important insects in this country are those which, by sucking

[1] Mr. King has lately been employed in mapping out tsetse fly areas in the Lado District of Mongalla Province—A.B.

blood or by other means, are responsible for, or aid in, the spread of diseases among man and animals. A number of species of blood-sucking flies, hitherto unrecorded, from the Anglo-Egyptian Sudan, has been taken during the past two years, among them being several species new to science, while the distributions of others have been proved to be wider than was originally known. The new species have been, or are being, described by Mr. E. E. Austen, the well known authority on blood-sucking *Diptera*. As far as possible, all those species which have not previously been figured either in the Reports of these Laboratories or in Austen's *African Blood-sucking Flies*, published by the British Museum (Nat. Hist.) in 1909, are shown in the accompanying plates, as it is thought that an accurate coloured drawing of a fly is of infinitely greater value for purposes of identification—at any rate to the untrained observer—than a detailed technical description. A list is given of all the species of blood-sucking flies—other than mosquitoes—which are recorded from the Anglo-Egyptian Sudan, together with, as far as possible, the localities in which they have been taken.

New blood-sucking flies

Several species of ticks have also been added to the list of those occurring in this country, and a synoptic table has been drawn up which it is hoped will be of some aid to collectors. Living specimens of *Ornithodoros savignyi* have been sent to the London School of Tropical Medicine and to Prof. S. Ruge of Kiel for experimental purposes, and a small but excellent collection of cattle and other ticks has been received from Dr. Dschunkowsky of the Zoornabat Anti-Rinderpest Station in Transcaucasia. A collection of blood-sucking insects and ticks has also been very kindly presented to the laboratories by the Governor of Portuguese East Africa.

Ticks

As many of the inspectors, and other officials stationed in the provinces, expressed their willingness to collect insects if they could be furnished with the means of preserving them, two gross of wooden postal blocks, $7 \times 1\frac{1}{4} \times 1\frac{1}{4}$ inches, were purchased in 1908. Each of these blocks held two glass tubes, $2\frac{1}{4} \times \frac{7}{8}$ inches, in one of which was placed alcohol and in the other entomological pins of various sizes, for pinned dry specimens. Directions for the collection and preservation of blood-sucking insects and ticks were drawn up, and printed in English and Arabic, and a copy of these directions sent with several postal blocks to anyone known to be willing to collect. It was found that while these postal blocks were excellent for the preservation of ticks, fleas, and other specimens in alcohol, the tubes were too small to take the larger blood-sucking flies, so, in consequence of this, a gross of postal blocks, $6\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$ inches, each containing two tubes, 2×2 inches, was bought this year. These are intended for pinned dry specimens, and both tubes in the smaller blocks are now filled with alcohol. To ensure that everyone is asked to collect, a number of parcels, each containing one large block and two small ones, with a copy of the directions, has been sent to each of the Governors of the various provinces, with a request that he will distribute them among the officials in his province. Similar parcels have been sent to most of the Medical Officers of the Egyptian Army. It may give some idea of the spirit which animates those working in this country, when it is stated that no one who has been asked to collect has refused, while many have taken very considerable trouble in obtaining specimens which they conceived to be of interest. Reports have been issued on some two hundred and twenty-five specimens received in these postal blocks.

Postal blocks for preserving and forwarding insects

In consequence of a suggestion made by the Governor of Mongalla Province, that the fish *Girardinus pœcilloides*, popularly known as "Millions," which has proved to be of value in the control of mosquitoes in Barbados and elsewhere, should be introduced into the Anglo-Egyptian Sudan, an effort has been made to ascertain whether any of our indigenous fishes would perform similar services. The results obtained from an experiment made with *Cyprinodon dispar*—a species recommended for trial by the Superintendent of Game Preservation—were very promising, but a second experiment, carried out on a larger scale, has not been so successful. It is, however, yet early to say definitely whether or not this fish can be considered a valuable factor in the control of the members of the Fam. *Culicidæ*.

Control of injurious birds

The control of injurious birds is perhaps scarcely the work of an entomologist, but in the absence of an official to whom this duty could be assigned, the matter has been given some attention. Almost incredible amounts of grain are lost by cultivators yearly, owing to the ravages of sparrows and other small grain-eating birds. Particularly is this the case in Sennar and some of the other eastern provinces, while, in Dongola Province, the Governor estimates these losses to amount to a quantity equal to one-third of the grain harvested, or over 70,000 ardebs, worth more than £E 70,000. This latter province, situated as it is in an almost rainless region, where grain-eating birds are practically dependent on the cultivations for their food, suggested itself as being best adapted for the carrying-out of an experiment in the control of these small depredators. In June of this year, an estimate was made of the probable cost of such an experiment and a sum of £E 1,255 asked for, to be spread over two years. It is confidently hoped that this experiment, if carried out, will yield results fully justifying its cost. Mr. A. L. Butler, Superintendent of Game Preservation, having kindly undertaken to identify any birds collected, it is proposed to prosecute some investigations on the food of those species which are suspected of being either beneficial or injurious.*

During the winter 1908–9, the sum of £E 35 was voted by the committee of the Sudan Government Museum to be spent on an entomological show-case. A glass-fronted mahogany cabinet containing forty drawers was purchased, and an exhibit prepared of blood-sucking insects and ticks, and insects injurious to agriculture and to stored goods.

Owing to lack of funds, an application for an untrained assistant could not be granted, but the Director of Laboratories has allowed Mr. Marshall, an assistant in the bacteriological section, to give me one hour of his time every day. Mr. Marshall has been of help in cataloguing bulletins and journals and in attending to living occupants of breeding-cages, when I have been out of Khartoum.

The Bureau of Entomological Research

The Bureau of Entomological Research (Tropical Africa) has been of very great assistance in the determination of insects and ticks. Two papers dealing with the bionomics of six species of blood-sucking flies (Fam. *Tabanidæ*) have been published in the bulletin issued by the committee.

Mr. Austen has been good enough to contribute some notes on three new species of *Tabanidæ*, and descriptions of several recently described species will be found in this report. Plate VII. is reproduced by kind permission of the Editor of the *Journal of Economic Biology*, and Plates III. and V. from the *Bulletin of Entomological Research*. The figures on Plates VIII. and IX. have been drawn by Miss C. M. Beard, with her usual care and skill, while Plates I., II., IV. and VI. are by the well-known artist Mr. A. J. Engel Terzi.

In conclusion I wish to express my indebtedness to those who have helped me in my work. Mr. J. Currie, Director of Education in the Sudan, and Dr. A. Balfour, Director of the Wellcome Tropical Research Laboratories, have always given me every

* Mr. Butler has recently counselled delay until we are in possession of more complete information regarding the species of birds chiefly responsible for the damage. From the information he supplies this would certainly seem to be advisable, but Mr. King's note has served to direct attention to this important question.—A.B.

assistance in their power, and I have benefited greatly from their advice. I am similarly indebted to my colleague, Dr. W. Beam. My thanks are due to Mr. F. V. Theobald, Vice-Principal of the South-Eastern Agricultural College, Wye, Kent, for the determination of mosquitoes; to Dr. G. H. F. Nuttall and Mr. C. Warburton for the determination of ticks; and to Mr. E. E. Austen, of the British Museum (Nat. Hist.), for the determination of blood-sucking flies and for help in connection with the drawings illustrating this report. Others to whom I would express my gratitude are Mr. G. A. K. Marshall, Scientific Secretary to the Entomological Research Committee (Trop. Africa), Sir G. F. Hampson and Mr. G. A. Boulenger of the British Museum (Nat. Hist.).

The names of those in the Sudan who have rendered valuable aid by collecting and forwarding specimens are far too numerous to give here, but I cannot conclude without mentioning in this respect Captain Hills, A.S.C., Mr. Landon, Sudan Irrigation Service, Major Percival, Captains Mackenzie, Cummins, Drew and Anderson, R.A.M.C., and Mr. H. A. MacMichael, Junior Inspector, Kordofan. To these, and to many others, I would here express my sincere gratitude.

Animals Injurious to Man and Animals

Mosquitoes

Culicidæ

Among the mosquitoes collected during three months spent on the White Nile in 1909 were representatives of five new species and a new sub-species. One of the new species has been constituted the type of a new genus. Descriptions of all these appeared in Volume V. of Mr. F. V. Theobald's *Monograph of the Culicidæ of the World*, published by the British Museum (Nat. Hist.), but for the convenience of those in the Sudan who do not possess a copy of that work, these descriptions are given here. Other species taken during the last two years which had not previously been recorded from this country are *Grabhamia willcocksii*, Theob., found at Zeidab and *Kingia luteocephala*, Newstead, bred from larvæ taken from a hole in a tree near Bor, Mongalla Province.

Quasistegomyia dubia, Theobald

Mono. Culicid., V., p. 133 (1910)

Head black with a median snow-white area and a small white patch on each side; *Quasistegomyia dubia*
proboscis black; palpi nearly as long as the proboscis, acuminate, no hair tufts, black, the two last segments with basal snowy spots, a broad median white band and a narrow basal one; antennæ with deep brown plumes. Thorax black, with a median patch of flat silvery-white scales in front near head, a large patch of snow-white large broad curved scales on each side; a smaller patch in front of the wings, a patch of flat white scales behind on each side of the bare space in front of the scutellum; scutellum with flat, silvery-white scales.

Abdomen black, with basal white bands. Legs black, mid femora with a silvery spot at apex and on apical half; metatarsi of fore and mid legs, and first tarsal with basal white bands, hind femora also with spots, and a white basal band on second tarsal.

♀ Head clothed with flat black scales over most of its surface, two rows of flat silvery-white median scales, narrow dark line between, flat white scales at the sides, dusky upright forked scales at the back, black chætæ projecting forwards and inwards over the eyes; clypeus and proboscis black, basal lobe of antennæ black, with flat silvery white scales on the inside, joints banded black and brown, plume hairs deep blackish-brown;

palpi nearly as long as the proboscis, bluntly acuminate, black, the two apical segments nearly equal, each with a basal snow-white spot, both with a few long black chætæ, and some on the apex of the antepenultimate segment, which has a broad snow-white band near middle, and a narrow one basally.

Thorax black, clothed with narrow-curved bronzy-black scales, in front a large snow-white median spot of flat scales, on each side behind a large snow-white patch of broad curved scales, and a small one just at the roots of the wings; surrounding the bare space in front of the scutellum are flat silvery-white scales, with some broad curved ones in front showing mauve reflections; chætæ thick, black; scutellum black with flat snow-white scales; metanotum black; pleuræ black, with four patches of flat silvery-white scales.

Abdomen black, with basal silvery-white bands, the last two segments with lateral white patches.

Legs black, ornamented as follows:—Fore femora with a few white scales, mid with a snow-white apical spot, and another on the shaft with one or two white scales more basally, hind femora white ventrally on the basal two-thirds, then a silvery spot and another at the apex; tibiæ all black; metatarsi with a basal white band, broadest and whitest on the hind pair, fore and mid first tarsals with narrow white band, and in the hind legs the second tarsal also; fore and mid ungues unequal, the larger simple, the smaller uniserrate; hind equal and simple.

Wings with broad scales on the sub-costal and first long vein, *tæniorhynchus*-like ones on the second, thinner lateral ones on the other veins; fork-cells short, the first longer and narrower than the second, their bases about level, stem of the first more than half the length of the cell; stem of the second nearly as long as the cell; posterior cross-vein longer than the mid, about twice its own length distant from it. Genitalia with rather small, narrow claspers, with dark blunt apical spine.

Length.—4·8 to 5 mm.

Habitat.—Bor, Sudan (H. H. King).

Time of Capture.—June 8, 1909.

Genus *Kingia*

Genus *Kingia*, Theobald

Mono. Culicid. V., p. 135 (1910)

Head clothed with flat scales and upright forked scales, with traces of a few narrow-curved ones behind. Palpi of ♀ short.

Thorax with narrow-curved scales to the mesonotum and with flat scales in the anterior median line and a large lateral patch on each side of similar flat scales and others at the sides; scutellum with flat scales. Venter of abdomen slightly tufted. Wings very densely scaled with long *tæniorhynchus*-like lateral scales, the scales on the first, second and third veins all overlapping.

This genus is very near *Quasistegomyia*, Theobald, but can be told at once by the flat white lateral scales.

K. luteocephala

Kingia luteocephala, Newstead (1907)

Stegomyia luteocephala, Newstead (1907)

Annals Tropical Medicine and Parasitology I., No. 1, 15 (1907)

"Head yellow. Palpi black with white tips. Thorax brown, with two large, anterior, lateral silvery spots, a median yellow stripe and posterior lateral yellow spots; scutellum white. Abdomen black with pale narrow bands, terminal segments silvery. Legs black with silvery spots and white banded tarsi.

"♀. Head with large central area thickly clothed with large, loose, flat yellow scales, gradually merging into smoky-yellow in front; a narrow silvery-white line to the anterior half of the eyes, formed of a single series of broad, flat, closely appressed scales; between the marginal line and the central yellow patch is a broad band of brownish-black scales from which anteriorly arise several upright forked scales; nape with a few long, thick, straight or slightly curved pale golden scales, on either side of which is a group of upright forked scales, intermixed black and yellow; lower basal portion with flat dusky-white scales, the marginal ones forming two dull silvery spots, sharply divided by a dense black spot. Antennæ black, nodes white; hairs black, pubescence grey.

"Palpi black; tips with long silvery-white scales. Thorax: prothoracic lobes with flat silvery-white scales; mesothorax with a well-defined median line and two lateral spots of narrow-curved, golden-yellow scales; anteriorly there are also two large spots of flat silvery-white scales, and a few silvery-white scales on the lower margin of the posterior yellow spots; the rest of the mesothorax with rich dark brown scales; scutellum with flat silvery-white scales; pleuræ dark brown with two large patches of silvery scales.

"Abdomen rich bronzy-brown; segments 1 to 6 each with a well-defined, narrow basal band of smoky-yellow scales; penultimate segment with a large lateral patch and the terminal segment almost covered with brilliant metallic-silvery scales; venter with well-defined, more or less triangular patches of metallic-silvery scales narrowing towards the apex, where they appear as two divergent lines; the scales, forming the outer lateral angles of the spots projecting at the sides of the abdomen, appearing as *outstanding scales.*

"Legs bronzy-blackish-brown; coxæ and trochanters, ochreous; anterior and mid femora with scattered metallic-silvery scales; hind femora with a central anterior band and an apical group of silvery scales; anterior and mid tarsi with narrow dull-white basal bands to the first three segments, metatarsal band broadest; hind tarsi with a broad white basal band to the first, a narrow one to the second, and the third segment almost entirely white above, basally it is not so.

"Wings uniformly pale brown, rather densely scaled, first sub-marginal cell much longer and slightly narrower than the second posterior."

The wings show the following:—First fork-cell much longer and narrower than the second fork-cell, its base nearer the base of the wing, its stem a little more than one-third the length of the cell; stem of the second fork-cell not quite as long as the cell, posterior cross-vein longer than the mid, not quite twice its own length distant from it.

♂. Head with rather loose ochreous yellow scales becoming dusky and then black except in the middle line, a patch of silvery-white scales on each side at the eye border, numerous ochraceous forked scales along the nape becoming dusky in the middle. Antennæ black, with dull grey bands, dense black plumes, showing grey reflections at the tip; proboscis long, thin and black; palpi as long as the proboscis, thin, black, a very narrow white band at the base of the apical and penultimate segments, a broad one in the middle of the antepenultimate, last two segments nearly equal, a few black hairs on each side of the penultimate, fewer on the apical segment, and a few on the apex of the antepenultimate.

Thorax as in ♀, but the median yellow line and the lateral yellow-scaled spots more pronounced.

Abdomen unbanded, the segments with prominent silvery-white basal lateral spots; hairs black with golden sheen; claspers apparently simple, basal lobes of genitalia long and narrow.

Fore and mid ungues unequal, simple; hind equal and simple.

Wings with short fork-cells, the first longer and narrower than the second, its base if anything a little nearer the base of the wing, its stem a little less than half the length of the cell; stem of the second fork-cell about two-thirds the length of the cell; posterior cross-vein about two and half times its own length distant from the mid; wing scales mostly rounded apically.

Length, 4·5 to 5 mm.

Habitat.—Kimba, Congo Free State (Newstead); Sudan (H. H. King); Mpuma, Uganda (Sir David Bruce).

Stegomyia gebeleinensi

Stegomyia gebeleinensis, Theobald

Mono. Culicid. V., p. 157 (1910)

Head as in *Stegomyia scutellaris*, Walker. Thorax rich brown with a rather broad median white line in front, and where it terminates, a small white spot on each side, pleuræ white scaled, scutellum white scaled. Abdomen black with narrow basal silvery-white bands on the dorsum and venter. Legs black with narrow basal white bands on some of the joints.

♀ Head as in *Stegomyia scutellaris*, Walker. Thorax black, clothed with small narrow-curved bronzy-brown scales, a rather broad median white scaled line, running from the front to about the middle, narrowing posteriorly, where it ends is a small white scaled spot on each side of similar scales, and just anterior to these run two indistinct paler scaled lines back to the scutellum, paler scales also before the scutellum, which is covered with flat white scales and has black border-bristles; metanotum dark brown; pleuræ dark with dense rather loose flat white scales, especially above; prothoracic lobes with flat white scales.

Legs damaged; the femora white scaled at the base; the mid pair with a narrow pale basal band to the metatarsi and first tarsal.

Wings with typical *stegomyia* scales; fork-cells short, the first longer and slightly narrower than the second, their bases nearly level, stem of the first nearly as long as the cell; stem of the second as long as the cell; posterior cross-vein not quite three times its own length distant from the mid.

Abdomen black, with narrow basal snow-white bands which spread out laterally, basal segment all dark-scaled; border-bristles pale golden and brown; venter dark with basal white bands.

Length, 3·5 mm.

Habitat.—Gebelein, Sudan (H. H. King).

Stegomyia lilii

Stegomyia lilii, Theobald

Mono. Culicid. V., p. 160 (1910)

Head black with snow-white median area and white at the sides; palpi black in ♀ with snow-white apices; proboscis black. Thorax black with a large lateral snow-white spot in front, and a smaller one behind before roots of wing; two narrow median yellow and two sub-median white lines run from the middle of mesonotum to the scutellum; scutellum white; pleuræ dark with white puncta.

Abdomen black with basal silvery-white bands, last segment with two white spots, no band.

Legs black with basal white bands.

♀ Head clothed with flat black scales, a double row of flat snow-white ones in the middle and white at the sides, a narrow white border due to reflection around the eyes, thick black chætæ project over the eyes inwards; palpi black with snow-white apices; proboscis and antennæ black. Thorax black, clothed with small narrow-curved black scales, in front on each side a large silvery-white triangular patch of broader scales, behind this a smaller patch just in front of the roots of the wings; from the middle of the mesothorax run backwards two parallel thin yellow lines and two sub-median snow-white ones, the latter quite reaching the scutellum; chætæ jet black; scutellum clothed with flat silvery-white scales, dusky in some lights; metanotum brown; pleuræ black with three prominent silvery-white spots of flat scales.

Abdomen black, the second segment with trace of white basal band, the third, fourth, fifth and sixth with prominent silvery-white basal bands, the seventh with two white basal spots, eighth dark, also the basal segment; chætæ and border-bristles black; venter with broad white basal bands.

Legs, black, the fore and mid metatarsals and first tarsals with basal white bands, rest of tarsals black; in the hind legs the femora are pale on the basal half, the black apical half with two silvery-white spots, one apical, the metatarsi and first and second tarsals with basal snow-white bands, the third all dark, the fourth white.

Wings with dark scales, especially along the outer costal border; fork-cells rather short, the first longer and slightly narrower than the second, its base slightly nearer the base of the wing, its stem about half the length of the cell, stem of the second posterior not quite as long as the cell; posterior cross-vein about the same length as the mid, about its own length distant from it.

Length, 4·5 mm.

♂ Head as in the ♀; palpi as long as the proboscis, blunt, no hair tufts, a few black bristles, black, a ventral white area at the base of the apical segment, a broad median white band and a narrow basal one; antennæ banded black and white with black plume hairs.

Thorax as in the ♀, but the median thin yellow lines curve around the bare space in front of the scutellum and reach it, the last part being composed of broader curved scales.*

Abdomen and legs as in the ♀; fore and mid ungues unequal and simple; hind equal and simple.

Length, 4·5 mm.

Habitat.—Bor (H. H. King).

Time of capture.—May 26, 1909.

Genus *Hispidimyia*, Theobald

Genus *Hispidimyia*

Mono. Culicid. V., p. 245 (1910)

Head clothed with flat scales, except for a small group of minute narrow-curved ones on the nape, and a larger group of upright forked scales. Proboscis swollen on the apical third, composed of two segments, the joint at the apical third; labella acuminate. Antennæ of ♂ densely plumose with two very long terminal segments pilose only; other segments thick, basal one globular; palpi of male a little longer than the proboscis, clavate at the apex; of two segments the apical one short and clavate? with ventral chætæ and two large and some small apical ones. Palpi of ♀ about one-fourth the length of the

* This probably also occurs in the ♀ as there are traces of these larger scales.—F.V.T.

proboscis. Prothoracic lobes with large curved spines in ♂, smaller in ♀; mesothorax and scutellum with narrow-curved scales, the whole thorax with long dense-curved backwardly projecting chætæ. Abdomen densely hairy in the ♂, especially ventrally, also hairy in ♀. Wings with only median vein scales, spatulate in the ♂, some lateral broad short scales on the second vein, etc., in the ♀. Fork-cells short in both sexes, the first with its base nearer the apex of the wing than the second.

Hispidimyia hispida

Hispidimyia hispida, Theobald

Mono. Culicid. V., p. 245 1910

Head brilliant creamy-white; proboscis ochreous, dark at apex; palpi of ♂ clavate, a little longer than proboscis, ochreous, dark brown on clavate area, which is spiny below, apex spiny; antennæ flaxen-brown. Thorax rich brown with two median pale parallel shiny lines, which seem to continue around the bare space before the scutellum, a darkened area on each side of the parallel lines in front; pleuræ pale ochreous. Abdomen deep brown with basal lateral yellow spots which form almost a continuous line on each side, densely hairy. Legs unbanded, deep brown, except base and under side of femora, with brassy reflections; tibiæ spinose. Wings with scanty brown scales.

♂ Head clothed with flat creamy-white scales with ochreous and iridescent reflections, a small area near the nape of narrow-curved golden scales, a larger area of black upright forked scales and some almost golden along the nape; four long black chætæ on each side on the ocular border projecting inwards, a few small short golden chætæ in front between the eyes and two long black chætæ; there is a median parting of the flat scales.

Clypeus apparently very small; proboscis ochreous with some dark scales above, dark at the apex, which is slightly swollen; palpi a little longer than the proboscis, clavate and blunt at the apices, ochreous below, some dark scales above, clavate area black with violet reflections; clavate area with black chætæ below, two large black apical chætæ and some smaller ones.

Antennæ with the segments thick and short, except the last two, which are long, thin and pilose, rest with dense flaxen-brown plume hairs; basal segment very large, globular and dark.

Thorax rich ochreous brown, clothed with black narrow-curved scales, showing bronzy-metallic reflections, leaving two median bare parallel lines; bare space in front of the scutellum, pale, especially at the sides, the area looking like a continuation of the two bare pale median lines; numerous black, backwardly curved chætæ, a patch of small golden ones before the base of the wing; scutellum shiny, with pale reflections like the bare space before it, clothed with narrow-curved bronzy scales; six posterior border-bristles, three on each side of the mid lobe; metanotum ochreous brown, darker in the middle; prothoracic lobes ochreous with numerous long curved brown chætæ, with bright golden reflections, pleuræ pale ochreous, with grey reflections, some dusky and white semi-transparent flat scales.

Abdomen clothed with black scales with dull violet reflections, each segment with large basal lateral yellowish spots, which on some of the segments extend to their apical borders, last segment with many ochreous scales; posterior border-bristles golden, dense lateral and apical bristles brown, with golden reflections; venter densely hairy.

Legs blackish-brown, with dull violet reflections; femora pale-creamy at the base and below, fore femora spinose and all the tibiæ, especially of the hind legs; fore ungues unequal, the larger biserrate, the smaller simple.

Wings with short fork-cells; the first a little longer and narrower than the second, its base nearer the apex of the wing, its stem longer than the cell, stem of the second fork-cell longer than the cell; mid-cross vein longer than the supernumerary, posterior as long as the mid, curved, about half its own length distant from it; the second to the sixth veins with only a single row of median vein scales, no lateral scales.

Genitalia with small narrow basal lobes; claspers as long as the lobes, simple, with a dark terminal spine.

Length, 5 mm.

♀ Head very similar to the ♂, but the scales not quite so pale and the few scanty dark fork-scales spreading more over the occiput; three black chætæ only on each side on the ocular line; proboscis ochreous in the middle, dark at base and apex, with numerous short pale hairs; palpi about one-fourth the length of the proboscis, brown, with short fine hairs. Antennæ brown, pilose.

Thorax black with narrow-curved bronzy-black scales; paler behind almost ochreous, but dark brown through the bare space before the scutellum, with dull golden curved scales around it and dark ones at the sides, the golden scales broader than the dark; chætæ long, black in the middle and in front, golden over the roots of the wings; scutellum ochreous, darker on mid lobe, scales narrow-curved (?); six golden-brown posterior border-bristles, three on each side of the mid lobe; metanotum ochreous dark in the middle; pleuræ bright ochreous with grey sheen and pale hairs, pale golden ones also between the dark mesonotum and pale pleuræ.

Abdomen black with violet reflections and basal lateral yellow spots and many yellow scales on the apical segment, posterior border-bristles pale golden; venter pale, dull ochreous.

Legs as in the ♂, but the femora paler, almost ochreous in the hind legs, fore femora spinose and all the tibiæ; ungues equal and simple.

Wings with median vein scales only to most of the veins, if lateral ones of pyriform shape; fork-cells small, the first about the same length as the second and narrower, its base near the apex of the wing, its stem a little longer than the cell; stem of the second about the same length as the cell; mid cross-vein longer than the supernumerary, posterior about the same length as the mid, not quite its own length distant from it.

Length, 4·5 mm.

Habitat.—Near Gebel Ahmed Aga and Bor, Sudan (H. H. King)

Time of capture.—May 2 and 20 and June 20, 1909

Grabhamia willcocksii, Theobald *Grabhamia willcocksii*

Mono. Culicid. IV., p. 296 (1907).

Thorax clothed with bright golden-brown and ochreous or creamy scales; in the middle there are two lines of a pale creamy hue; pleuræ pale with grey scales. Abdomen mostly pale scaled, but with two more or less distinct dark areas on each segment. Legs with apical and basal pale bands; all ungues are equal and uniserrate in the ♀. Wings mostly pale scaled, a few scattered dusky ones, but variable. Ungues of male, fore and mid unequal and uniserrate; hind equal and simple.

♀ Head deep brown, clothed with pale creamy narrow-curved scales and pale creamy upright forked scales on the occiput, becoming bright ochreous laterally, and a few deep black ones behind on each side, flat creamy and dusky lateral scales. Palpi mottled with dark and creamy scales; proboscis mostly ochreous scaled, with a few scattered dark scales, the apical region black; antennæ brown.

Thorax black, densely clothed with bright golden-brown narrow-curved scales, except for two creamy lines running nearly the whole length of the thorax and widest in front; scales in front of the scutellum much paler; traces of brighter scaled lines also laterally in some specimens; scutellum with pale creamy scales; chætæ bright reddish to golden-brown; metanotum bright brown; pleuræ brown with flat white scales.

Abdomen brown, mostly clothed with ochreous and white scales, the latter form a median line and a large patch either median or basal laterally, the ochreous ones more confined to the apical borders of the segments, the dark scales form more or less marked dorsal lateral dark areas, but pale scales may be dotted about over these; basal segment with two tufts of flat white scales; venter mostly creamy scaled.

Legs with the femora ochreous, with a few scattered black scales; femora dark brown with scattered white scales above, mainly ochreous with a few dusky scales below; first tarsals with more dark scales, in the fore and mid legs there is a pale band involving both sides of the first and second tarsals, and another involving the joint between the second and third tarsals, rest dark scaled; in the hind legs the bands are wider and extend to all the joints, the last tarsal being pure white; ungues on all the legs equal and uniserrate.

Wings with the majority of the scales pale creamy, some bright ochreous ones on the costa and first long vein and some scattered black ones here and there on the other veins; fork-cells short, the first sub-marginal longer and narrower than the second posterior cell, its base nearer the apex of the wing than that of the second posterior cell, its stem about three-fourths the length of the cell; stem of the second posterior about two-thirds the length of the cell; mid cross-vein longer than the supernumerary or posterior, the latter about its own length distant from the mid; halteres with slightly fuscous apex clothed with grey scales and a dark line on the ochreous stem.

Length, 3 to 4 mm.

♂ Palpi straw-coloured, a narrow dusky band at the apex of the penultimate and antepenultimate segments and some dusky scales at the apex, apical segment shorter than the penultimate; hair-tufts moderate, flaxen. Antennæ with flaxen hairs.

Abdomen with basal grey bands and most of the apical segments grey scaled. Genitalia with rather long, narrow basal lobes, long claspers curved apically with long terminal spine; harpes prominent, curved, broadened at the middle. Ungues of fore and mid legs unequal, uniserrate; hind ungues equal and simple.

Length, 4·5 to 5 mm.

Time of capture.—June.

Habitat.—Kafr-el-Dawar, Egypt (F. Wilcocks); Zeidab, Sudan (H. H. King).

Culex tigripes var. *bimaculata*

Culex tigripes, Grandpre, var. *bimaculata*, Theobald

Mono. Culicid. V., p. 393 (1910)

Legs with marked lines of creamy spots as in type. Thorax with two pronounced median small pale spots, a pale scaled line from each, running backwards, also a pale scaled median spot near the head, an indistinct one on each side and some pale scales over the wings. Abdomen with the second to fifth segments dark with narrow yellow apical bands, the second to fourth each with two nearly median yellow spots; remaining apical area golden-yellow.

Habitat.—Meshra-el-Zeraf (H. H. King).

Uranotænia alboabdominalis, Theobald

Mono. Culicid. V., p. 508 (1910)

Head pale blue; palpi and proboscis black. Thorax rich bright brown, a silvery-white line running up to base of wing for about half the length of the thorax, and another parallel one on the pleuræ, which are ochreous. *Uranotænia alboabdominalis*

Abdomen with the first four segments almost entirely creamy-white scaled, rest dark with basal median creamy-white patches. Legs dark brown, unbanded.

♀ Head clothed with pale blue and some scattered creamy flat scales, deep violet in the middle at the back, dusky at the extreme sides, with *four* black upright forked scales and a large tuft of long creamy scales projecting between the eyes; few chætæ, black; palpi and proboscis black; antennæ brown, basal segment bright testaceous.

Thorax bright brown, clothed with scanty dark and dull golden narrow-curved scales and a white line of spindle-shaped scales running from the base of the wings to about two-thirds the length of the mesonotum forwards, chætæ deep brown; scutellum clothed with small flat dusky scales; metanotum deep brown; pleuræ pale ochreous with greyish areas, a broken line of flat white scales running from the prothoracic lobes, parallel with the line to the roots of the wings; both with very pale blue reflections; prothoracic lobes covered with very pale blue, almost white flat scales.

Abdomen with the 2nd to 5th segments almost entirely creamy-white scaled, a few brown ones at their bases; 6th, 7th and 8th segments with median creamy basal scales, not forming bands; basal segment very small brown; border-bristles pale golden.

Legs uniformly deep brown with bronzy reflections; ungues small, equal and simple.

Wings with brown scales, but with a white line at the base continuous with the white thoracic line; scales on ends of veins large and lanceolate, on most of third long vein, pale compared to median vein scales; first fork-cell shorter and slightly narrower than the second, its base much nearer the apex of the wing, its stem about twice as long as the cell; stem of the second fork-cell about one and a quarter as long as the cell; posterior cross-vein longer than the mid, about one and a-third times its own length distant; apex of second long vein close to the first.

Length, 3 mm.

♂ Head more white scaled than the ♀, with more dark upright forked scales in the middle; antennæ with pale internodes, plume hairs brown.

Thorax and abdomen as in ♀. Fore and mid ungues unequal, curved, simple; hind equal and simple.

Wing very much like the ♀.

Length, 3 mm.

Habitat.—Bor to Mongalla, Sudan (H. H. King)

Time of capture.—May 19 and 20, 1909.

Uranotænia abnormalis, Theobald

Mono. Culicid. V., p. 513 (1910) *Uranotænia abnormalis*

♂ Head as in the ♀; antennæ brown with dusky plume hairs, pale at the tips; proboscis and palpi black.

Thorax as in the ♀, also the abdomen.

Legs unbanded; fore legs with short thick metatarsi nearly one-half the length of the first tarsal, last tarsal very small; tibia with claw-like apical spine, ungues equal and simple, curved almost at a right angle, broad, spines above; the segments following metatarsi, thin and bent; mid legs with short metatarsi, second tarsal normal, third bent under the fourth and projecting with two dark unequal claws, like ungues and with two lateral leaf-like processes on each side of the claws, ungues on terminal segment equal and simple; hind legs with the tibiæ with five basal bristles in a row, contracted at one-third their length, where there is a tuft of five long orange to brown spines of nearly equal length, three together bent apically and also a sixth much longer spine, near the middle of tibia is a single long spine; metatarsi and tarsi thin, ungues equal and simple.

Wings much as in the ♀; the first fork-cell much smaller than the second, its base much nearer the apex of the wing, its stem nearly three times the length of the cell, stem of second fork-cell about one-and-a-half times the length of the cell; posterior cross-vein longer than the mid, about one-and-a-half times its own length distant; second long vein close to first. Genitalia small and hidden; claspers thick and blunt, basal lobes triangular.

Length, 3 mm.

Habitat.—Sudan, Bor to Mongalla, 21 specimens including 3 ♂'s (H. H. King).

The female of this species was described by Mr. Theobald in the Third Report of these Laboratories under the name of *Uranotænia pallidocephala* sub. sp. *cæruleus*, but later, on examining the male, he raised it to the rank of a species.

The Control of Mosquitoes

The control of mosquitoes on artificially irrigated farms is a matter of considerable importance, bearing as it does directly on the subject of the health of those living in the neighbourhood. Without mosquitoes the northern provinces are—except for the heat—healthy, but if anophelines are allowed to exist in any numbers, malaria at once becomes rife.

The ordinary native-owned cultivation is dependent for its water-supply on a sakia—a cumbrous, wooden water-wheel, turned by cattle—and very few mosquitoes breed out on these sakia-lands. The volume of water raised is so small that the owner cannot afford to allow any of it to go to waste. The floors of the gudwals—as the water-channels are termed—are usually above the level of the surrounding land, and consequently when the sakia ceases to turn, the gudwals run dry. The only breeding-places provided for mosquitoes under such conditions are occasional puddles among the grass growing on the sides of the gudwals, due to unsuspected leaks.

Pump irrigation more dangerous than sakias

The water used in irrigating a farm of from a few hundred to several thousand feddans is raised by means of pumps, worked by engines, and in this case a comparatively large volume of water has to be dealt with. The water is conveyed from the pumps by a main canal from which open smaller canals. From these canals the water passes along large gudwals, and from them by smaller ones directly on to the land. Each canal and gudwal is, roughly, at right angles to those with which it connects. There may be many canals and gudwals of various sizes, and when a heavy weight of water has to be supported by earthen banks, leakages are bound to occur. The floors of the gudwals—which are always much larger than any used on sakia-land—are generally below rather than above the level of the surrounding land, and these water channels cannot therefore be emptied. Consequently, when the gudwal is not in use, the water in it remains stagnant until it either soaks away and evaporates—a process which may occupy several weeks—or the gudwal is used again. In some localities, owing to the chemical composition of the soil, water is continually soaking through the canal and gudwal banks to form little pools on the other side. A bank of this nature is known as a "weeping" bank. The canals invariably contain numbers of small fish, and, moreover, the water in them is usually moving, so there is not much chance for mosquitoes to breed out in them, but the gudwals, and especially the smaller ones, may not be used for weeks at a time, and a more ideal nursery for mosquitoes than stagnant water in an overgrown gudwal can scarcely be imagined. Each gudwal terminates in a "dead" or "blind" end, that is to say, there is no opening from a gudwal at its extreme end. As a result of this, the water in these "blind" ends is always more or less stagnant, and generally bears a covering of green slime. These "blind" ends are necessary to prevent the flow of the water from wearing away the banks.

"Weeping" banks and "blind" ends

Anyone who has had experience in the control of mosquitoes in tropical or sub-tropical countries will be able to understand what a source of danger a farm of this kind can be to the inhabitants of the neighbourhood if suitable precautions are not taken. In one instance I attributed all the mosquitoes, which had caused a serious outbreak of malaria in a native village, to a single "blind" end.

It is generally thought that mosquitoes cannot be controlled on a large artificially irrigated farm except at a very considerable—and frequently in the owner's opinion, an unnecessary expense. If the matter is gone into carefully, however, it will be found that not only can the mosquitoes be kept in check at a comparatively small cost, but also that it will pay the owner to do so. It must be remembered that when from one to two-thirds of the staff of labourers employed on a farm are suffering from intermittent attacks of fever, they are absent from work for varying periods during the month, and are also often physically unfit for hard and protracted toil during the times when they are supposed to be working.

The life-cycles of the species of mosquitoes found in the northern provinces occupy about ten days, consequently if all stagnant water on any given area is examined, and, if found to contain mosquito larvæ, treated with paraffin or some other larvicide at intervals of a week, no mosquitoes can breed out in that area. It is not always easy to detect mosquito larvæ in stagnant water bearing a covering of slime, nor is it possible to approach many of the pools in a gudwal owing to the softness of the mud surrounding them. For practical purposes, therefore, it is better to assume that all stagnant water requires to be treated with paraffin once every week—a great saving of time will be thus effected. A man armed with a stick with a bundle of rag tied at one end, and accompanied by a donkey bearing a tin of paraffin, can walk a long way in a week, paraffining all the stagnant pools he finds on his way, and an intelligent native at a monthly wage of from £E3–4, with a little supervision from the British overseers on the farm, can be trusted to carry out this work. The upkeep of the gudwals is, of course, the duty of the owner—or the tenant, if the land is let out to tenants—and if this is well done, the work of the "mosquito men" will be very considerably lightened. It should be the duty of these men to report to their employer the condition of any gudwal which is either leaky or overgrown.

Mosquito precautions not necessarily expensive

Paraffin is the larvicide most generally in use against mosquitoes, for it is effective, moderately cheap, and obtainable almost everywhere. A sufficient quantity should be applied to form a film over the entire surface of the water. Another larvicide which has been used with great success by Mr. J. A. le Prince, Chief Sanitary Inspector, Panama Canal Zone,[1] is made from carbolic acid, resin, and caustic soda prepared in the following way:—

Larvicides

"Crude carbolic acid containing about 15 per cent. phenol is heated to 212° F., finely pulverised resin is added, and the mixture kept boiling until the resin is all dissolved. Caustic soda solution is then added and the mixture kept at 212° F. for about ten minutes, or until a perfectly dark emulsion without sediment is obtained. The mixture is thoroughly

[1] Ross, R. (1910), *The Prevention of Malaria*, p. 357.

stirred from the time the resin was added until the end." Mr. le Prince states that as the composition of crude carbolic acid varies greatly, the proportion of ingredients of the larvicide will vary, and it is necessary to have small experimental lots made in the laboratory and tested before the batch of larvicide for use in the field is manufactured. One part of this mixture placed in five thousand parts of water containing mosquito larvæ is said to kill them all within five minutes. If it is used in the proportion of one to eight thousand the larvæ are killed in thirty minutes.

"Basin irrigation" is not dangerous

A method of irrigation, practised in some districts, notably in the province of Dongola, is that known as "basin irrigation." Where the land-levels admit of its being done, a canal is dug, along which water flows from the river when it is in flood on to land situated generally behind the sakia-lands. There is, I think, little fear of mosquitoes breeding out in the pools left by these basins when the Nile falls, as the myriads of fish, which are brought in from the river with the water, are constrained by hunger to devour any mosquito larvæ they can find, even though under more normal conditions, such larvæ would not be very palatable to them.

During some three months spent on the White Nile in 1909, I endeavoured to find a species of fish which would emulate the example set by *Girardinus pœcilloides*. This Barbados fish has gained for itself a world-wide reputation as a mosquito-destroyer, under the name of "Millions," and it was suggested by the Director of the Laboratories that possibly some species of fish existed in this country which would be of like value. Such a fish, to be capable of yielding the best results, must possess several characteristics. It must be capable of living and breeding in stagnant as well as in running water, it must be small, preferably not more than 10 cm. in length, a prolific breeder, hardy enough to bear transportation and, last but not least, so fond of mosquito larvæ that it will take them in preference to anything else. It is sometimes said that any fresh water fish will eat mosquito larvæ, and this may possibly be the case when no other food is available, but it certainly is not so with Nile fish living in their natural habitat. In some of the marshes bordering the White Nile, shoals of tiny fish can be seen in water literally alive with mosquito larvæ and yet making no effort to catch them. Many species of fish exist in these marshes and all which could be caught were given a trial. Some would not live in glass jars—no other and larger vessels were available—while others, though they throve in the jars, refused to eat mosquito larvæ until they had been without food for periods varying from one to three or four days. A single species,—later determined by Mr. G. A. Boulenger of the British Museum (Natural Hist.) to be *Ophiocephalus obscurus*—taken in a khor situated between Gebel Ahmed Aga and the river, appeared to look on mosquito larvæ as its natural and only food. The specimens caught were small fry—in which stage they rather resembled tadpoles—and though only 1·5–2 cm. in length would tackle large *Stegomyia* and *Scutomyia* larvæ with the keenness of terriers catching rats. They remained healthy although the water in their jar was sometimes unchanged for several days and allowed to become green and slimy. Later, when mosquito larvæ could not be obtained, they were fed on earthworms. This fish, therefore, possesses all the characteristics needed for a mosquito controller, except one, or perhaps two—when full grown *O. obscurus* attains a length of 35 cm. and possibly it does not breed freely. In swamps and similar places, where the fry after feeding in the shallows—and it is in shallow water that mosquitoes prefer to breed—could as they increased in size regain the deeper parts, I believe this fish, when once established, would yield the very best results, but its size unfits it for use on artificially irrigated farms. On a farm with a system of water channels as described

Fish as larvicides

above, the fry would be carried into the gudwals and there do good work, but they would be unable to return to the deep canals and so would eventually be captured by some native who had an eye for the "pot." Only those fish which spent their entire life in the canals would be able to perpetuate their species.

At the suggestion of Mr. A. L. Butler, Superintendent of Game Preservation, the fish *Cyprinodon dispar* was, later in the year, made the subject of an experiment. This fish, when mature, attains a length of 8 cm. and exists in Khor Arbat in untold myriads. Khor Arbat is a stream of slightly brackish water running in a gorge in the rocky hills about twenty-two miles N.N.W. of Port Sudan. When in flood I believe it is in places seven or eight feet deep, but at other times it is a shallow stream rippling over and around stones, and eventually losing itself in the desert. A visit was paid to this Khor early in September, 1909, and one hundred living specimens brought to Khartoum. Considerable difficulty was experienced in persuading them to live in captivity until it was found that while, if placed in jars nearly full of water, most of them died within twelve hours, yet if given only about two inches of water over a layer of sand, they could be transported fairly easily. The jars containing them were carried to Port Sudan by hand and from there to Khartoum by rail. No mosquito larvæ were obtainable at Khor Arbat, but a number, offered them on their arrival at Khartoum, were readily taken. This, however, is not conclusive proof that *C. dispar* feeds on mosquito larvæ in its natural state, as the fish had then been without food for two days. As they did not thrive in captivity, advantage was taken of the permission very kindly granted by Mr. A. MacIntyre, Acting Manager of the estate at Zeidab belonging to the Sudan Plantation Syndicate, Ltd., to place them in a gudwal on the Company's Estate. A short length of gudwal—about fifty yards—was utilised for the purpose, and the pipe connecting it with the canal, netted to prevent other fish gaining access. This gudwal was not needed for irrigation purposes so the water was allowed to stagnate, fresh water being occasionally added to prevent it from drying out. Owing to various reasons—leave and duty—I was unable to visit Zeidab again until March, 1910, when I was told by Mr. MacIntyre that the fish had lived in the gudwal until the end of January—that is, for over four months—when, as the water had become very overgrown with weeds and slime, he had transferred them to one of the canals, fearing that though still apparently healthy they would die if left longer in the filthy water. During the four months that they were in the gudwal he had been unable to find any mosquito larvæ in it. It is almost certain that mosquitoes laid eggs in this gudwal during that period, for in March there were numbers of the larvæ of *Pyretophorus costalis* and a *Culex* sp. in another gudwal containing water not far distant.

Cyprinodon dispar

The results of this experiment were so promising that it was decided to make an attempt to establish *C. dispar* in some place in or near Khartoum, from whence supplies might be sent to anyone requiring them. H. E. the Governor-General very kindly granted permission for a large reservoir in the Palace gardens to be used for the purpose, and Mr. C. J. Slade, Town Engineer, Khartoum, and Mr. F. S. Sillitoe, Superintendent of Gardens, rendered invaluable aid to the scheme by having all the fish already in the reservoir removed—no small task—and by giving general assistance. This reservoir is some eight feet deep, has brick sides, and is fed from the river by a pump, the water being conveyed from the pump to the reservoir by a wooden gutter. This gutter was fitted with a wire net to prevent river fish from finding their way into the reservoir. Early in April over two thousand living fish of various sizes, mostly immature, were brought from Khor Arbat and of these about sixteen hundred were placed in the

Experiments with *C. dispar*

reservoir. The remainder were put in a small tank in the Gordon College garden for the use of which I was indebted to Mr. M. F. Simpson, Assistant Director of Education. Mr. Addison, Assistant Engineer in the Gordon College Workshops, kindly undertook to see that this tank was kept supplied with water. All those in the tank died within a few days, apparently from the attacks of a fungus, for prior to death, the fish assumed a light furry appearance on the shoulders, and swam aimlessly about. At the same time a number of those in the reservoir died, showing similar symptoms, but how many could not be determined as several kingfishers were in the habit of fishing in this water and they may have removed some of the sickly fish. On my return from Dongola at the end of May no *C. dispar* could be found by searching the edges of the reservoir, nor have any been noticed since, so it is feared that they have all perished. It is possible, though, that there are still some hundreds remaining, for the volume of water contained in the reservoir is very considerable.

It is difficult to understand why these fish brought up in April should have perished, while those caught in the previous September flourished for over four months in a stagnant gudwal. Possibly some simple precaution, which should have been taken to ensure their remaining in good health throughout their rather trying journey, was overlooked, and in any case the species seems deserving of another trial for it is one of the few "small" fish which occur in this country, and, judging from the numbers which exist in Khor Arbat, it is a most prolific breeder.

Blood-sucking flies other than Mosquitoes

Blood-sucking flies other than Mosquitoes

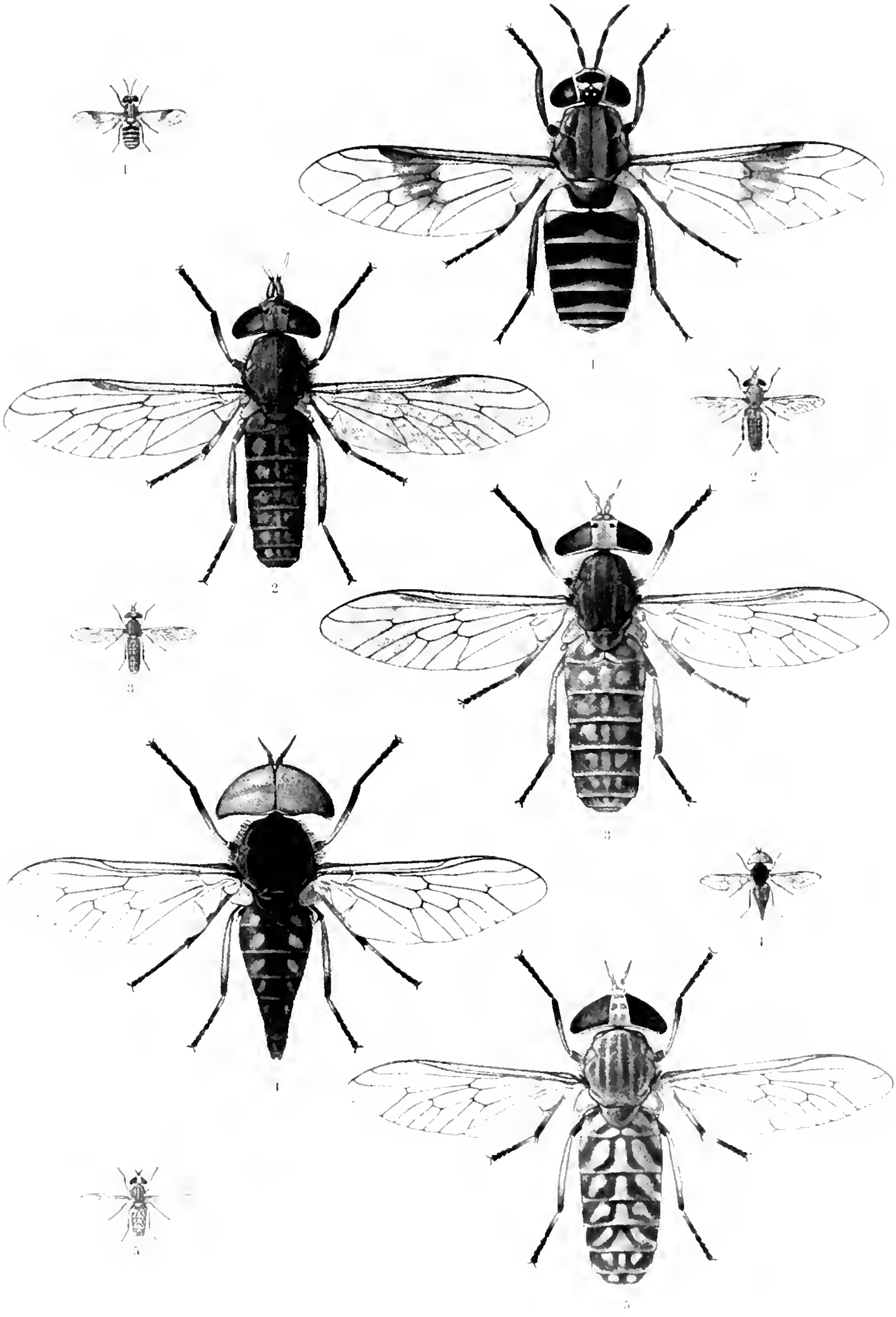
As will be seen from the list given some forty-nine species of blood-sucking *Diptera* other than mosquitoes are now known to occur in the Sudan. Of these, two tabanids, one from Ragaa and Dem Zubeir, Bahr-El-Ghazal Province, and the other from the Lado District, Mongalla Province, are as yet nameless, as the specimens taken were not in sufficiently good condition to allow of an accurate description being drawn up. A third nameless tabanid, from Malakal, is also possibly representative of a new species near *Tabanus fuscipes*, Ric., but, up to the present, only very much rubbed specimens have been captured. Descriptions by Mr. E. E. Austen of three new seroots, all from the same locality, viz. Khor Arbat, Red Sea Province, are embodied in this report for the convenience of those who may not have seen the publications in which they have appeared.

Of the small seroot, *Tabanus sufis*, Jaenn., two forms occur, specimens taken at Khor Arbat being invariably slightly larger and uniformly paler than those from other localities (Plate I., figs. 4 and 5).

Three of the species figured—*Chrysops fuscipennis*, Ric. (Plate I., fig. 1), *Tabanus distinctus*, Ric. (Plate II., fig. 1) and *Hæmatopota abyssinica*, Surcouf (Plate I., fig. 2)—do not, so far as is known at present, occur within the bounds of the Sudan, but have been taken just over the borders. It has been thought advisable, however, to illustrate them.

Since the last Report of these Laboratories was issued, the name *Tabanus socius*, Walker, has been sunk as a synonym of *Tabanus tæniola*, Pal. de Beauv. It will probably be noticed that the closely-allied species, *Tabanus variatus*, Walker, has not been included in the list of Sudanese blood-sucking *Diptera*. This is because I am convinced that it is not a valid species. Mr. Austen, in his *African Blood-sucking Flies*, alludes to the possibilities of these two species proving to be one and the same, and the examination

PLATE I



1. *Chrysops fuscipennis*, Ricardo ♀
2. *Hæmatopota* [illegible], Surcouf ♀
3. *Hæmatopota brunnescens*, Ricardo ♀
4. *Tabanus sufis*, Jaennicke ♂
5. *Tabanus sufis*, Jaennicke ♀

Small illustrations indicate natural size

of some hundreds of specimens of the various forms of this tabanid has led me to believe that the name *T. variatus* must be sunk as a synonym of *T. tæniola*. *T. variatus* has been distinguished from *T. tæniola* by the median dorsal abdominal stripe which is present in both forms but which in *T. variatus* consists of a series of complete triangles with their apices pointing forward. In *T. tæniola* it consists of either a clear stripe of varying widths in different specimens or a series of truncated triangles. Flies can be taken showing every gradation between the two extremes of a narrow even white stripe and a series of complete triangles, and one not infrequently meets with a specimen which—if the name *T. variatus* holds good—may be determined as belonging to either species. The two forms exist together in the same localities, though usually in any given locality one form is more common than the other. For these reasons, therefore, I have included the form known as *T. variatus*, Walker, under the name of *T. tæniola*, Pal. de Beauv.

A fly which should possibly be included in the above list is an asilid *Promachus* sp. nov. A specimen was taken by Mr. J. King in October, 1909, at Nahud, Kordofan Province, and sent to these laboratories with a note that it had attempted to suck blood from his hand. Only slight inflammation resulted from the puncture it made. It is, of course, possible that this species lives mainly upon the blood of mammals but more probably its normal diet is the body-juices of insects.

The notes on the bionomics of *Tabanus par*, Walker, *T. tæniola*, Pal. de Beauv., *T. ditæniatus*, Macq., *T. kingi*, Austen, *T. camelarius*, Austen, and *T. mordax*, Austen, have appeared in the *Bulletin of Entomological Research*.

Tabanus camelarius, Austen

Plate II., figs. 3, 4

Bulletin of Entomological Research, Vol. II., Part 2 1911

♂ ♀.—Length, ♂ (1 specimen) 12·5 mm., ♀ (2 specimens) 11·6 to 12·8 mm.; width of head, ♂ 4·25 mm., ♀ 3·75 to just under 4 mm.; width of front of ♀ at vertex 0·6 mm.; length of wing, ♂ 8·75 mm., ♀ 8·25 to 8·4 mm. *Tabanus camelarius*

Somewhat narrow-bodied, elongate species; dorsum of thorax mouse-grey in ♂, blackish slate-coloured in ♀, and in both sexes longitudinally striped with light grey, though less distinctly in ♂ than in ♀; dorsum of abdomen dark brown in ♂, clove-brown or blackish-brown in ♀, and in both sexes with three longitudinal stripes, which are smoke-grey in ♂ and whitish-grey in ♀; one stripe is median and continuous; midway between this and the lateral margin on each side is a stripe, which is largely composed of disconnected, longitudinally elongate spots; venter light grey, with a broad, blackish, longitudinal stripe, interrupted on hind margins of segments and in ♀ very conspicuous, in ♂ much less distinct and inconspicuous unless viewed from behind; femora slate-grey, with a whitish-grey bloom, tibiæ partly cream-buff, front tarsi entirely black, middle and hind tarsi blackish-brown, except proximal two-thirds of first joints, which are cream-buff.

This species is allied to and superficially resembles *Tabanus gratus*, Lw., from which, however, it is distinguishable by, among other characters, the paired abdominal stripes, which, instead of being continuous, are broken up into disconnected spots after the second segment.

Tabanus mordax, Austen

Plate II., fig. 5

Bulletin of Entomological Research, Vol. II., Part 2 (1911)

♀.—Length (5 specimens) 12 to 15·4 mm.; width of head 3·75 to 5 mm.; width of front at vertex just under 1 mm. to 1 mm.; length of wing 8·2 to 10·1 mm. *T. mordax*

Slaty-black: dorsum of thorax covered with a thin greyish bloom, striped with grey, and clothed with minute, yellowish or whitish hairs; dorsum of abdomen with a more or less distinct, median, longitudinal stripe (composed of elongate, grey triangles, with their apices directed forwards and truncate), between which and the lateral margin on each side is a longitudinal series of very conspicuous and sharply defined, oblique, oval, light grey spots; lower portion of front immediately above antennæ produced into a very prominent, shining black, transverse protuberance, on the under surface of which the antennæ themselves are situated.

Although on a cursory examination *Tabanus mordax* may easily be mistaken for *T. leucostomus*, Lw., since the abdominal markings, in the female sex at any rate, are identical in each case, the former may be distinguished from the latter by the great development of the supra-antennal protuberance, and by the absence of an appendix to the anterior branch of the third longitudinal vein.

Tabanus par, Walker

Plate III., figs. 6 and 8–13

Occasional specimens of this tabanid are met with on the White Nile from Gebelein southwards, but it is rarely noticed boarding river steamers in any numbers. In the country behind Bor there were several small belts where females abounded but no males were seen. These females spent their time resting among the vegetation, especially the low dom palms, until some animal, such as a cow, approached, when they would at once fly off and attack it. They did not, however, seem to follow cattle very far. No eggs could be found, though a careful search was made in all the places that were considered likely to serve as breeding grounds, so a number of females, gorged with blood, was placed in a breeding-cage in which was also a dish containing mud, water, and growing grass and weeds. They fed on sugar and water and though the majority died within the first two days, the survivors eventually produced three small batches of eggs.

Breeding experiments

On some flowering bushes by Khor Felus, on the Sobat River, about seven miles from its junction with the White Nile, several males were taken, feeding on the flowers. Only two or three females were seen, but as there were no cattle grazing in the immediate vicinity it is probable that they had gone afield in search of more satisfying food.

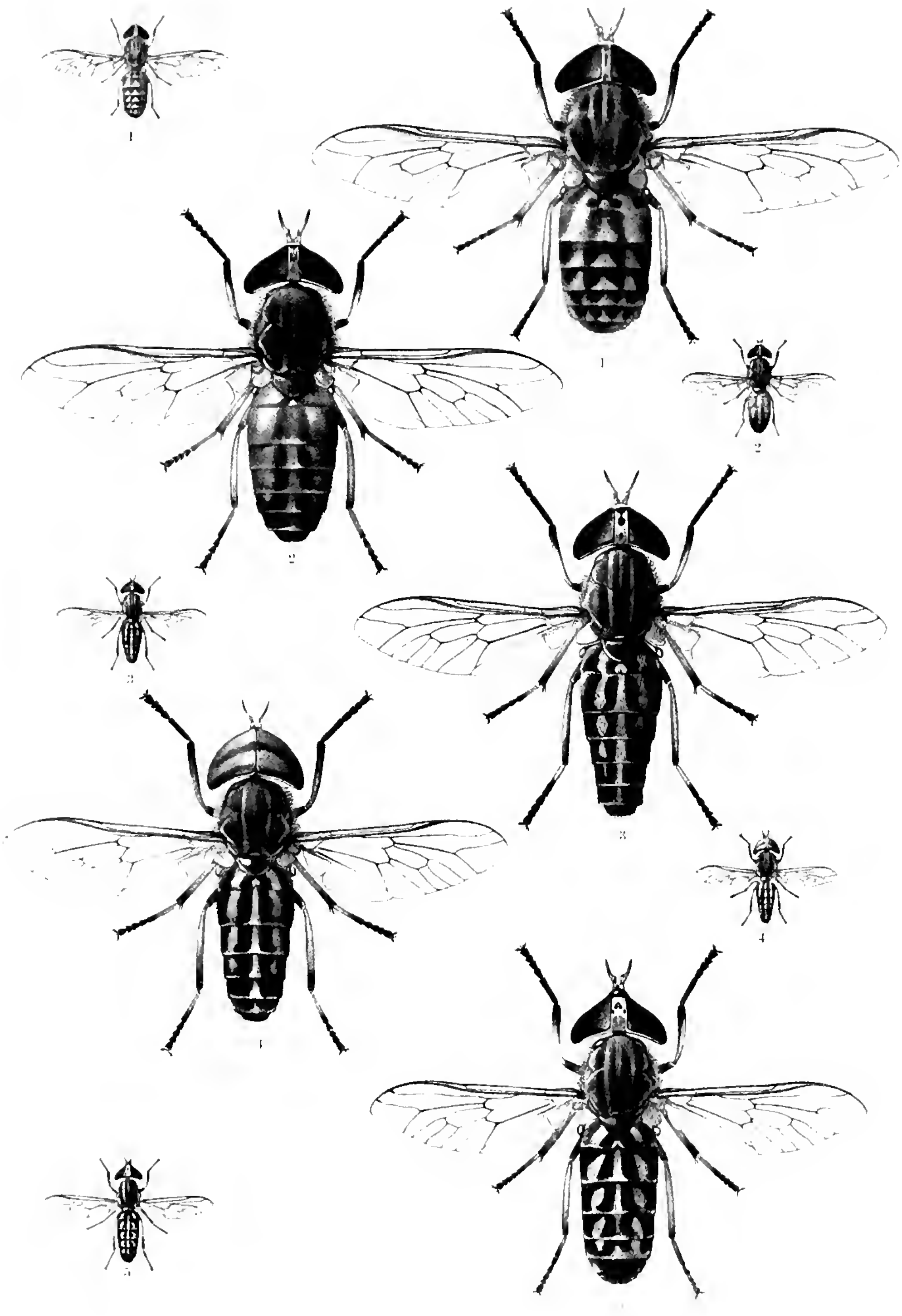
The eggs, obtained as described above, were deposited on May 23 and 24, on the undersides of the leaves of a water weed. Unlike the eggs of most members of the genus *Tabanus*, they were not closely packed in a rounded mass, but placed vertically and separately though in a cluster.[1] They hatched on May 30, and the tiny larvæ were divided into three lots and placed in glass basins containing mud, water and growing grass. These basins, for purposes of reference, were lettered A, B and C.

At the time when the eggs hatched, I was in the Sudd region, where it was impossible to land and obtain any subterraneous insect larvæ or tiny fresh-water crustaceans for them, so they were offered the expressed stomach contents of gorged female ticks—*Rhipicephalus simus*—taken from a dog. A few fed once or twice but the majority refused, and all buried themselves in the mud.

On June 11, the larvæ from A were transferred from mud to clean river sand and water, and given freshly killed mosquito larvæ. They fed on these readily and grew apace, though at greatly varying rates.

[1] The arrangement of the eggs in the cluster is not well shown in the figure.

PLATE II



1. *Tabanus distinctus*, Ric. ♀ 2. *Tabanus kingi*, Austen ♀
3. *Tabanus camelarius*, Austen ♀ 4. *Tabanus camelarius*, Austen
5. *Tabanus mordax*, Austen ♀

Small illustrations indicate natural size

The larvæ in B were also given mosquito larvæ from June 11, but they refused to feed, and the mud in which they were living was several times allowed to dry up. On July 11 they were placed in clean river sand and water, and at once began to feed and grow.

On July 19, I returned to Khartoum, and, owing to the difficulty in obtaining mosquito larvæ, changed their diet to freshly-killed and bruised earthworms. They did not take readily to this food and some died, while others disappeared from their basins. At the time it was thought that they had become cannibals, but eventually it was found they were being taken by mice. The stock of larvæ from A and B had by this time become reduced to one, which appeared to be full grown, and so was killed and preserved.

On July 26, the larvæ from C were transferred to clean river sand and water. It was then fifty-seven days since they had emerged from eggs, and they had spent a great part of that time in a dry cake of mud. Occasionally, this mud had been moistened, and food offered them, but they had very rarely taken it. Most of them were alive, but with the exception of a few which were slightly larger than when just hatched, they had not grown at all. They now, under more favourable conditions, fed readily on a mixed diet of earthworms and mosquito larvæ and grew, some rapidly, others more slowly. On September 3 1, one pupated lying on the surface of the sand, partly submerged in water, and six days later gave rise to an adult female.

Completion of life-cycle

By October 18, several more had completed their life-cycles, and, on that date, as I was proceeding to England on leave, the remaining ones were killed and preserved.

All those that pupated did so on the surface of the sand, some high and dry, others half in and half out of the water. Probably, under more natural conditions, the pupal stage would be passed buried in the soil—the structure of the pupal case seems to indicate this.

The average pupal period was from six to eight days.

Descriptions :—

The *egg* (Plate III., fig. 8) is spindle-shaped, about 1·15 mm. in length and white in colour, becoming darker as the embryo within develops.

The mature *larva* (Plate III., fig. 11), when fully extended, measures about 13·5 mm. Colour, white with a greyish tinge. Mandibles dark brown to black, serrated. On the anterior third of each abdominal segment, except the eighth, is a ring of pseudopods, eight in each ring—two dorsal, two lateral and four ventral—except on the first abdominal segment, where the two dorsal ones are wanting. On the second abdominal segment the two dorsal pseudopods are very small. The pseudopods are largest on the third, fourth and fifth abdominal segments, and are always more developed on the ventral than on the dorsal surface. Each pseudopod bears a crown of colourless spines or hooks, and there are patches of dark spines between the pseudopods. The spines on the dorsal sections of the rings on the first and second abdominal segments are dark. The anus is situated ventrally, at the base of the eighth segment and is fringed with blackish hairs. The siphon tube consists of two segments, and when exserted is as long as the eighth abdominal segment.

Characters of the mature larva

The *pupa* (Plate III., fig. 13) is from 12 mm. to 15 mm. in length and at first yellowish-white in colour, becoming darker as it nears maturity. The eyes show plainly through the pupal case as dark greenish-purple. The empty pupal case is yellowish-brown, the thoracic tubercles and the spiracles being darker than the surrounding parts. On the apical third of the second abdominal segment is a fine ring of backwardly pointing spines. Similar but broader rings bearing longer and stronger spines are on the third, fourth, fifth and sixth abdominal segments, and one of intermediate breadth on the seventh abdominal segment. The eighth abdominal segment terminates in a coronet of six teeth, in colour shining brown becoming darker at the tips. The dorsal pair are smallest and close together, the ventral pair next in size and wider apart and the lateral pair longest and arising from almost the same level as the dorsal pair. Ventrally placed to this coronet of teeth are two rows of small teeth, from two to four in each row, together forming an interrupted transverse row. These teeth are of unequal size and vary in their relative sizes in different specimens.

Characters of the pupa

Tabanus tæniola, Palisot de Beauvois

Plate III., figs. 1–5 and 7

This is the most common and most widely distributed tabanid found in the Anglo-Egyptian Sudan, and is the one most frequently accused of causing the death of camels. On the White Nile it occurs as far north as Dueim, and stray specimens, brought in by cattle, have occasionally been taken in Khartoum. Often it will board a river steamer, and being, like other seroots, a vicious blood-sucker, will drive any animals travelling on the barges nearly frantic with pain. It will follow cattle and other animals long distances—on one occasion, after walking straight inland from the river for five hours without seeing a single seroot of any kind, numbers of this tabanid in company with *Tabanus ditæniatus*, Macq., were found attacking a buffalo which they had doubtless followed from some fly belt near or through which the animal had passed. Males are rarely seen, though single specimens will sometimes board a river steamer, and early in June, 1909, some twenty or thirty of this species were noticed on flowering shrubs on Khor Felus, Sobat River.

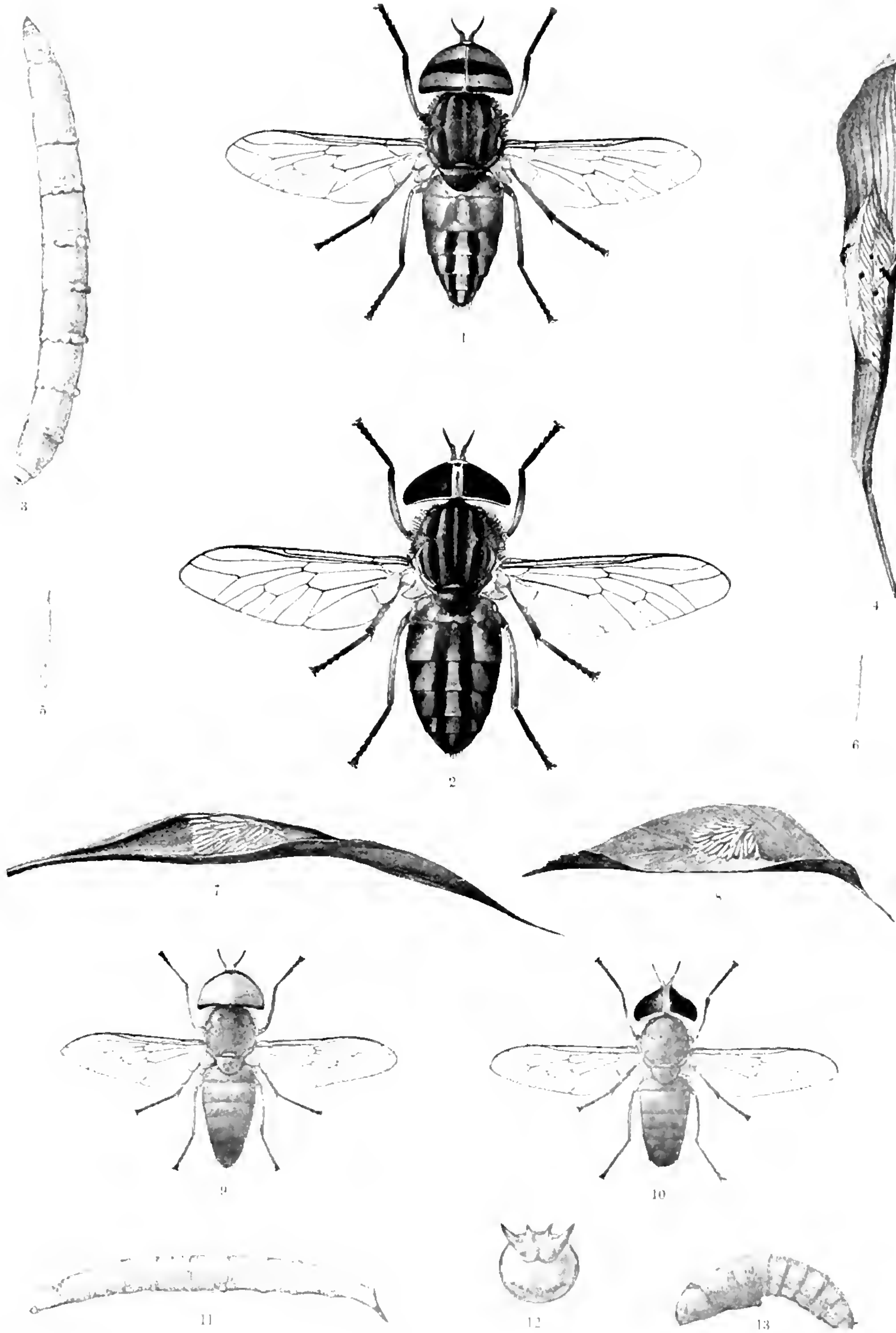
Persistence in following its victims

Gorged females were taken in May, on cattle grazing near Bor, and placed in a breeding-cage with a dish containing grass and weeds growing in mud and water. They were fed on sugar and water, and a few egg-masses were obtained. A single egg-batch was taken in May on a blade of grass overhanging a dried up water pool near Kanissa wood-station, and a number of egg-masses was collected early in July from grasses and weeds overhanging rain-pools at Gebelein.

The eggs are placed by the female fly on the upper side of a blade of grass or some similar plant and, with the exception of the single egg-mass taken at Kanissa wood-station, all those found were overhanging water. An unfinished egg-mass in plan resembles an arrow-head. The eggs are closely applied to each other and left bare, so that the mass can easily be seen when freshly laid, owing to its shining white to yellowish-white colour. Prior to hatching, the egg-mass becomes darker.

The eggs obtained in the breeding-cage were laid on May 24–25, and hatched on May 29. The larvæ were placed in glass basins containing mud, growing grass and water, and offered the expressed stomach contents of female ticks—*Rhipicephalus simus*—taken from a dog. They fed readily on this until June 11 when they were placed in clean river sand and water and their diet changed to mosquito larvæ. These mosquito larvæ were either killed or laid living on the wet sand out of reach of the water, when the tabanid larvæ were able to kill them. In water, the mosquito larvæ were too active to be caught. On July 16, their food was changed again to freshly-killed and bruised earthworms, and these they also ate readily. While still young they became vicious cannibals, and consequently each larva had to be given a separate dish. They were brought to Khartoum on July 19, and, a few days later, it was noticed that the majority were not taking their food. They were then nearly, if not quite, full grown, so it was thought that they had

PLATE III



Tabanus ton[illegible] [illegible] B.

1. Adult ♂
2. Adult ♀
3. Full-grown larva
4. Egg-mass with Chalcid parasites
5. Young larva
7. Egg-mass

Tabanus par. Walk.

6. Young larva
8. Egg mass
9. Adult ♂
10. Adult ♀
11. Larva, almost full-grown
12. Anal segments of pupa
13. Pupa

T. tæniola larvæ destroyed by mice

buried themselves in the sand prior to pupating. A careful search, however, revealed the fact that they had disappeared, and it was not until later that mice were discovered to be the cause of the loss. The two remaining larvæ were then killed and preserved. It is possible, therefore, that the larva described below is not quite mature.

T. tæniola larvæ are more active and ferocious than those of *T. par*, vigorously attacking any other larva with which they may come in contact. They have not, however, the power possessed by *T. par* of lying dormant in the soil for at least fifty-seven days if the conditions are unfavourable for their development.

Descriptions—

The *egg* (Plate III., fig. 7), is spindle-shaped, about 1·75 mm. in length and, when first laid, white in colour. It becomes darker as the embryo within develops.

The *larva* (Plate III., fig. 3), when fully extended, measures about 29 mm. Colour white to greyish-white. Mandibles black. On the anterior third of each abdominal segment, except the eighth, is a ring of pseudopods, eight in each ring—two dorsal, two lateral, four ventral—except on the first abdominal segment, where the dorsal pair are wanting. On the second abdominal segment the dorsal pair are very poorly developed. The ventral pseudopods are always larger than the dorsal. Each pseudopod bears a crown of colourless spines or hooks, and between the prolegs there are also spines or hooks, often darker in colour, and forming a continuous ring. The anus is situated ventrally at the base of the eighth abdominal segment and is edged with dark hairs. On either side of the anus is a patch of dark hair, roughly kidney-shaped, and beyond each patch, laterally placed on the segment, are two small round spots of dark hair. The siphon tube consists of two segments and when exserted is shorter than the eighth segment. The whole surface of the larva is more or less shiny, with varying longitudinal striation, the areas bearing very fine striæ being markedly duller than the rest. The prothorax has the dorsal area smooth in the anterior two-thirds and rather coarsely striate posteriorly; the ventral area is almost entirely smooth and divided in two by a median furrow; the two lateral areas are finely striated in the basal third and more coarsely so in the anterior parts. The mesothorax has the dorsal and ventral areas smooth and shining in the anterior two-thirds, and rather coarsely striate posteriorly, the ventral area having no furrow; the lateral areas are a little more finely striate than those of the prothorax, and there is a rather broad dull non-striated band at both the anterior and posterior margins. Similar dull bands occur on the metathorax and the abdominal segments, but completely encircling the segment. The abdominal segments 1 to 7 have the dorsal and ventral areas moderately shiny, and the striation is rather coarser and irregular; the lateral areas appear much duller, owing to the extreme fineness of the striation. On the eighth abdominal segment the striæ are moderately well-marked and of similar appearance on all the faces.

A parasitic enemy of the eggs of *T. tæniola*

A natural enemy. From an egg-mass of *T. tæniola*, taken at Gebelein, numbers of a small Hymenopteron were bred.[1] This has not yet been identified, but is figured in the accompanying plate, together with the parasitised egg-mass showing the exit hole of the parasites.

Tabanus ditæniatus, Macq.

Plate IV., figs. 1 and 2; Plate V., figs. 1–10

The distribution of this tabanid as given by Austen[2] is a very wide one. In Africa it occurs from the Transvaal in the south to Egypt in the north, while outside the bounds of

[1] This insect belongs to the family *Chalcididæ*, and has since been described under the name of *Telenomus beneficiens*, Crawford.—Guy A. K. Marshall.

[2] Austen, E. E. (1909), *African Blood-sucking Flies*, pp. 118, 119.

Africa it is found in Baluchistan, India, Ceylon, China and Japan. In the Anglo-Egyptian Sudan it occurs fairly commonly in the south, but until this year it had not been recorded from the northern provinces.

The larvæ were taken early in March of this year in a small water channel—locally known as a gudwal—on the estate belonging to the Sudan Plantation Syndicate, Ltd., at Zeidab, Berber Province. The water was for the most part overgrown with a covering of green slime, and if this was cleared away a few larvæ could generally be seen on the surface. On stirring up the mud at the bottom and edges of the water, more would appear, while if one waited for an hour or so specimens would continue to rise. They were apparently living in the mud at the bottom of the pools and coming periodically to the surface to breathe, for they could be seen rising to the surface by a lashing motion, and if left undisturbed would, after a few seconds, sink out of sight again.

Some forty odd larvæ of various sizes were taken on March 9 and placed in a jar containing water, slime and hollow grass stems—most of these had disappeared by the next morning, the larger ones having devoured their smaller brethren. On March 10 more than a hundred were secured, and, together with the survivors from the previous day, divided among three jars—only three jars were available—two containing wet mud and the third water with hollow grass stems and other debris. Earthworms were provided as food but were not taken very readily—the larvæ seemed to prefer to eat each other.

Larvæ of *T. ditæniatus*

They were brought to Khartoum on March 11, and the following morning each of the thirty-three, which was still living, was placed in a separate jar containing clean river-sand and water. They fed freely on tiny earthworms, but their numbers steadily decreased until about April 16, when the thirteen survivors, having attained maturity, ceased to feed. Up to this stage, if the sand in which they were living was allowed partially to dry out, they became very restless until water was given them again, but hereafter they preferred sand which was only slightly damp. In appearance as well as habits they altered considerably at this stage of their existence. While young and growing they possessed well developed pseudopods and conspicuous dark dorsal markings—now, however, their pseudopods became small and in colour they appeared uniform yellowish-white.

These thirteen larvæ were left undisturbed until April 26, when one specimen was washed out and found to have pupated—probably within the previous two days as the eyes had not begun to show the colour which they acquired later. On the following day, by carefully picking over the sand, two more pupæ were discovered. Prior to pupating, the larvæ had made a number of tunnels in the sand, and the pupæ were lying in a more or less upright position in the tunnels and near the surface.

On April 28, I left Khartoum and was absent travelling in the provinces until May 30, by which date one larva had died and twelve completed their life-cycles, producing eight females and four males. The first had emerged on April 29 or 30, so the period passed in the pupal stage was probably about six days.

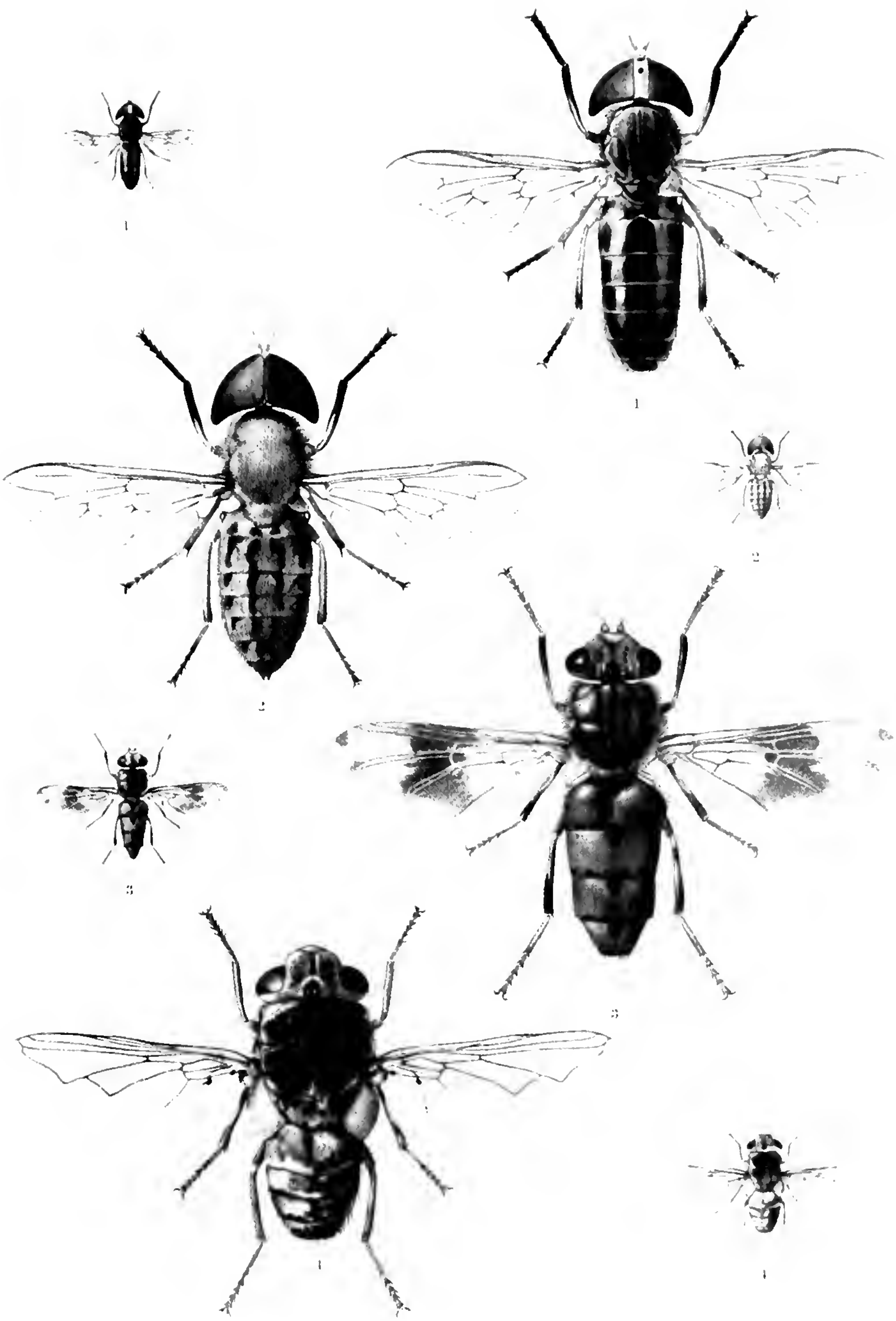
Descriptions—

Immature larva (Plate V., figs. 1–3)—Length, 18 mm. Colour yellowish-white with dark markings composed of pubescence. Mandibles dark brown to black, slightly serrated. Anterior margins of the meso- and meta-thoracic segments dark except on the venter. A ring of pseudopods, eight in each ring,—two dorsal, two lateral, four ventral—on the anterior third of each abdominal segment except the

Immature stage

eighth, well developed except the dorsal pairs on the first and second segments, and bearing spines or hooks. Spines are also situated between the pseudopods on each

PLATE IV



1. [illegible] Macq[illegible] 2. [illegible] Macq[illegible]
3. *Gastrophilus asin[illegible]*, Brauer 4. *Oest[illegible]*, Lw

[illegible] natural size

ring. The rings on the first and second segments edged before and behind with dark pubescence, especially on the dorsum, the pubescence extending between the dorsal and lateral pseudopods, thus enclosing the dorsal pseudopods in a dark ring. On each of the third to the seventh segments, inclusive, is a patch of dark pubescence between the lateral and dorsal and between the dorsal pseudopods—three patches on each ring—the median patch being conspicuous. To the naked eye these median patches constitute a median dorsal line of black dots. On each of the third to the sixth segments, inclusive, are two patches of dark pubescence immediately anterior to the dorsal pseudopods. The posterior margin of the eighth segment bears dark pubescence. The surface of the larva, other than that bearing pubescence, is shiny and longitudinally striated.

Mature larva (Plate V., figs. 1–7)—Length, 25 mm. Colour yellowish-white. Mandibles dark brown to black, slightly serrated. Thoracic segments shiny and longitudinally striated except the anterior margins which are opaque and pubescent. On the prothoracic segment are five longitudinal grooves—one ventral, two sublateral, two subdorsal—not extending to the posterior border. On the meso- and meta-thoracic segments are eight such grooves, four on either side. The first abdominal segment bears one pair of ventral pseudopods, the second segment one pair of ventral, one pair of lateral, the third to the seventh inclusive two pairs of ventral and one pair of lateral. Traces of most of the other pseudopods are present, especially of the dorsal pseudopods on the fourth to the seventh segments inclusive. The pseudopods bear small colourless spines or hooks and similar though smaller spines are situated between the pseudopods and on the dorsum of the first, second and third segments where the pseudopods are wanting. On the dorsum of the first and second segments these spines constitute a double band. The posterior thirds of the abdominal segments are shiny and longitudinally striated. The anus is edged with pubescence. The siphon when exserted appears rather shorter than the eighth segment. Description of the mature larva

Pupal case (Plate V., figs. 8–10)—Length, 17 mm. Colour yellowish-brown, thoracic tubercles and abdominal spiracles darker, the former bearing hairs. On the posterior third of the second to the seventh abdominal segments inclusive is a ring of backwardly pointing spines, shortest on the second segment and longest on the seventh. The eighth segment terminates in a coronet of six teeth chestnut-brown in colour, darker at the tips, the lateral pair by far the largest, the dorsal and ventral pairs being about equal in size, the former sometimes slightly the larger. The dorsal pairs arise from between the lateral teeth, the four teeth constituting a row. Ventrally placed to this coronet are two rows of similar teeth, each row consisting of from two to five teeth, the two rows together constituting an interrupted transverse row. These teeth are unequal and vary in size and number in different specimens.

The pupa, when first formed, is yellow with a greenish tinge, especially on the thorax. Later, as the image within develops, the eyes show a deep maroon, and the thorax becomes generally darker.

Tabanus kingi, Austen

Bulletin of Entomological Research, Vol. I., p. 291, January, 1911

Plate II., fig. 2; Plate V., figs. 11–18

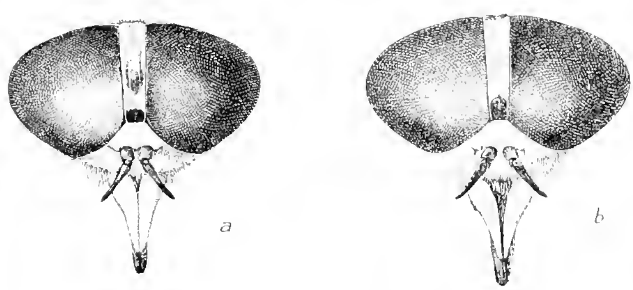
♀ Length (four specimens) 13 to 16 mm.; width of head 4·4 to 5·5 mm.; width of front at vertex 0·5 mm. to just under 1 mm.; length of wing 10 to 13 mm. *Tabanus kingi*

Superficially somewhat resembling *T. tæniola*, Pal. de Beauv., but distinguished by the more quadrate shape and blacker colour of the frontal callus (*vide* Fig. 12), the more

T. [illegible] *kin*[illegible]

ochraceous-rufous colour and usually greater breadth of the proximal portion of the third joint of the antennæ, the absence of conspicuous longitudinal stripes on the dorsum of the thorax, the less clearly defined median stripe or median longitudinal series of lighter markings on the dorsum of the abdomen, by the presence of an appendix to the anterior branch of the third vein, and by the middle and posterior femora being fawn-coloured instead of slate-grey. Dorsum of thorax mouse-grey, clothed with minute, appressed, buff-yellow mixed with minute black hairs; dorsum of abdomen tawny-ochraceous or ochraceous, with alternate longitudinal series of light and dark markings, last two segments clove-brown; wings tinged with sepia, anterior branch of third longitudinal vein bent at an angle, with a backwardly directed stump or appendix.

Head: light grey, occiput somewhat darker than face and jowls, front yellowish-grey, of moderate breadth, inner margins of eyes parallel, a more or less faintly marked light mummy-brown horizontal band between base of each antenna and margin of eye on same side; frontal callus black or clove-brown, rectangular, broader than high; front clothed with short, erect, blackish hair, immediately above callus with yellowish hair, lower surface of head clothed with whitish hair; *palpi* cream coloured, proximal joint clothed with whitish hair, terminal joint moderately swollen at base, then tapering to a point, clothed with minute, appressed, pale straw-yellow hairs, sometimes mixed in front with a few minute black hairs; first and second joints of antennæ ochraceous-buff, first joint clothed below with pale-yellowish and above with minute black hairs, third joint ochraceous-rufous with dark brown distal extremity, expanded portion of third joint fairly broad, terminal annuli shorter than in *T. tæniola*, Pal. de Beauv.



(*a*) *Tabanus kingi* ♀
(*b*) *Tabanus tæniola*, ♀

Thorax: Dorsum with but a faint trace of paler longitudinal stripes; swelling in presutural depression on each side tinged with fawn-colour, and clothed with fairly long blackish hair; pleuræ and pectus grey or smoke-grey, clothed with whitish hair, *scutellum* agreeing with remainder of dorsum in coloration and hairy covering.

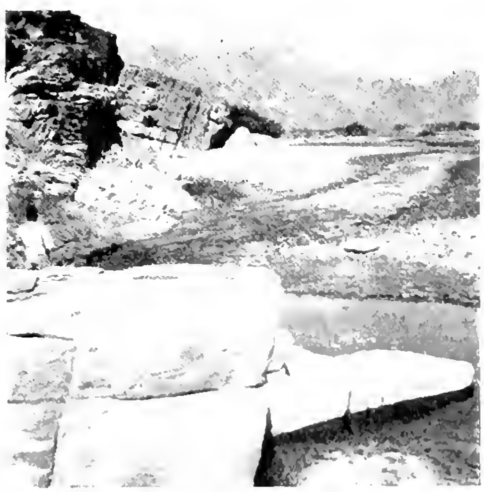
Abdomen: Dorsum marked as shown in Plate II., fig. 2, except that the median pale greyish stripe, which is clothed with minute, appressed, yellowish hairs, is sometimes more distinctly composed of a series of truncate triangles; when abdomen is viewed at a low angle from behind, median stripe or truncate triangle on second (*i.e.* second visible) segment is seen to extend, like its successors, to front margin of segment; hind margin of first segment with a small patch of yellowish hairs in middle line; admedian stripes dark sepia-coloured, clothed, like dark patch near each lateral margin of each of the first five segments, with minute black hairs; each of the first five segments with an elongate and somewhat ill-defined pale mark (clothed with minute buff-yellow hairs) on each side of middle line, between admedian stripe and dark patch near lateral margin; extreme lateral margins of first six segments clothed with whitish hair, hind margins of fifth and sixth segments clothed for most part with yellowish hair; sixth and seventh segments except posterior and lateral margins of former, clothed with black hair; venter ochraceous-buff, clothed with minute, appressed, straw-yellow hairs, hind margins of second to sixth segments inclusive cream-coloured or whitish, seventh segment entirely or for the most part dark greyish-brown, clothed with erect black hair, sixth segment also with some black hairs in centre, fifth and sixth segments sometimes more or less infuscated, especially towards posterior and lateral margins. Squamæ isabella-coloured, with buff margins. Halteres ochraceous-buff, tips of knobs cream-coloured.

Legs: Coxæ olive-grey or smoke-grey, clothed with whitish hair; rest of front legs black, except proximal halves, or rather less, of tibiæ, which are cream-coloured and clothed with minute, appressed, pale yellowish hairs; outer side of front femora greyish pollinose, clothed with fine yellowish hair, middle and hind femora fawn-coloured, clothed with pale yellowish hair; middle and hind tibiæ buff, brownish at tips, clothed partly with black and partly with yellowish hair; middle and hind tarsi dark brown, darker towards distal extremities.

Tabanus kingi is allied to an at present undescribed species of *Tabanus*, of which specimens from Abyssinia are contained in the British Museum collection. The Abyssinian species, however, which agrees with *T. kingi* in the shape of its frontal callus and in the anterior branch of the third vein being bent at an angle and provided with an appendix, is distinguished from it, at any rate in the female sex, by:—the frontal callus being dark mummy-brown instead of black or clove-brown; by the much darker colour of the dorsal surface of the body; by the dorsum of the thorax being distinctly striped, and clothed mainly with black instead of with buff-yellow hair, by the series of pale marks on the dorsum of the abdomen, outside the admedian stripes, taking the form of clearly defined light grey spots, which are distinctly ovate in shape; and by the ground colour of all the femora, and not merely of those of the front legs, being black.

A haunt of *T. kingi*

Khor Arbat (Fig. 13), the locality in which this seroot occurs, is situated about twenty-two miles N.N.W. of Port Sudan, and consists of a stream of slightly brackish water running in a gorge in the rocky hills. On emerging from the hills into the plain the stream loses itself in the sand. In the autumn, during the brief rainy season, it comes down in spate, and is then of considerable size, but in April—the month in which these observations were made—it is, except where pools exist, not more than a few inches in depth. The bed of the stream is stony and there is little or no vegetation growing on its banks.



Situations chosen for ovipositing

The female fly (Plate II., fig. 2) deposits her eggs in a rounded mass on a rock rising sheer from the water (Fig. 14) generally slightly overhanging, and from 6 inches to 15 inches above water level. Rocks chosen for this purpose overhang comparatively deep pools—from 18 inches upwards—in which the water moves but slowly. Such rocks occur only every here and there—in the mile or so of stream searched—only three rocks bearing traces of having been used by this tabanid for purposes of ovipositing being found. On one of them were the remains of several hundred egg-masses lining a small crack in the face of the rock from 2 feet to $3\frac{1}{2}$ feet above the water level. As none of the fresh egg-masses found were situated more than 15 inches above water level, these old masses had probably been deposited when that level was higher. Altogether seven females were taken in the act of ovipositing, and several more seen. No particular time of the day seems to be chosen for the act—one was taken ovipositing at 11.40 a.m. and another at 4.40 p.m.—and unlike *T. biguttatus*, Wied., the only other seroot I have observed ovipositing in the field, this tabanid does not lose her natural wariness while engaged in depositing her eggs. In fact, she is often more difficult to capture then than when merely sunning herself on a rock.

Ta anus king.

The egg-masses (Plate V., fig. 12) vary in size, and no count of the number of eggs contained was made, but the average mass is believed to consist of about five hundred. When freshly laid the mass is glistening white and can be seen from a considerable distance, but within a few hours it takes on a mottled grey hue which so closely resembles the colour of the rock that it is not easily detected. While the fly is occupied in laying her eggs, numbers of a tiny Hymenopteron assemble and proceed to add their eggs to the mass, continuing to do so after the fly has gone away. From some twenty egg-masses collected from the rocks about equal numbers of this egg parasite and of the tabanid larva were obtained. Specimens of this Hymenopteron have been sent to the Scientific Secretary of the Entomological Research Committee for determination.[1]

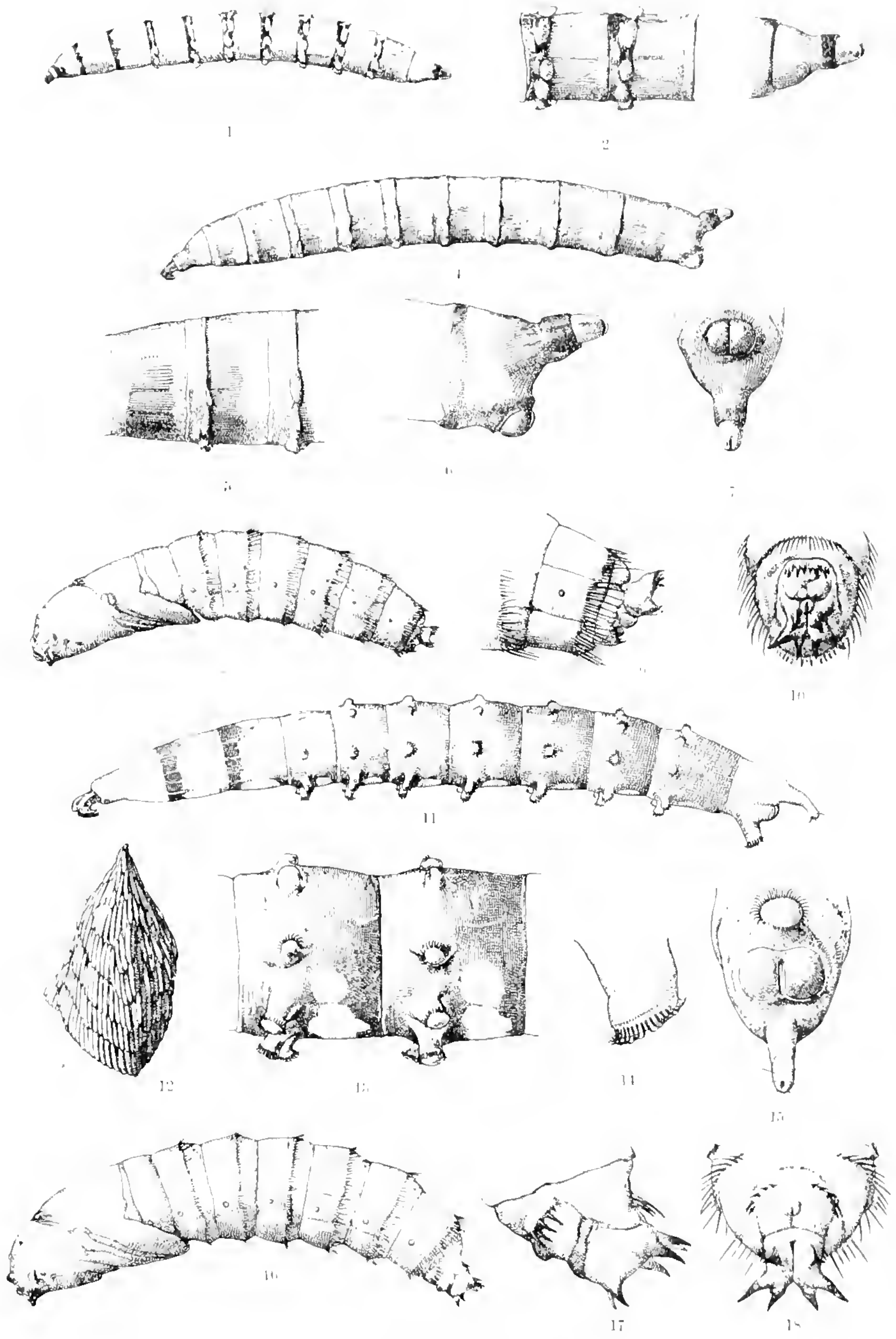
Incubation period

One seroot, taken in the act of ovipositing, completed her egg-laying in a collecting box on the evening of April 13. These eggs had hatched by the morning of April 19, the incubation period being therefore about five days. Under normal conditions, exposed to the sun, it may possibly be less. The larvæ from these eggs were allowed to fall from the egg-mass into a basin containing water and stones and were provided with portions of earthworms, and tiny coleopterous and dipterous larvæ obtained from wet moss. They refused to feed, however, and all perished—probably at this stage of their existence they require brackish running water.

In places, the stream at Khor Arbat is very shallow and ripples over and around stones—under these stones, larvæ of various sizes, mostly nearly mature, were taken. Apparently, stones which were not quite or were barely covered with water were chosen by the larvæ in order that they might come up to breathe without losing their hold and so be in danger of being carried away by the current. Usually only a single larva was found under one stone, and, in every case where two or three were together, a mortal combat was taking place. If a larva was placed on one's hand it would at once endeavour to drive its mouth hooks through the skin, and where the skin was thin it would succeed in inflicting a sharp pricking pain. Owing to their cannibalistic habits the number of larvæ which could be transported was restricted to the number of vessels available, so, though nearly two hundred were taken from the stream, only forty-two were brought alive to Khartoum. There they were placed in jars containing coarse sand (brought from Khor Arbat) and water, and fed on medium-sized earthworms. They took these willingly when hungry but appeared to need food only once every two or three days.

[1] This proved to be a new species of *Chalcida*, and has been described by Mr. J. C. Crawford, of Washington, under the name of *Telenomus Kingi*—Guy A. K. Marshall.

PLATE V



1–10. *Tabanus ditaeniatus*, Macq.

1. Lateral view of immature larva × 3 *diam.*
2. Third and fourth abdominal segments of immature larva × 6 *diam.*
3. Eighth abdominal segment of immature larva × 6 *diam.*
4. Lateral view of mature larva × 3 *diam.*
5. Lateral view of first and second abdominal segments of mature larva × 6 *diam.*
6. Lateral view of anal segment of mature larva × 6 *diam.*
7. Posterior view of anal segment of mature larva (inverted) × 6 *diam.*
8. Lateral view of pupa × 3 *diam.*
9. Lateral view of sixth, seventh and eighth abdominal segments of pupa × 6 *diam.*
10. Posterior view of eighth abdominal segment of pupa (inverted) × 6 *diam.*

11–18. *Tabanus* [illegible], Austen

11. Lateral view of mature larva × 3 *diam.*
12. Egg-mass × 6 *diam.*
13. Lateral view of fourth and fifth abdominal segments of mature larva × 6 *diam.*
14. Lateral view of anal pseudopod of mature larva.
15. Posterior view of anal segment of mature larva (inverted) × 6 *diam.*
16. Lateral view of pupal case × 3 *diam.*
17. Lateral view of anal segment of pupal case × 6 *diam.*
18. Posterior view of anal segment of pupal case (inverted) × 6 *diam.*

I left Khartoum on April 28, and on my return on May 30, the majority of these larvæ were dead one, however, had completed its life-cycle and seven were still living. Six of these seven pupated during the next three weeks but died as pupæ. The pupal period is probably about six days, for one which pupated on May 5 appeared to be mature on May 11, when it perished.

One empty pupal case was taken under a stone in the bed of the Khor Arbat stream—the fly must have crept up the stone through several inches of running water before gaining the air.

Marked differences between larval stage of *T. kingi* and *T. tæniola*

Although this tabanid in its adult form closely resembles *T. tæniola*, Pal. de Beauv., in its larval stage it differs markedly from that species. The larva is admirably adapted for clinging to stones in rapidly running water, its unusually long pseudopods, armed with powerful hooks, being retractile and capable of being used as suckers. None of the tabanid larvæ which I have seen hitherto have possessed an anal proleg.

Besides the seven specimens mentioned above as having been taken in the act of ovipositing, two more were caught sucking blood from camels. No males were seen.

Descriptions—

Egg.—Length, 2 mm. Colour white, becoming darker as the embryo within develops. Spindle-shaped.

Description of larva of *T. kingi*

Mature larva (Plate V., figs. 11, 13–15). Length, 35 mm. Colour, pale grey to dusky-grey to deep chestnut-brown. Mandibles, dark brown to black, long and powerful, slightly serrated. Anterior margins of meso- and meta-thoracic segments dark. A smooth shiny pale area on the dorsum of each thoracic segment—on the prothorax this area is concave anteriorly, convex posteriorly and with parallel sides; on the meso- and meta-thoracic segments it appears to the naked eye diamond-shaped, though sometimes it is actually hexagonal. On the venter of the prothorax are two shiny pale longitudinal areas, each bearing several long black hairs arising from a single pore; a similar but larger area is striated on each of the meso- and meta-thoracic segments, bearing two similar tufts of hair. On either side of the meso- and meta-thoracic segments are three longitudinal areas not extending to the margins of the segments, longitudinally and deeply striated. On the anterior margins of the meso- and meta-thoracic segments on either side are four paler lines extending backwards to form the divisions and edges of the three striated areas. On the anterior third of each abdominal segment except the eighth is a ring of pseudopods, eight in each ring—two dorsal, two lateral, four ventral—except on the first segment where the dorsal pair is wanting. The dorsal pseudopods are never well developed, and, with the exception of those on the fifth, sixth and seventh segments, unprovided with hooks. The lateral and ventral pseudopods are very long and bear at the apices long, strong hooks, chestnut-brown in colour, sometimes darker at the tips. On the median pair of ventral pseudopods on the fourth, fifth and sixth segments these hooks form a complete circle, but on the remaining pseudopods bearing hooks the circle is incomplete. Immediately below these hooks is a row of tiny spines. Immediately behind the ventral pseudopods on the first to the seventh segments inclusive is a shiny striated area. On the venter of the eighth segment, anteriorly placed to the anus, is a pseudopod equal in size and similar to the ventral pseudopods on the other segments, and bearing an incomplete circle of hooks. Scattered over the surface of the larva are occasional black hairs. The siphon, when exserted, is shorter than the eighth segment, and bears a number of black hairs. The dark appearance of the larva is due to tiny dots of pubescence arranged closely together, except on the shiny areas mentioned above.

The skin of the larva frequently bears scars of old wounds.

Pupal case (Plate V., figs. 16–18). Length, 20 mm. Colour, yellowish-brown, thoracic tubercles and abdominal spiracles darker, the former bearing hairs. On the posterior third of the second to the seventh abdominal segments inclusive is a ring of backwardly pointing spines, shortest on the second segment and longest on the seventh. The eighth segment terminates in a coronet of six teeth, chestnut-brown in colour, darker at the tips, the lateral pair by far the largest, the dorsal and ventral pairs being equal in size. These teeth are arranged roughly in a circle. Ventrally placed to this coronet are two rows of five comparatively thin spines, of varying lengths, together constituting an interrupted transverse row. Dorso-laterally placed to the coronet are two rows of spines similar to the ventral row.

The dorsum of the abdomen is sometimes clothed with black pubescence arranged in four longitudinal stripes. On the sixth and seventh segments these stripes merge and on the seventh segment the pubescence is confined to the posterior third. The pubescence is wanting on the dorsum of the eighth segment but is present on the venter of the seventh and a small patch is situated immediately below the coronet on the eighth segment.

The pupa when first formed is yellowish. Later, as the imago develops, the eyes show as dark with a greenish tinge and the thorax becomes generally darker.

My thanks are due to Captain W. B. Fry, R.A.M.C., for tending the larvæ of *Tabanus ditæniatus* and *T. kingi*, while I was away from Khartoum.

LIST OF BLOOD-SUCKING FLIES, OTHER THAN MOSQUITOES, RECORDED FROM THE ANGLO-EGYPTIAN SUDAN WITH THE LOCALITIES IN WHICH THEY ARE KNOWN TO OCCUR:—

CHIRONOMIDÆ *Culicoides* sp. (Plate VI., fig. 9).—Khor Arbat.

Culicoides sp. incert. (Plate VI., fig. 10)—Bor (Rev. Shaw).

SIMULIDÆ *Simulium damnosum*, Theob. (Plate VI., fig. 8).—Third Cataract; Selim; Shereik (Capt. F. Burges); Abu Hamed; Khartoum.

Simulium griseicollis, Becker (Plate VI., fig. 7).—Third Cataract to Khartoum.

Simulium sp. incert.—Erkowit.

PYSCHODIDÆ *Phlebotomus papatasii*, Scop.—Khartoum.

Phlebotomus sp. incert.—Khartoum.

TABANIDÆ *Chrysops brucei*, Aus.—Lake No; Sudd Region; Shambe; Bor; Lado District (Captain Mackenzie, D.S.O., R.A.M.C.).

Chrysops distinctipennis, Aus.—Lake No; Bor.

Pangonia ruppellii, Jænn.—Kurora; Gedaref (K. Cornwallis); near Gebelein (C. E. Lyall); El-Obeid (El-Bimb. Williams); Rufaa.

Tabanus africanus, Gray.—White Nile from Gebelein southwards.

Tabanus latipes, Macq.—White Nile from Gebelein southwards.

Tabanus fasciatus, Fabr. sub-sp. *niloticus*, Aus.—White Nile from Gebelein southwards.

Tabanus biguttatus, Wied.—White Nile from Gebelein southwards; Bahr-El-Zeraf (L. Landon); Kongor; Gebel Katla, Kordofan (Captain Hills, A.S.C.); Talodi (Lieut. N. G. B. Halhed).

Tabanus ditæniatus, Macq. (Plate IV., figs. 1 and 2). Zeidab; near Gedaref (Captain Knott, A.V.C.); Ragabah (Captain Mackenzie, D.S.O.); White Nile from Gebelein southwards and southern provinces generally.

TABANIDÆ (*continued*)

Tabanus par, Walk. (Plate III., figs. 9 and 10).—Southern provinces generally.

Tabanus gratus, Lw.—Third Cataract.

Tabanus leucostomus, Lw.—

Tabanus sufis, Jaenn. (Plate I., figs. 4 and 5).—Third Cataract; Darmali; Zeidab; Shendi; Khartoum; Khor Arbat; Blue Nile (Dr. W. Beam); Gebelein; Renk wood-station.

Tabanus tæniola, Pal. de Beauv. (Plate III., figs. 1 and 2).—Near Gedaref (Captain Knott, A.V.C.); Blue Nile (Dr. W. Beam); Kordofan; White Nile from Dueim southwards and southern provinces generally.

Tabanus unitæniatus, Ric.—Wau.

Tabanus kingi, Aus. (Plate II., fig. 2).—Khor Arbat.

Tabanus camelarius, Aus. (Plate II., figs. 3 and 4).—Khor Arbat.

Tabanus mordax, Aus. (Plate II., fig. 5).—Khor Arbat.

Tabanus sp. incert.—Malakal.

Tabanus sp. incert.—Ragaa (Major Percival); Dem Zubeir (Captain Drew, R.A.M.C.).

Tabanus sp. incert.—Lado District (Captain Mackenzie, D.S.O.).

Hæmatopota brunnescens, Ric. (Plate I., fig. 3).—Taufikia.

Hæmatopota tenuis, Aus.—Shambe; Bor; about forty miles north of Gondokoro; Lado District (Captain Mackenzie, D.S.O.).

Hæmatopota denshamii, Aus.—Southern Bahr-El-Ghazal; Lado District (Captain Mackenzie, D.S.O.).

Hæmatopota decora, Walk.—Bahr-El-Ghazal (Captain Hadow).

Hæmatopota vittata, Lw. (syn. *pulchrithorax*, Austen).—Lado District (Captain Mackenzie, D.S.O.).

Hæmatopota taciturna, Aus.—

Hippocentrum versicolor, Aus.—Lado District (Captain Mackenzie, D.S.O.)

MUSCIDÆ

Glossina palpalis, Rob.-Desv.—Bahr-El-Ghazal Province; Lado District.

Glossina morsitans, Westw.—Southern Kordofan; Bahr-El-Ghazal Province; Lado District.

Stomoxys calcitrans, L.—Selim; Khartoum; Gedaref (K. Cornwallis); Renk; Mafaza.

Stomoxys nigra, Macq.—White Nile from Renk southwards; Ragabah (Captain Mackenzie, D.S.O.); Mafaza.

Lyperosia minuta, Bezzi (Plate VI., fig. 2).—Berber; Khartoum; El-Obeid (El-Bimb. Williams).

Lyperosia thirouxi, Roubaud (Plate VI., fig. 3).—Gebelein.

Lyperosia exigua, de Meijere (Plate VI., fig. 1).—Near Meshra-El-Zeraf.

HIPPOBOSCIDÆ

Hippobosca camelina, Leach.—Desert provinces generally.

Hippobosca capensis, V. Olf.—Port Sudan (Dr. E. V. Crispin); Berber.

Hippobosca maculata, Leach.—Desert provinces generally; White Nile.

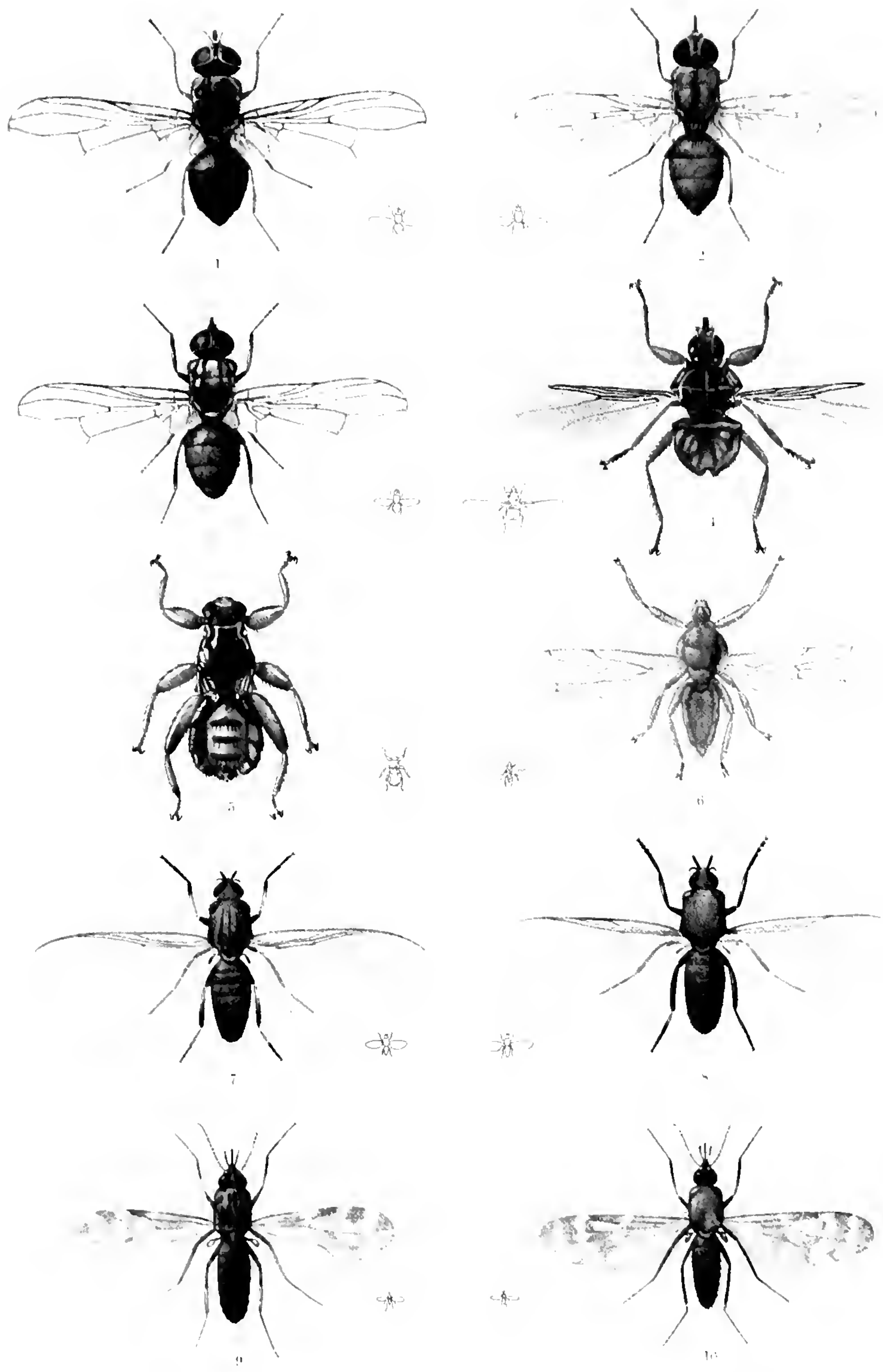
Lynchia maura, Bigot (Plate VI., fig. 4).—El-Obeid (Lieut. N. G. B. Hallhed).

Nycteribosca africana, Walk. (Plate VI., fig. 6).—Khartoum.

Lipoptera chalcomelæna, Speiser.—Port Sudan (Dr. E. V. Crispin).

Echestypus sepiaceus, Speiser (Plate VI., fig. 5).—Kio.

PLATE VI



Functions of the
Wellcome Tropical Research Laboratories
Gordon Memorial College, Khartoum

a. The study of tropical hygiene and of tropical disorders, both of man and beast, especially the communicable diseases peculiar to the Sudan; and to render assistance to the Officers of Health and to the clinics of the Civil and Military hospitals.

b. The study of plant diseases, both those due to fungi and other vegetable parasites, and those caused by insects; the study of harmful and beneficial insects, and especially of insects in their relation to tropical medicine.

c. To carry out investigations in connection with cases of poisoning, and to develop methods for the detection of the toxic agents which may be employed by the natives.

d. To carry out chemical and bacteriological tests in connection with water, food-stuffs, and other sanitary questions.

e. To make analyses or assays of minerals, ores, fuels, etc.

f. To carry out investigations in connection with agricultural and forest products or operations, and, generally speaking, of any material which may be of practical interest in the economic development of the Sudan.

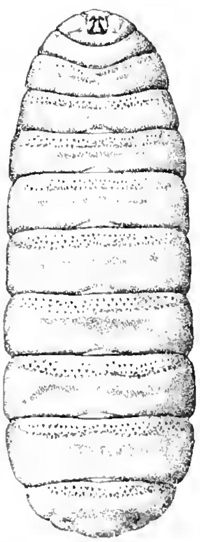
CIMICIDÆ

When the last Report of these Laboratories was issued, it was believed that bed-bugs were responsible for the spread of the usually fatal disease known as kala azar. Since then, however, the researches of Capt. D. S. B. Thomson and Lieut. W. E. Marshall, R.A.M.C., in this country, and of others working elsewhere, seem to prove that in this case, at any rate, these obnoxious insects may possibly have been unjustly accused.

Of the two species found in the Sudan, *Cimex lectularius*, Linn., occurs thoughout the northern provinces, and has also been taken at Bor and other stations in the south. *Cimex rotundatus*, Sig., has twice been taken at Port Sudan and at Suakin on pilgrims from Yemen. Quite recently Captain Percival sent specimens from the Lado District.

OESTRIDÆ

Comparatively little is known at present of the *Œstridæ* of the Sudan. *Œstrus ovis*, L., occurs but does not appear to be common. Mr. G. H. Storrar, Sudan Government Railways, bred out one specimen from a larva expelled from a goat at Rabak in 1909, and occasionally it is noticed in Khartoum. Almost every hartebeeste which one kills on the White Nile harbours the larvæ of *Œstrus variolosus*, Lw. (Plate IV., fig. 4 and figs. 15 and 16), and numbers have been received here, taken from hartebeeste shot on the Blue Nile. The larva of another species of *Cephalomyia* (*C. maculata*, Wied.) is a common parasite of camels.



Œstrus [illegible], × [illegible] diam.

Œstrus [illegible], × [illegible] diam.

A single adult specimen of *Gastrophilus flavipes*, Oliv., was taken in Khartoum in 1909 by El-Bimb. Williams, Veterinary Department, and an adult female of *Gastrophilus asinus*, Brauer (Plate IV., fig. 3), was captured near Renk in June, 1909, attempting to oviposit on the legs of a donkey. It was interesting to notice how panic-stricken a donkey became on hearing the distinctive hum made by this fly when on the wing. Three loose donkeys, on hearing it, stampeded, and when the œstrid transferred its attentions to another donkey tethered near by, this unfortunate animal, unable to get away, rolled on the ground, kicking as if in the last stages of fright. These same donkeys would show little or no excitement when numbers of seroots were sucking, or attempting to suck, blood from them.

Mr. J. C. Walker, Sudan Government Railways, has sent to these laboratories a number of œstrid larvæ taken from under the skin of an ariel gazelle shot at Khor Arab; the larva of another species has been taken by Mr. MacMichael from a similar situation in a dorcas gazelle killed at Gebel Sungur, N.W. Kordofan, and Captain Spencer has sent yet another specimen from gazelles shot in the Red Sea Province. Larvæ of a different species living under the skin of a bohor reed-buck, shot on the Meshra-Wau road in May, 1909, have been received from Col. Mathias, D.S.O., P.M.O. Egyptian Army.

Ticks

Ixodoidea

Ticks

There are now twenty-one species of ticks known to occur in this country. Of these, the following species have been placed on record since the last Report of these Laboratories was issued:

Argas brumpti. Nine immature specimens were taken among the rocks at the foot of one of the hills or gebels at Gebelein. This tick was originally described from specimens taken by Dr. Brumpt in somewhat similar situations in Somaliland. Judging from the effects produced by a nymph which attached itself to my forearm one evening, its bite is a thing to be carefully avoided. At the time, the pain was hardly noticeable and the tick was allowed to remain sucking blood for several minutes until circumstances compelled me to remove it. As I am usually very resistant to the bites and stings of ticks and insects, I was considerably surprised to find the following morning that the site of the puncture was marked by a small hard red lump around which was a slightly swollen and very much discoloured area, resembling a bruise, some three inches long and two inches wide. The discoloration lasted for several days, while the hard red lump remained for weeks and was sometimes the seat of a certain amount of pruritis.

A. brumpti probably attacks wild animals as well as man—from the fact that the Arabs living around Gebelein were unaware of the presence of "Khaim" (as they term ticks of the genera *Argas* and *Ornithodoros*) in the gebels, it seems probable that it relies almost entirely on creatures other than human beings for its food. These gebels harbour leopards, warthogs, hyænas, honey-badgers, conies, etc., besides untold myriads of bats.

Argas vespertilionis.—Eight larvæ were taken from an undetermined species of bat, in Khartoum. They differ slightly in appearance from English specimens.

Hæmaphysalis leachi.—This species has been taken on the dog and hare, on the White Nile, and on a stoat (? possibly a species of mongoose) at Erkowit (Dr. E. V. Crispin, Sudan Medical Department).

Dermacentor rhinocerotis.—A large number of both sexes was taken on grass and bushes in the vicinity of Azzar, a few miles south of Bor.

Specimens of this tick were also collected by Major Brakenridge, R.A.M.C., from a rhinoceros shot by H.R.H. the Duke of Connaught in British East Africa.

Ixodes sp.—A single female was taken from a dog, at Renk wood-station, and a nymph of what may be the same species, also from a dog, at Kaka wood-station. The adult specimen differs from *I. cavipalpus* in possessing a longer scutum but in other respects closely resembles that species. Owing to its mouth-parts being broken it cannot be definitely determined.

Aponomma exornatum.—This has been taken a few miles south of Meshra-el-Zeraf on the White Nile, and at Kassala (Captain Bousfield, R.A.M.C.), in both cases from a large lizard.

Aponomma sp. incert.—A nymph of a species of *Aponomma* which could not be determined, was found with its rostrum buried in the quill of a partially-formed feather on a wild guinea-fowl at Azzar. This is the first instance recorded of a member of this genus attacking a bird.

Amblyomma tholloni.—A single female was taken on an elephant.

Amblyomma sp. incert.

For the determinations of these ticks I am indebted to Professor G. H. F. Nuttall, F.R.S., who very kindly examined a quantity of material collected on the White Nile in 1909.

The tick referred to in the last Report, issued by these Laboratories, as *Margaropus annulatus* var. *decolorata*, has been determined by Professor Nuttall to be identical with *Boophilus australis*. This species appears to be widely distributed throughout the southern provinces, and a number of specimens has been received from Portuguese East Africa. *Ornithodoros savignyi* has been taken by Mr. H. A. MacMichael in several parts of Kordofan, and no fewer than three hundred and seventy specimens were collected, in the space of two hours, from under a single tree by a well, a few miles N.N.E. of Khartoum North in August, 1909. This tick has been the subject of some investigations carried out by the Bacteriological Section of these Laboratories.

In the following synoptic table of Sudanese ticks, as far as possible, only those characters which can readily be made out are utilised. Many of these characters are those used by Salmon and Stiles in their work on the cattle ticks of the United States.* This table is incomplete as regards some of the species of *Amblyomma* owing to lack of available material, but all the recorded members of this genus are nevertheless mentioned. *Ornithodoros moubata*, the transmitter of relapsing fever in Uganda and elsewhere, is included, as it is more than possible that it occurs in the Bahr-El-Ghazal and other southern provinces, and in any case it is useful to be able to distinguish between it and the closely allied *O. savignyi*. It must be remembered that although this table deals with all the species known at present to occur in this country—with the exception of the undetermined species of *Aponomma* from a guinea-fowl—it is almost certain that the names of others will have to be added to the list as time goes on.

Synoptic Table

Synoptic Table of Sudanese Ticks

1	Scutum absent	2
	Scutum present	7
2	Margin of body differing in structure from general integument	3
	Margin of body not differing in structure from general integument	5
3	Dorsum pitted by symmetrically arranged polygonal depressed areas bounded by rugose ridges	*Argas brumpti*
	Dorsum not pitted by such depressed areas	4
4	Body longer than broad	*Argas persicus*
	Body broader than long	*Argas vespertilionis*
5	Body panduriform; found in ear	*Ornithodoros megnini*
	Body oval	6
6	Eyes present on supra-coxal fold	*Ornithodoros savignyi*
	Eyes absent	*Ornithodoros moubata*
7	Palpi short, subtriangular, not or only slightly longer than broad; capitulum short	8
	Palpi longer than broad; capitulum long	18
8	Dorsal surface of capitulum hexagonal	9
	Dorsal surface of capitulum rectangular	17
9	Stigmata comma-shaped	10
	Stigmata nearly round	*Boophilus australis*
10	Male	11
	Female	14
11	Punctations on scutum unequal (large and small)	12
	Punctations equal or nearly so	13

* Salmon and Stiles, (1902), *Cattle Ticks of the United States*, United States Dept. of Agriculture.

Synoptic Table (*continued*)

12	Punctations distributed regularly	*Rhipicephalus sanguineus*
	Punctations distributed irregularly	*Rhipicephalus punctatissimus*
13	Punctations separated (distinct)	*Rhipicephalus simus*
	Punctations contiguous, making the scutum rough (shagreened)	*Rhipicephalus evertsi*
14	Scutum elongate oval	15
	Scutum short oval, or as long as broad	16
15	Scutum with unequal (large and small) punctations	*Rhipicephalus sanguineus*
	Scutum with equal punctations	*Rhipicephalus punctatissimus*
16	Punctations separated (distinct)	*Rhipicephalus simus*
	Punctations contiguous, making scutum rough (shagreened)	*Rhipicephalus evertsi*
17	Eyes absent: coxæ 1 not bidentate	*Hæmaphysalis leachi*
	Eyes present: coxæ 1 bidentate	*Dermacentor rhinocerotis*
18	Anal groove surrounds anus anteriorly and open posteriorly	... *Ixodes* sp. incert.
	Anal groove surrounds anus posteriorly and opens anteriorly	19
19	Eyes absent; anal plates absent ...	... 20
	Eyes present	21
20	Scutum marked with green metallic spots	*Aponomma exornatum*
	Scutum not marked with green metallic spots	*Aponomma lœve*
21	Scutum with metallic reflections	22
	Scutum without metallic reflections	*Hyalomma ægyptium*
22	Male	23
	Female	26
23	Eyes flat	.. 24
	Eyes hemispherical, in sockets ...	25
24	Marginal groove present	*Amblyomma marmoreum*
	Marginal groove absent ...	*Amblyomma tholloni*
25	On either side of scutum a dark triangular-shaped area without a light mark	*Amblyomma* sp. incert.
	On either side of scutum a dark triangular-shaped area containing a light mark	*Amblyomma variegatum—hebræum*
26	Eyes flat	... 27
	Eyes hemispherical, in sockets	... 28
27	*	*Amblyomma tholloni*
	*	*Amblyomma marmoreum*
28	*	*Amblyomma variegatum—marmoreum*
	*	*Amblyomma* sp. incert.

Animals injurious to Farm and Garden Crops

The Dura Stem-borer

Sesamia cretica

Dura Stem-borer

The larva, pupa and adult of this moth were figured and an account of its life history given in the Third Report of these Laboratories.[1] It is a difficult pest to control as it breeds throughout the year on *dura*, maize (*Dura shami*), and sugar-cane, and, moreover,

* Neither specimens nor descriptions of these ticks available.—H. H. K.

[1] *Third Report, Wellcome Tropical Research Laboratories*, 1908, *page* 222

except when in the adult stage, it passes the whole of its existence hidden within the stem or the sheathing leaves of the plant it attacks. Some investigations have been carried out in Dongola Province with a view to ascertaining whether it would not be possible, in that region at any rate, for the farmers to lessen its numbers by concerted action.

The seasons in Dongola Province are roughly as follows: The main crop of the year is the flood or *demera* crop, sown at high Nile, and consists mainly of *dura* and maize. It is harvested some four months later. The wheat crop is put in in December. The winter or *shitwe* and the summer or *saifie* crops are comparatively small and miscellaneous but include a proportion of *dura*.

The larvæ present in the dried *dura* stalks after harvest

When the *demera* crop is harvested, the second brood of borers is in the larval stage, most of these larvæ being within the stalks. A few, however, are in the roots. The stalks, which are known as *gussab*, and which constitute the staple diet of the farm live-stock throughout the greater part of the year, are removed from the cultivations and stacked, usually on the roofs of houses, but the stubble is left in the ground. The houses are situated among the cultivations and the stock are fed close to the houses. *Gussab* is not very palatable fodder and, consequently, stock prefer to eat only the tops and leaf, and to reject the hard stems—those very parts, in fact, in which the caterpillars like to take up their winter quarters. The *gussab* from a *demera* crop frequently lasts until after the next *demera* crop has appeared above the ground.

Occasionally, a strip of land is left with the stalks of the *demera* crop standing to act as a wind-break to protect other crops. As many as seventy larvæ, together with a few pupæ, have been taken within the short space of half an hour from a wind-break of this kind.

The dura stem-borer will sometimes attack wheat, and the larvæ have also been found wintering in *duku* stubble.

A number of stalks containing larvæ from a *demera* crop was collected in Dongola Province in February and placed in a breeding-cage in Khartoum. One moth emerged in March, four in April, thirty-five in May and June, eleven early in July, and the last had made its appearance by August 6, the total number of moths obtained from these stalks being fifty-two. The natives assert that while the *demera* crop is always heavily infested, there are comparatively few caterpillars to be found in the *shitwe* and not very many more in the *saifie* crops. Observations made in the field and on the times at which the moths emerged in the breeding-cage confirm this statement.

The obvious method of dealing with this pest is to collect and burn all the stalks and stubble of the *demera* crop while the borers are within—that is, immediately after the grain has been harvested. Unfortunately, however, this is not possible in Dongola Province, for, it being an almost rainless region, there is little or no grazing for farm live-stock, which are therefore dependent on this *gussab* for their existence. In districts where grazing is obtainable, this could and should be done. I believe, however, that by the careful and concerted action of the farmers in Dongola Province, the amount of damage done by the borers could be lessened very considerably. The measures which should be carried out to effect the control of the *Sesamia cretica* are as follows:—

Measures for the control of the Dura Stem-borer

(*a*) When any cereal crop is harvested, the stubble should be collected into heaps and burnt.

(*b*) In districts where the *gussab* is not needed for provender it should be collected into heaps and burnt as soon as possible after the grain has been harvested.

(*c*) When *gussab* is fed to stock, the harder parts of the stems are frequently not eaten—these should be collected every day and burnt.

(*d*) When a young crop of *dura*, maize, sugar-cane or wheat is about a foot in height, all plants containing caterpillars should be pulled up, and the caterpillars cut out and squashed. This operation should be carried out again two or three weeks later.

Plants containing caterpillars can be known by their young centre leaves being withered and dying or dead, while their outer lower leaves are still green and living.

(*e*) Stray plants of *dura*, maize, sugar-cane or wheat should not be allowed to grow among other crops or in odd places such as the edges of gudwals (water channels).

The Black or Greasy Cutworm

Agrotis ypsilon, Rott.

Black or Greasy Cutworm

A very considerable amount of damage was suffered by crops on Nuri and Gureir basins in Dongola Province, owing to the ravages of this cutworm, in November and December of 1909. *A. ypsilon* is a well-known pest in many other countries, including the United States, Ceylon and Egypt, attacking tobacco, tea, cotton, berseem and a host of other plants.

Life history and habits.—The female moth deposits her eggs on the lower parts of the food plants, and, on hatching, the larvæ at first feed freely on the foliage. After a few days spent in this way they acquire the habit of feeding only by night and hiding by day in cracks and holes in the soil. As these older larvæ are poor climbers they usually cut off young seedling plants close to the ground to enable them to feed more easily on the tender leaves. They will also sometimes attack the plant below the ground. When mature they are about two inches in length and of a dirty green colour with darker spots or tubercles. If alarmed they at once curl up and feign death. They pupate in cells hollowed out in the soil and after about fourteen days give rise to dull greyish-coloured moths.

The basin system of irrigation

In Dongola Province, up to the present, this pest has confined its attentions to crops grown on land irrigated on the basin system and has not attacked the sakia crops. Sakia land is irrigated by means of waterwheels—sakias—which lift the water from the river or from wells. The basin system of irrigation is briefly as follows.—Where the land levels permit of its being done, canals are dug, along which water flows from the river while it is in flood on to land situated generally behind the river-sakia land. These basins are therefore flooded each year for periods varying with the height to which the river attains, and the crops are sown when the land has become sufficiently dry to enable men to walk about on it. The moths of *A. ypsilon* lay their eggs on the weeds which spring up as soon as the water has gone and are particularly fond of *terroba*—probably a *Chrozophora* sp.—a weed which is very plentiful on the basins. The cultural methods practised by the cultivators of these flooded lands are of the simplest. No effort is made to break up or clean the soil prior to sowing the seed by hand in holes made with a stick—or *seluka* as it is termed—and as might naturally be expected, the land is very foul. When the crop of wheat, barley, or whatever it happens to be, appears above the ground the land may be lightly hoed to give it a chance of getting ahead of the weeds, and it is then left to itself—unless possibly an effort is made at bird-scaring—until it is ready for harvesting. The cutworms, which are probably already present on the weeds when the seed is put in, attack the crops either from choice, or from necessity if the weeds on which they started life are uprooted just when the crops are available for food.

In 1909 the crops on Nuri basin were badly attacked, those on Gureir basin to a less extent, while those on the new basin on Kerma plain escaped altogether. This cutworm has appeared on Nuri basin in previous seasons, increasing in numbers every year. Some four years ago the area of land in this basin, available for cultivation, was considerably increased by the construction of a canal, and the occurrence of *A. ypsilon* in noticeable numbers appears to date from then. In 1909, the barley and other crops were entirely destroyed when they were only a few inches in height and the land was then thoroughly hoed. Numbers of birds followed the men engaged in this work and devoured the larvæ which were exposed, a bird known locally as *gairdoun*—a species of wagtail—being particularly beneficial in this way. The crops were then resown and were not again attacked by cutworms. The basin was searched for cutworms in the latter end of May, 1910, and although there was a considerable area of land under crops watered by well-sakias, and the whole basin was more or less covered with *terroba* and other weeds, the only traces of the pest which could be found were empty pupal cases in the soil. It is believed that the moths were in hiding in the deep cracks in the ground—these cracks may extend to two metres in depth—or in similar places.

Bird enemies of the cut-worm

Preventive and remedial measures.—In other countries *A. ypsilon* usually produces several generations in the course of the year, but in Dongola Province it appears to be single-brooded. Should it continue to be single-brooded in the future its control should be effected by purely cultural methods, and even were it to acquire the habit of breeding throughout the year it should never attain the importance, as a pest, of the dura stem-borer—*Sesamia cretica*—if measures are taken to keep it in check. The cultural methods recommended are as follows. When the water soaks away or recedes from the basins, and as soon as the land is sufficiently dry to permit of its being done, the soil should be well hoed, or ploughed, and cleared of all weeds. This operation will enable birds to devour numbers of the larvæ, others will be crushed and the remainder will be hard put to it to find sufficient food to enable them to complete their life-cycles. This hoeing should also yield good results in other ways—it will tend to conserve the supply of water in the soil by preventing undue evaporation, and the soil itself will be sweetened by the action of the sun and air. If there is no second breed of cutworms, crops sown on land treated in this way will be safe from attack, but should a second brood appear it will be necessary to have recourse to the use of poisoned baits or to hand-picking. This latter process is somewhat costly and needs to be very thoroughly done to be effective, moreover sufficient labour for the purpose may not be available, and consequently it cannot be recommended except for small areas. The destruction of the larvæ by means of poisoned baits has been found in other countries—notably in the United States—to be the most practical and efficient method of dealing with cutworms over large areas, the substances used as baits including bran, meal, etc., and green forage. The latter has several advantages over bran and meal, and is used in the following way. Any available green-stuff—*e.g. berseem*, grass, barley, young succulent weeds, etc.—is collected, cut up into small pieces of about half-an-inch to an inch in length and moistened with a mixture made up of 1 lb. arsenite of soda, 8 lb. treacle and 10 gallons water. This poisoned forage is then thinly scattered over the infested land. This should be done a few days before the crop appears above the ground and, if necessary, again if injury is noticed after the plants have begun to grow. The land should be thoroughly cleared of weeds before the first application. Cutworms will take green forage treated with this mixture in preference to untreated growing plants, owing to their love for sweet things. By applying the poison in this way there is very little danger of cattle, sheep, donkeys, etc., being poisoned, for the pieces of green forage are too small to be readily picked up. Care should be taken, nevertheless, that live-stock, including poultry, do not have access to land which has recently been

Prevention of the Greasy Cutworm

treated. Poisoned forage should always be applied in the evening, as it will then be fresher and more attractive to the cutworms than if it has been allowed to dry and harden in the sun.

There is evidence to prove that in bygone centuries large areas of land in Dongola Province were irrigated by means of flood canals during high Nile, and by well-sakias during the remainder of the year. On Kerma plain there still exist the remains of sakia-wells showing that at some time the water-level in the soil was sufficiently high to enable cultivation to be carried on. During recent years there has been but a small area of land irrigated in this way, but considerable sums of money have been, during the last four years, and are now being spent in the construction of canals which will result in many thousand feddans of land being rendered available for cultivation. It is highly important, therefore, that the natives cultivating these basins should realise the necessity of doing something more to the land than merely dibbling in the seed.

The Asal Fly

Aphis sorghi, Theobald

Asal Fly

As stated earlier in this report, a considerable amount of time has been spent in endeavouring to trace the life history of the so-called asal fly and to devise some method for controlling it. It is to be regretted that up to the present these endeavours have not been crowned with success. Mr. Chas. P. Lounsbury, Government Entomologist, Cape of Good Hope, and Mr. Claude Fuller, Chief of the Division of Entomology and Horticulture, Natal, have very kindly furnished me with what information concerning the bionomics of this aphis they possessed, and my thanks are due to them. The work in this direction will be continued in the hope of discovering some effective and practical remedy for dealing with this pest.

The Cotton Stem-borer

Sphenoptera neglecta, Klug

Plate VII.

The Cotton Stem-borer

This beetle has been found attacking cotton and garden hibiscus throughout the northern Nile provinces, and it appears probable that unless measures are taken to keep it in check it will have to be regarded as a serious pest when the area of land under cotton in the Sudan increases. Mr. C. O. Waterhouse, of the British Museum (Nat. Hist.), has determined it to be a member of the genus *Sphenoptera*, probably *S. neglecta*, Klug. A member of the same genus—*S. gossypii* is recorded by Lefroy[1] to attack cotton in Bombay, Central Provinces and the Punjab—possibly the species here noted is identical with the Indian cotton stem-borer.

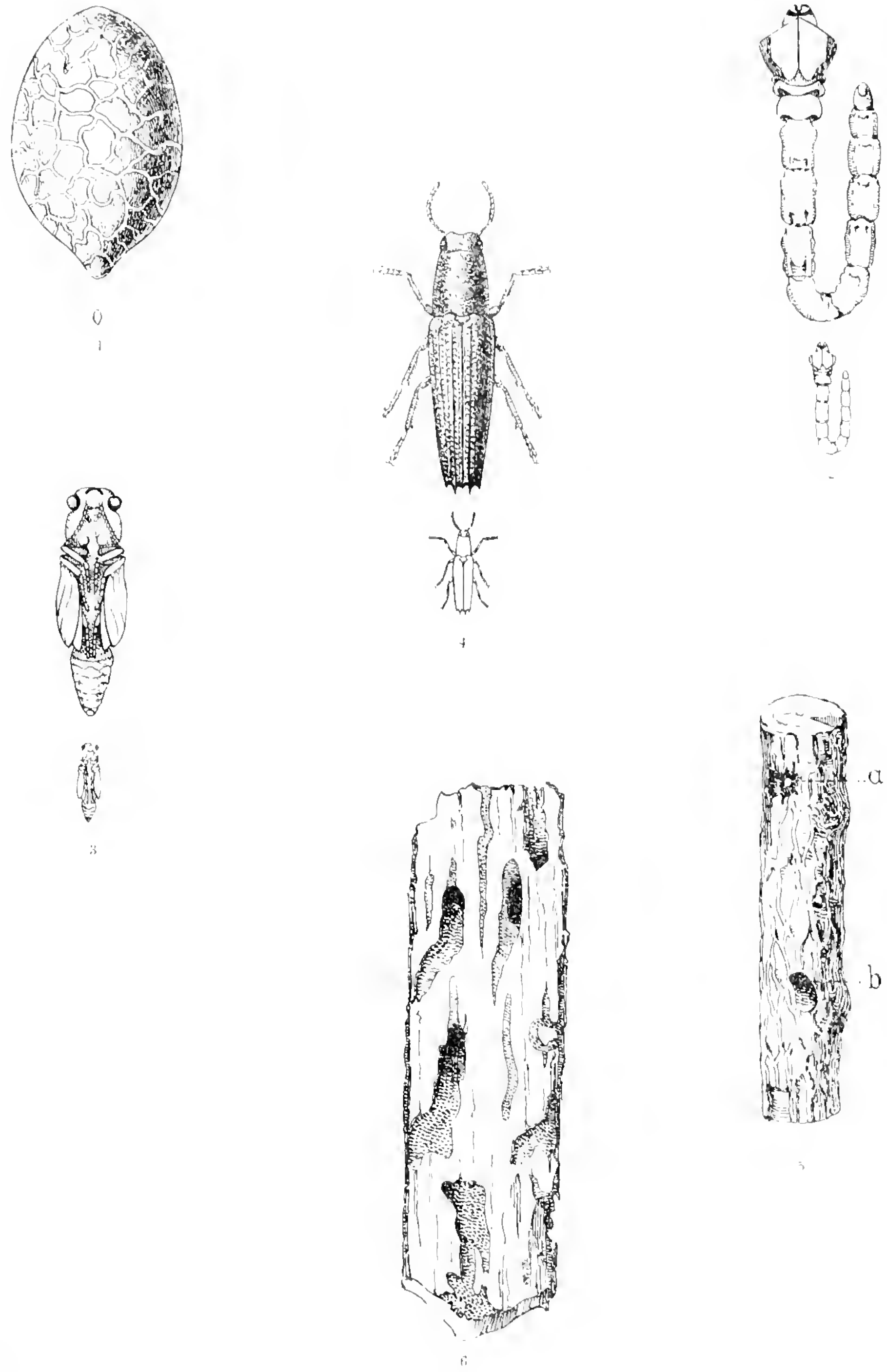
Descriptions

Egg (fig. 1). Length, 1·25–1·50 mm. The embryo is enveloped in a thin, transparent to whitish membrane, which is covered by a dull, greenish-blue, scale-like shell, in shape roughly oval, and bearing a number of irregular crinkles or ridges.

Larva (fig. 2). Length up to 29 mm. Colour, head brown, mandibles black, thorax and abdomen yellowish-white. The larva is of the typical Buprestid shape, the small head being retracted into the broad, flattened, first thoracic segment, and the abdomen being long and comparatively slender. The first thoracic segment bears

[1] *Bulletin Imperial Institute*, 1907, Vol. V., No. 2, *page* 164

PLATE VI



C[illegible]N S[illegible]EM-B[illegible] [illegible] K[illegible]

1. Egg 2. Larva
3. Pupa 4. Adult
5. Portion of stem of cotton plant, showing egg (a) and exit hole [illegible] (b)
6. Longitudinal section of stem of cotton plant showing tunnels made [illegible]

[illegible]

both a dorsal and a ventral shield, the former being cut by a longitudinal median groove not quite extending to the anterior border, and the latter by a **Y**-shaped, forwardly pointing groove, also barely reaching to the anterior border. The remainder of the body is flattened and wrinkled. The anus is situated at the apex of the terminal segment. The whole body bears a few scattered short pale hairs.

Pupa (fig. 3). Colour, yellowish-white, eyes dull purple.

Adult (fig. 4). Length, 9–10·5 mm. Colour, greenish to reddish-bronze.

When first it emerges from the pupal cell the beetle is covered with a fine yellowish meal, especially on the frons, sides of the pronotum, prosternum, metasternum, and venter generally. Head, pronotum, scutellum and venter, reddish-bronze, irregularly punctured and bearing a few scattered, short, pale hairs. Mesonotum and metanotum, bright metallic green, punctured. Metanotum bears a **V**-shaped, backwardly pointing groove or gutter, in which is a median ridge, black. Dorsum of abdomen, bright metallic green, punctured, and bearing a few scattered, short, pale hairs, with the exception of the basal margins of the segments, and a longitudinal median ridge, which are smooth, and have a bronzy tinge. Antenna of twelve segments—first, small, globular; second, elongated, swollen; third and fourth, smaller; remainder of antenna serrate. Elytron reddish-bronze, with punctures arranged in longitudinal rows, ridged towards the apex, and terminating in three short spines. Hind wing slightly clouded, especially towards the apex; costa terminates in a short spine; apical margin irregular. Tibiæ with longitudinal rows of short, sharp spines; fore tibiæ bear at the apices one longer spine; mid and hind tibiæ two similar spines.

Habits and life history

Habits and life history.—The eggs are deposited singly on the bark of the plant, on either the main stem or the branches—usually the former—and preferably in a crevice or wound. As many as nine eggs have been found on a stump of caravonica cotton, scarcely twelve inches high, but these had probably been laid by several beetles.

On hatching, the larva burrows into the stem, without rupturing the external shell of the egg, and commences a tortuous tunnel in the wood. Frequently this tunnel runs immediately under the bark for some distance, but it may go deeper in the wood, especially as the larva grows older, and may even, in the case of smaller branches, follow the course of the pith. It may also extend below the level of the ground. As the larva proceeds it packs the tunnel behind it with *frass*[1] and wood chips, which, at first light in colour, become dark brown in course of time. It invariably lies in its tunnel in a doubled-up position.

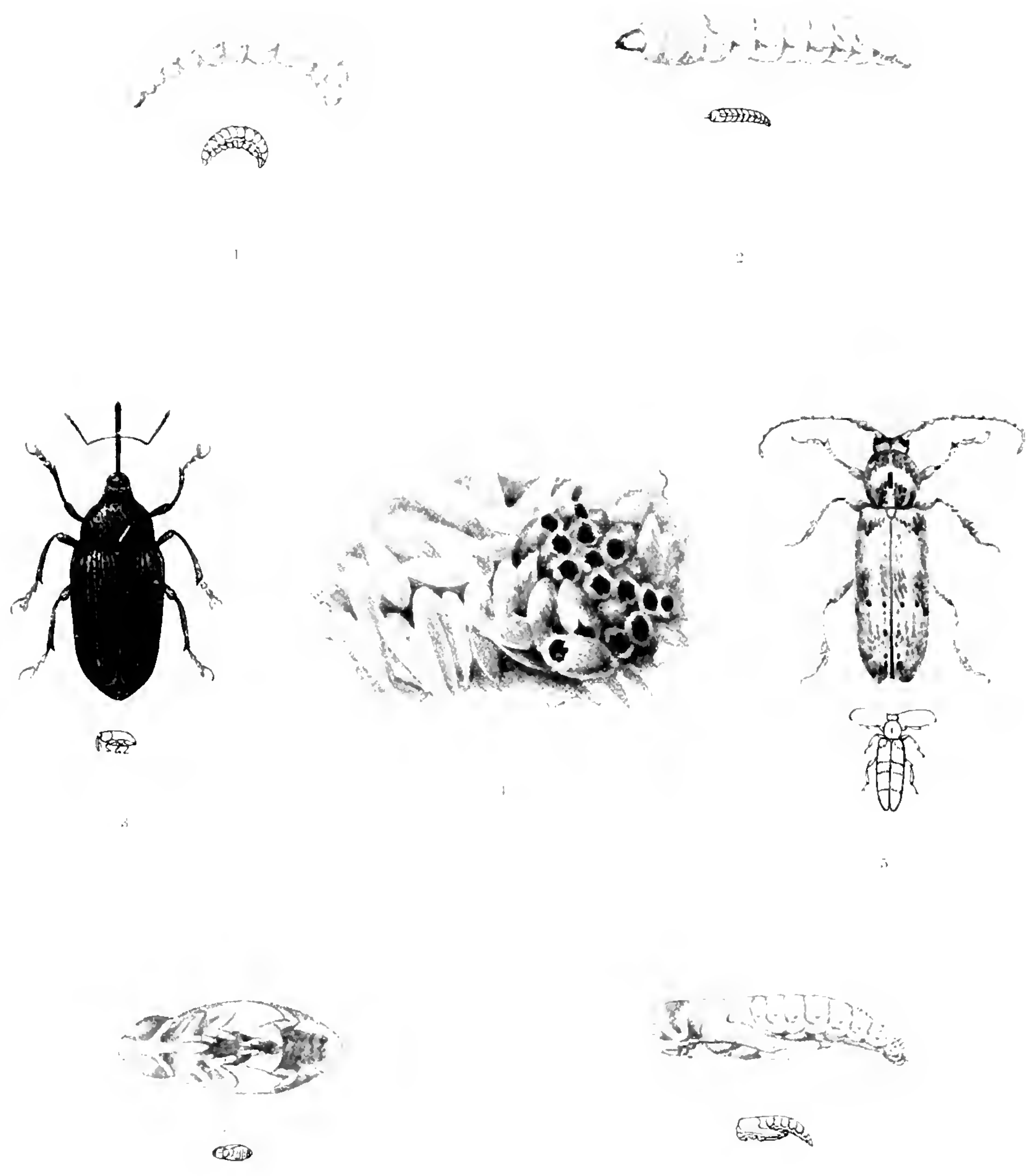
On attaining maturity the larva hollows out for itself a little chamber, usually near the bark, and pupates with its head end pointing towards the bark. The adult eventually gnaws a circular hole through the bark and makes its exit.

Duration of the life-cycle.—The observations made on the life history of this pest indicate that there are at least two, and probably three, broods in the course of the year. The season for planting cotton varies in different provinces from February to July, and the crop usually remains on the ground for about eight months. The eggs of the first brood are laid on the young seedling plants while they are only a few inches high, and breeding continues until the cotton wood is dead. If an infested plant of any size is pulled up and thrown aside, the larva can complete its development in the dead wood.

Damage done by the borers.—Young plants are killed outright, but older plants, unless they harbour several of the borers, usually live to the end of the season, though obviously unhealthy and stunted in growth. White ants (termites) if present in the soil, at once

[1] *Frass*—The term applied to the excreta of insects

PLATE VIII



Melon Weevil *Baris* [illegible] Auriv.

1. Larva — 3. Adult

4. Pupae cells — 6. Pupa

Melon Stem Borer. *Apomecyna binubila*, Pasc.

2. Larva — 5. Adult

7. Pupa

Illustrations are natural size unless otherwise indicated attack a plant which has been weakened by the work of the borer, and the entire damage is then not infrequently attributed to these smaller insects.

Preventive and remedial measures. To control the various insect pests of cotton, it is absolutely essential that the remains of the old crop should be collected and burnt as soon as the cotton has been gathered, and before the new crop is sown. The effect of this measure on *S. neglecta* will be to lessen its numbers very considerably, as it is usually present in all its forms in the old cotton wood at the end of the season. When the young crop appears, all infested plants should be collected and burnt to prevent the occurrence of a second brood. Prevention of the Cotton Stem-borer

THE MELON WEEVIL

Baris traegardhi, Auriv.

Plate VIII., figs. 1, 3, 4 and 6

Reference to this pest of sweet melons was made in the Third Report of these Laboratories.[1] It does not appear to be nearly as common as the melon fruit-fly—*Dacus* sp.—but is nevertheless responsible for a certain amount of damage. The Melon Weevil

Description—

Adult (fig. 3).—Length, 4–6·5 mm. Colour uniformly black, elytra sometimes faintly tinged with brown. Head bears comparatively few punctures, smaller than those on the thorax. Proboscis curved, about equal in length to the prothorax, densely punctured, grooved on either side to take the folded antennae. Antenna of nine segments, first segment long, finely punctured, apically swollen; second segment one-third the length of first segment; third to eighth segments small; ninth segment swollen, consisting of four rings, and clothed with greyish pubescence; second to eighth segments inclusive bear black spines or bristles, shortest on second segment and longest on eighth. Prothorax as broad as long, densely punctured, anterior margin constricted to form a collar. Elytra densely punctured and longitudinally and deeply grooved, the grooves converging towards the apex and a marginal groove extending around the whole elytron except the basal margin; a small hump is situated in the exterior basal angle of each elytron. Pygidium and venter densely punctured. Besides these deeper punctures the whole surface of the beetle is very finely punctured. Legs densely punctured, femora bear a few short curved grey hairs; tibiae bear greyish or black spines or bristles and a cluster of strong black spines at the apices, and terminate in a brown claw-like process; tarsi four-jointed; under-surfaces of apices of tibiae and under-surfaces of tarsi clothed with yellow hair.

Preventive and remedial measures. All infested melons should be collected and burnt. They should on no account be thrown into the river, as there would be a danger of their floating down-stream and becoming a source of infection to other cultivations.

THE MELON STEM-BORER

Apomecyna binubila, Pasc.

Plate VIII., figs. 2, 5 and 7

Complaints are occasionally received of damage done by this longicorn which was referred to in the Third Report of these Laboratories.[2] Melon Stem-borer

[1] *Third Report, Wellcome Tropical Research Laboratories*, 1908, *page* 232

[2] *Third Report, Wellcome Tropical Research Laboratories*, 1908, *page* 233

Remedial measure. The only method which can be recommended of dealing with an attack, is that of cutting out and destroying the larvæ when the plant shows signs of being infested.

The Melon Leaf Beetle

Aulacophora foveicollis, Kuster

Plate IX., fig. 5

Melon Leaf Beetle

This beetle is frequently found, in company with the plant-eating lady-bird, *Epilachna chrysomelina*, Fab., devouring the leaves of melon plants. The larval stage has not been seen.

Preventions and remedies. Clean cultivation will do a lot towards lessening the numbers of both these pests, and where plants are attacked a dressing of a mixture of Paris green and flour, in the proportion of one to ten, dusted over the foliage, will either poison the beetles or drive them away.

Diamond-back Moth

Plutella maculipennis, Curtis

This pest has a world-wide distribution, occurring in Great Britain, New Zealand and many other countries. In the northern provinces of the Sudan it is frequently found attacking cabbages.

Diamond-back Moth

Description and life history.—The eggs, white, cylindrical bodies, are deposited on the under-surface of the leaf of some plant belonging to the Nat. Order *Cruciferæ*. The larvæ, on emerging, feed on the soft tissue of the leaf, generally leaving the upper epidermis intact. These caterpillars are green in colour, spindle-shaped, and when full fed about 13 mm. in length. When alarmed they drop from the leaves and hang suspended by silken threads which enable them to regain their places when the danger is past. The pupæ are white to yellowish, with darker markings as the imago within develops, and are enclosed in a whitish silken cocoon attached to the leaf, usually in the angle at the junction of two veins. The moth is about 7 mm. in length and has a wing expanse of 13–14 mm. In colour it is a greyish-brown with a light irregular stripe on the posterior margin of the forewing. When at rest, the wings are closed, and these light stripes together form two or three diamond-shaped pale areas, to the presence of which the insect owes its popular name of "Diamond-back Moth."

Plants attacked by this pest present a peculiar and characteristic bleached appearance, owing to the habit of the larvæ of leaving uneaten the upper epidermis of the leaf.

Preventive and remedial measures.—As this caterpiller feeds only on plants belonging to the Nat. Order *Cruciferæ*, no wild plants belonging to this order should be allowed to grow in or near a garden in which it is proposed to cultivate cabbages, turnips, radishes, etc.

In gardens, where only small areas of cabbages, etc., are cultivated, the best method of dealing with an infestation of these caterpillars is to sprinkle the plants with boiling water by means of a watering can, fitted with a fine rose. This remedy is recommended by Mr. W. W. Froggatt, Government Entomologist, New South Wales. On large areas where this may not be practicable the young plants should be sprayed with paraffin emulsion.

The Cabbage Bug

Bagrada picta, F.

Plate IX., fig. 6

This brilliantly coloured plant-bug occurred in large numbers on cabbages in some of the gardens in Khartoum during the winter 1909-10. It can be distinguished from the closely allied *B. picta hilaris*, Burm., by the markings on the scutellum—in *B. picta* the scutellum bears a median longitudinal yellowish-white stripe extending from the basal margin to the apex, while in *B. picta hilaris* this stripe is present on the apical half of the scutellum only. Cabbage Bug

Preventive and remedial measures. Gardens should be kept free from weeds, especially those belonging to the Nat. Order *Cruciferae*, and any bugs noticed attacking cabbages or other plants should be collected and destroyed without delay to prevent them depositing eggs.

The Rigla Gall Weevil

Baris lorata, Marshall, sp. nov.

Plate IX., fig. 2

This small weevil has been noticed in Khartoum attacking *Portulaca oleracea*, Linn. —Arabic name *Rigla*—which is cultivated as a vegetable and for use in salad. The larva lives in the stem, its presence causing a gall to form, and frequently a plant may be seen bearing upwards of thirty galls. Rigla Gall Weevil

An undetermined species of Hymenopteron is parasitic upon the larval stage of this beetle.

Descriptions—

Larva—head, chestnut-brown; body, yellowish-white, curved and transversely wrinkled.

Pupa—yellow, eyes black, mandibles brown. The body bears a few scattered long pale hairs.

Adult—Length, 3 mm. Colour brown, with a darker brown to black median lateral area on each elytrum. Head densely and finely punctured, and also sparsely and coarsely punctured. Proboscis curved, about equal in length to the prothorax, punctured, grooved to take the folded antennæ. Antenna of nine segments, first segment long, slender, apically swollen, second to eighth segments small, bearing narrow white scales, ninth segment swollen, consisting of four rings, clothed with greyish pubescence. Prothorax densely and deeply punctured except the anterior margin which is densely but finely punctured; a lateral patch on either side of mixed yellowish-white and yellowish-brown, almost circular, scales extending from the posterior margin three-fourths of its length. Each elytrum bears a basal lateral patch and an apical patch of mixed yellowish-white and yellowish-brown scales, while smaller brown scales are scattered over the median dorsal areas, and the remaining surface bears longitudinal rows of narrow dark brown scales, and the whole surface of the elytrum is longitudinally grooved. Pygidium clothed with yellowish-white and yellowish-brown scales. Venter punctured and bearing patches of white to yellowish-white scales. Legs punctured and clothed with narrow white to yellowish-white scales, tibiæ terminate in a black, claw-like process, tarsi four-jointed.

The arrangement of the scales varies considerably in different specimens.

The Fig Stem-boring Beetle

Sinoxylon sudanicum, Lesne

Plate IX., fig. 1

Imported fig trees attacked by the Fig Stem-boring Beetle

A number of young fig trees imported from Egypt by Mr. Geoffrey Nevile and planted in his garden at Darmali were severely damaged by this beetle early in 1910. When first planted out, the trees were naturally in a weak condition and the beetles—for Mr. Nevile told me that they were usually in pairs—bored into the twigs immediately either above or below a bud, and then circled the twig within the bark in such a way that at the slightest strain it would break at that point. This had the effect, on all but the main stems, of completely cutting off the flow of sap and so killing the twig. If left undisturbed, the beetles continued to tunnel in the dead and dying wood and presumably had the intention of depositing eggs, though no larvæ were taken from twigs collected in March. A single adult emerged from one of these twigs in July. Healthy, strongly growing trees were not attacked.

S. sudanicum can be distinguished from the more common *S. senegalense* by its coloration—the latter species is uniformly dark brown to black, but *S. sudanicum* has the basal halves of the elytra tinged with yellow.

Preventive and remedial measures.—As this beetle confines its attention to trees which are for some reason in a sickly condition, it is only necessary to keep trees healthy to avoid an attack. When trees are first transplanted and until they have established themselves the vicinities of the buds should be smeared with some substance—such as tar—which is offensive to the beetles. Newly transplanted trees should also be examined every day or two, and all beetles found attempting to bore into twigs, collected and destroyed. If a beetle has succeeded in making a tunnel, in a small twig, of sufficient length to conceal itself, that twig should be cut off below the tunnel and burnt.

Mr. Nevile saved most of his trees by picking the beetles out of their tunnels with a pin and removing the twigs which were either dead or dying. When seen in July, these trees had established themselves and made a quantity of new growth, which the beetles had not attacked.

White Ants

Termitidæ

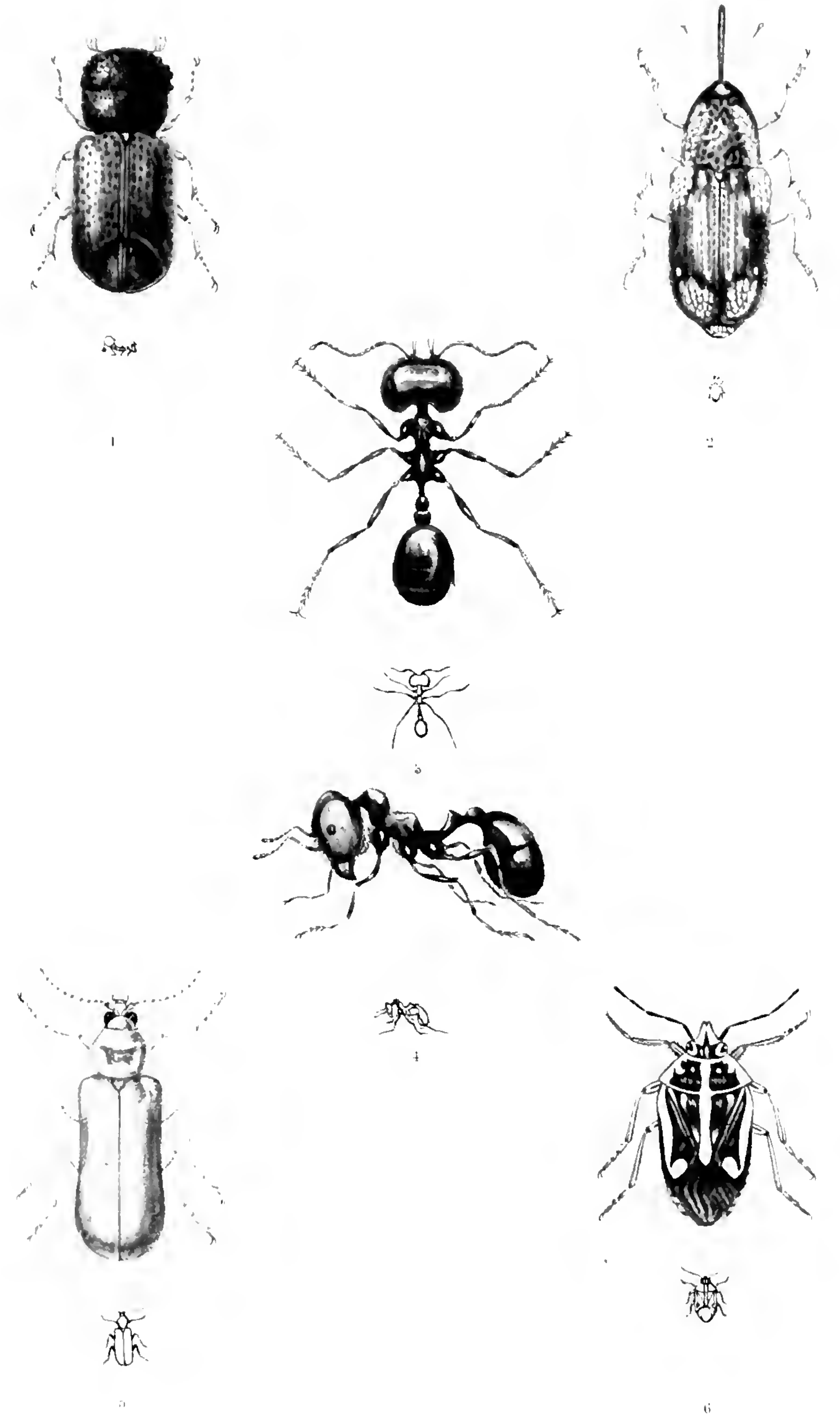
Transvaal experiments in prevention of damage by White Ants

In view of the enormous amount of damage done yearly by certain species of the Fam. *Termitidæ*, or as they are popularly termed, "White Ants," the selection of some chemical with which to treat wood used in the construction of houses, etc., or for telegraph poles, to protect it from the attacks of the insect is a matter of considerable importance. No series of experiments has as yet been started in this country to test the respective values of the various chemicals recommended for the purpose, though it is proposed to do so during the coming year. A very comprehensive series of experiments in this direction was started in the Transvaal, in 1906, by Mr. C. W. Howard, who then held the post of Government Entomologist to that Colony, and has been continued by his successor, Mr. F. Thomson. As the results obtained up to the present from these experiments cannot but be of interest to many in the Sudan, extracts from the articles published by Mr. F. Thomson giving these results are quoted here:—

[1] "The tests were carried on in the following manner. About 800 pieces of wood of a uniform size, 3 × 3 × 12 inches, were obtained. These were mostly of deal, but

[1] *Transvaal Agricultural Journal*, No. 27, 1909, p. 513

PLATE IX



1. Fig Stem-boring Beetle, [illegible], Lesne
2. Rigla Gall Weevil, [illegible], M[illegible]
3 and 4. Black Garden Ant, [illegible], L.
5. Melon Leaf Beetle, [illegible] Kuster
6. Cabbage Bug, [illegible], F.

[illegible]

some blue gum, bockenhout, and lemon wood (*Nuxia monospora*) were employed, all of which woods are readily eaten by white ants. In selecting the material with which to treat the woods, we tried to test such substances as the farmer would have at hand or could easily obtain, also giving attention to patent mixtures, for sale on the South African Market, which are recommended for this purpose.

"The methods for treating the wood were four in number, *i.e.* (1) soaking in the mixture for 24 hours; (2) soaking for 24 hours and then bringing to the boiling point over a fire, and boiling for from one to two hours; (3) painting the surface with one or two coats of the mixture; (4) boring a hole ½ inch in diameter down the middle, filling this with the liquid or dry chemicals and plugging up the opening, leaving the chemical to soak through the wood. A certain number of pieces of deal and blue gum were left untreated, to act as a check on the experiment.

"When the pieces of wood were all ready they were thoroughly mixed up, so that any two pieces that had been similarly treated should not be together, and were then planted in the soil about 12 feet apart each way, with the upper ends above the surface. Care was taken to choose a place to bury the wood where termites were very abundant. For this purpose Mr. E. F. Bourke, of Pretoria, kindly allowed us to make use of his farm Kalkheuvel, near Pienaar's River Station, District of Pretoria. Parts of this farm are badly infested with white ants, and the worst parts were employed for this experiment. The wood was buried on March 27 and April 15, 1906. [1] The first examination was made on June 4, 1907, the second examination was made on August 21, 1908, and the third examination took place on July 15, 1909.

"Termites were present on the day of examination on or near the pieces of wood.

"*Arsenical compounds.*—It was found that mostly all the pieces of wood treated with the arsenical compound were still untouched, and it is very plain that these arsenical mixtures are very effective. The following table will show this:

Great efficiency of arsenical preparations against White Ants

Arsenite of soda, 10 per cent.: All wood treated not eaten at third examination.

Atlas Preservative, full strength: All wood treated not eaten at third examination.

Atlas Preservative, 10 per cent.: All wood treated not eaten at third examination.

Demuth's Dip, 10 per cent.: All wood treated not eaten at third examination.

Cooper's Dip, 1 pint to 9 gallons water: All wood treated not eaten at third examination.

Alderson's Cattle Dip, 4 lb. to 8 gallons water: All wood treated not eaten at third examination.

Street's White Ant Cure was not effective; all those pieces of wood which had been treated with this compound were eaten.

"*Tar and creosote compound.*—Of all the pieces of wood treated with any of the tar compounds only two pieces, painted twice with coal-tar, withstood the ravages of the termites for three years; all those treated with stockholm tar, creosote, carbolic acid, Jeyes' fluid, carbolineum, solignum, asphanite, etc., were more or less attacked and eaten.

"*Tobacco extracts.*—At the third examination all the pieces of wood treated with these extracts were found to have been eaten.

"*Oils and paints.*—These pieces were also destroyed, with the exception of two pieces of deal painted with raw linseed oil, white lead and arsenic mixed; two pieces of deal painted with raw linseed oil, red lead, and arsenite of soda mixed; two pieces of lemonwood painted with raw linseed oil, red lead, and arsenic mixed.

[1] *Transvaal Agricultural Journal*, No. 29, 1909, p. 86.

"These pieces of wood had not been touched at the time of the third examination, and were as good and perfect as they were three years ago at the time they were planted.

"*Soaps.*—Nothing can be said in favour of soap in solution with water or mixed with other chemicals, as all pieces of wood were eaten.

"*Copper sulphate (Bluestone).*—Only those pieces of wood which had been thoroughly soaked in an absolute copper sulphate solution withstood the attacks of the termites, whereas those pieces which were only slightly treated were eaten.

"*Native woods.*—Of all the various native woods which had been used in this test, and which are not treated with any chemicals, the following remained untouched for three years:—

Six pieces of leadwood (*Combretum prophyrolepis*)

Three pieces black ironwood (*Olea laurifolia*)

One piece vaalbosch (*Brachylæna discolor*)."

Besides devouring dead wood, white ants not infrequently attack living plants and trees, especially those which from some cause are in a sickly condition. Trees newly transplanted, and cuttings, are often killed before they can become established. In June, 1908, Messrs. William Cooper & Nephews, of Berkhamsted, England, furnished these Laboratories with two 14 lb. tins of the soil fumigant Apterite for purpose of experiment. Of these, one tin was handed to Mr. F. S. Sillitoe, Supt. of Gardens, who very kindly undertook to test its value against white ants. The results he obtained were by no means satisfactory, as it neither killed nor drove away the white ants, and in one case a bed of eucalyptus seedlings appeared to be adversely affected by it. The other tin was very kindly taken by Capt. R. C. G. Owen, C.M.G, Governor of Mongalla, who used it to protect newly transplanted trees, and met with great success.

THE BLACK GARDEN ANT

Aphænogaster barbara, L.

Plate IX., figs. 3 and 4

Black Garden Ant

This is the large black ant which so frequently selects as a site for its nest some prominent position in a garden, such as a path or a tennis lawn. The nest appears as a low mound with several holes or entrances, from which well-marked tracks lead off in all directions. The ants are very fond of *dura* grain, and if the nest is situated near a granary they will remove very considerable quantities of this corn every night, to store away in their subterranean chambers. In gardens they damage growing plants by biting off and carrying away the leaves.

In cotton fields the localities of their nests are marked by bare patches, devoid of vegetation. One such patch on the Government Experimental Farm at Halfyia, in 1909, comprised some twenty-four square yards.

Technique for poisoning with carbon bisulphide

Remedial measure.—The best method of dealing with these insects is to poison them with carbon bisulphide, which should be used in the following way: Moisten the surface soil above the nest by pouring one or more buckets of water over it. Make two or three holes into the nest with a crowbar or pointed stick, to a depth of about eighteen inches (45 cm.), pour into each of these holes and into the entrance holes, one or two ounces of carbon bisulphide, and spread a wet blanket over the nest to prevent the fumes from escaping. After five minutes remove the blanket and apply a lighted match or piece of rag at the end of a stick to the mouths of the holes—the vapour will explode, shattering the nest and driving poisonous fumes into every corner of it. As soon as the dull report, made by the explosion, is heard, the blanket should be replaced over the nest and left for half-an-hour.

On no account whatsoever should a second quantity of carbon bisulphide be poured into the holes after an attempt has been made to ignite the fumes, even though no explosion has been heard.

Commercial carbon bisulphide is a heavy yellow liquid which vaporises at ordinary temperatures, the vapour being poisonous. With air, this vapour forms an explosive mixture. To prevent evaporation it should be kept covered with a layer of water. Caution must be used in dealing with this insecticide, and no fire—*e.g.* lighted cigarette or pipe—brought near it.

The Plants Diseases Ordinance, 1910

Explanatory Note

The object of this Ordinance is:—

(i.) To prevent the introduction into the Sudan of diseases and insect pests of plants, and Plant Diseases Ordinance

(ii.) To discover and eradicate such diseases and pests when they occur.

Colonial legislation with a similar object has been followed, in particular "The Orchard and Garden Pests Act, 1903" of New Zealand, "The Insect Pests Amendment Act, 1898" of Western Australia, and "The Plants Diseases Act, 1904" of Natal.

The Ordinance has been drafted at the request of and in consultation with the Director of Agriculture and Lands, and subject to the advice of the scientific experts attached to the Gordon College. It has also been submitted to the Director of Woods and Forests, and, since the re-arrangement of these Departments, to the Director of Agriculture and Forests.

Power is given to the Governor-General in Council by Order in the Gazette to prohibit the introduction of any plant, fungus, parasite or insect into the Sudan or from one part of the Sudan to another.

It is intended that all plants shall be inspected on introduction, and, if necessary, detained in quarantine and disinfected; for that purpose power is given to the Governor-General in Council to appoint special places of entry and quarantine grounds.

Some diseases are more dangerous than others and in respect of them duties are imposed on occupiers of plantations and Omdas and Sheikhs: power is given to the Governor-General to alter the list of such diseases.

Inspectors and sub-inspectors are to be appointed to carry the Ordinance into effect.

Their powers are contained in sections 8 and 9.

Contents

Contents

Contents (continued)

Section:

Sec. 10 provides for the cost of disinfection and other treatment of the plants, etc.

Sec. 11 provides for the service of notices.

Sec. 12 authorises the immediate destruction of plants infected with proclaimed diseases.

Sections 13, 14 and 15 define offences and penalties and how offences may be tried.

Sec. 16 imposes fees by means of a reference to a schedule.

Sec. 17 provides for the issue of regulations.

Sections 18 and 19 protect public servants and the Government against liability for action taken under the Ordinance.

The Plants Diseases Ordinance, 1910

An Ordinance for preventing the introduction of insect pests and plant diseases from places without the Sudan and providing for the control or eradication of insect pests and plant diseases within the Sudan.

It is hereby enacted by the Governor-General of the Sudan in Council as follows:—

Short Title and Commencement

1. (i) This Ordinance may be cited as the Plants Diseases Ordinance, 1910.

(ii) It shall come into force on such date as the Governor-General in Council shall by order prescribe.

Definitions

2. In this Ordinance, if not inconsistent with the context:

"Plant" means any tree, shrub or vegetation and the fruits, leaves, cuttings, bark and any part or product thereof whatever, whether severed or attached, but shall not include grain or seed of any kind unless the same is specifically named in an order or regulation made under this Ordinance or is cotton seed grown outside Egypt and the Sudan. Definition

"Disease" means any insect, fungus, parasite or bacterial or other disease which may be injurious to any plant.

"Proclaimed Disease" means any of the diseases named in the first schedule hereto and includes any disease which the Governor-General from time to time by order may declare to be a proclaimed disease for the purposes of this Ordinance.

"Diseased" means affected with disease.

"Infected" means infected with disease.

"Plantation" means any piece of ground on which any plant is artificially grown or cultivated.

"Package" means the case, packing, material, pot, earth, soil or moss in which any plant is placed for transport or protection.

"Occupier" in the case of any plantation which is unoccupied or of which the actual occupier is unknown or cannot be found, includes the owner.

"Inspector" means an inspector appointed under this Ordinance.

"Civil Court" means a court of a magistrate of the first class under the Civil Justice Ordinance, 1900.

"Director" means the Director of Agriculture and Forests, Sudan Government, and shall include any person acting for the Director, and all Government officials to whom the director shall delegate either generally or in any special case all or any of his powers under this Ordinance.

"Magistrate" means magistrate under the Code of Criminal Procedure or any other person having the powers of a magistrate under the Code of Criminal Procedure.

"Order" means an order made by the Governor-General in Council and published in the Sudan Gazette.

Articles exempted from the Ordinance

3. This Ordinance shall not apply to articles canned, dried or otherwise preserved in which there is no longer any plant life nor to any plant which shall be for the time being exempted by any order or regulation made under this Ordinance. Article exempted

Provided always that this exemption shall not apply to any articles which are in fact infected.

Special Powers of Governor-General in Council

4. The Governor-General in Council may from time to time by order:

to prohibit import or transfer of articles likely to cause disease

(a) prohibit absolutely or except in accordance with regulations to be issued under this Ordinance.

(i) the introduction into the Sudan either generally or from any specified places, of any plant, fungus, parasite, insect or any other thing which in his opinion is likely to produce any disease in the Sudan, or

(ii) the bringing into any specified portion of the Sudan from any other portion or specified portion of the Sudan of any specified plant, fungus, parasite, insect or other thing which is diseased or is in his opinion likely to spread disease:

to appoint places of entry

(*b*) appoint any specified places to be the only places of entry for plants or for any specified plant:

to appoint quarantine grounds

(*c*) appoint quarantine grounds where plants and packages containing the same or with which the same may have come into contact may be detained for the purpose of being inspected disinfected destroyed or otherwise disposed of:

to make exemptions

(*d*) exempt any plant from the provisions of this Ordinance or from any regulation or order made under this Ordinance:

to proclaim diseases

(*e*) extend amend or vary the first schedule hereto and declare any disease to be a proclaimed disease for the purposes of this Ordinance or remove any disease from the category of proclaimed diseases.

Appointment of Inspectors

Appointment of inspectors

5. The Governor-General may from time to time appoint inspectors and sub-inspectors to carry out the provisions of this Ordinance.

Inspectors and sub-inspectors shall be deemed to be public servants within the meaning of the Sudan Penal Code.

Director to have powers of Inspector

6. The director may exercise all or any of the powers of an inspector appointed under this Ordinance.

Occupiers to eradicate Proclaimed Diseases

7. (i) The occupier of every plantation shall at all times do whatever is necessary in order to eradicate any proclaimed disease from such plantation and prevent the spread thereof.

Occupiers and Sheikhs to report Proclaimed Diseases

(ii) The occupier of any plantation in which any proclaimed disease appears shall within 48 hours after first discovering or becoming aware of its presence send notice thereof to the mamour of the district or the governor of the province in which the plantation is situate, and it shall be the duty of all sheikhs and omdas to report to the mamour or to the governor of their province the presence of any proclaimed disease which comes to their knowledge.

Power of Entry and Inspection

8. (i) Any inspector or sub-inspector may at any time enter into any conveyance or upon any plantation land or building or on board any ship for the purpose of inspecting

any plants or the packages containing the same or with which the same may have come into contact and shall have all such powers and authorities including the power to dig up plants, open packages and otherwise as may be necessary for enabling him to inspect and examine any plant.

Procedure when Disease is Discovered

(ii) If an inspector or sub-inspector considers any plants or packages to be diseased or infected he may give a notice in writing to the owner or person in charge thereof and after the service of such notice no person shall remove or cause to be removed any plant from such conveyance, plantation, land, building or ship without the written permission of the inspector or sub-inspector or some superior authority and the owner or person in charge thereof shall forthwith take such measures and do such acts as are necessary to eradicate and prevent the spread of the disease.

Action by Inspector at Owner's Expense

(iii) If such owner or person fails so to do to the satisfaction of the inspector or sub-inspector such inspector or sub-inspector may do the same at the expense in all things of such owner or person who nevertheless shall not be thereby relieved from his other liabilities under this Ordinance.

Inspector may Treat or Destroy Diseased Articles

(iv) In the exercise of the powers conferred upon him by the last sub-section, an inspector or sub-inspector may remove, treat, disinfect, destroy or otherwise dispose of any plants or packages in such manner as he thinks fit.

Detention in Quarantine

(v) An inspector or sub-inspector may order the detention of any plant or package which he suspects to be infected or apprehends may introduce or spread disease and may cause the same to be removed to and detained in a quarantine ground or other convenient place for examination or disinfection or to be dealt with otherwise under this Ordinance.

Detention in quarantine

Seizure of Articles Introduced Contrary to Regulations

9. (i) Any plant, fungus, parasite, insect or other thing introduced or attempted to be introduced into the Sudan contrary to any order or regulation under this Ordinance may, together with any package containing the same or with which the same may have come into contact, be seized by an inspector or sub-inspector or an officer of customs and be disinfected, destroyed or otherwise disposed of as an inspector or officer of the customs shall direct at the expense of the owner or person in charge thereof.

Co-operation by Postal and Customs Officials

(ii) It shall be the duty of all officers of the Postal Department and of the Customs respectively to assist in carrying out the provisions of this section and in preventing the introduction of anything into the Sudan contrary to any order or regulation issued under this Ordinance.

Cost of Disinfection, etc.

Cost of disinfection, etc.

10. The costs of and incidental to the disinfection or destruction of any plantation, plants or packages under this Ordinance except the cost of inspection and mere detention in quarantine shall be paid by the owner, occupier, consignee or addressee thereof on demand and in default of payment, such costs may be recovered by action in a civil court and in addition the director shall be entitled to a charge on all disinfected plants and packages to secure the payment of such costs and shall be entitled to enforce the same by sale in case the owner, occupier, consignee or addressee fail to pay such costs within two months of the service upon him of a formal notice calling upon him to make payment or if he or some duly authorised agent in his behalf cannot be found.

Notices: how Delivered

11. Any notice to be given to any occupier or other person under this Ordinance may be given either by delivering the same to such person or by leaving it at or posting it addressed to him at his usual or last known place of abode or business in the Sudan or if he is unknown or cannot be found in the Sudan, then by affixing such notice on a conspicuous place on the land or building to which the notice relates.

Immediate Destruction of Plants Infected with Dangerous Disease

12. It shall be lawful for a Governor or for an inspector of a province authorised by a Governor to order or cause to be carried into effect the immediate destruction of any plants which are found to be infected with any proclaimed disease.

Offences under the Ordinance

Offences

13. Every person commits an offence against this Ordinance who directly or indirectly by himself, his servant or agent,

distribution of infected articles

(*a*) sells offers or exposes for sale or distributes in any manner any plant or package which to his knowledge is infected with any proclaimed disease or (except under the direction of an inspector or sub-inspector) brings or suffers the same to be brought upon or removes or suffers the same to be removed from any land or building in his occupation:

distribution of articles introduced contrary to regulations

(*b*) sells or offers or exposes for sale or distributes in any manner any plant or thing which to his knowledge has been introduced into the Sudan contrary to any order or regulation under this Ordinance, or (except under the direction of an inspector or sub-inspector) brings or suffers the same to be brought upon or removes or suffers the same to be removed from any land or building in his occupation:

breach of any regulation

(*c*) does or attempts to do any other act in breach of this Ordinance, or of any order or regulation thereunder;

failure to fulfil obligations

(*d*) fails to observe and perform any duty or obligation imposed on him by this Ordinance or by any order or regulation made thereunder or by any notice served upon him thereunder.

PENALTIES

14. Every person who commits an offence against this Ordinance is liable to a fine not exceeding £E 20 or in default to imprisonment for a period not exceeding three months. Penalties

TRIAL OF OFFENCES

15. Offences under this Ordinance may be tried summarily or otherwise before a magistrate of the first or second class under the Code of Criminal Procedure but no prosecution shall be initiated without the consent of the director or an inspector or some person authorised by the director in that behalf.

FEES

16. The fees set out in the second schedule hereto shall be payable in respect of the matters mentioned in such schedule.

ISSUE OF REGULATIONS

17. Regulations consistent with this Ordinance may be issued from time to time by the Governor-General in Council with reference to the following matters and when published in the *Sudan Gazette* shall have effect as if part of this Ordinance:— Issue of regulations

notice of importation

(*a*) prescribing that notice shall be given by any person introducing into the Sudan through the post or otherwise, any plants specified in such regulations and to whom and in what manner any such notice is to be given:

method of examination

(*b*) prescribing the manner in which any plant introduced into the Sudan shall be examined by an inspector or sub-inspector at the place or places of entry or before delivery through the post:

method of treatment

(*c*) prescribing the manner in which diseased plants and infected packages shall be treated, cleansed, destroyed or otherwise disposed of:

use of old packages

(*d*) prohibiting so far as the director may deem necessary the use of packages which have already been used as such:

fees

(*e*) altering the second schedule hereto by increasing, decreasing, varying or abolishing any of the fees chargeable under this Ordinance as also by fixing additional or other fees:

other matters

(*f*) generally for any other purpose for which regulations are contemplated by this Ordinance or for the better carrying out of the provisions of this Ordinance.

Protection of Public Servants

Protection of public servants

18. No suit or criminal prosecution shall lie against the director or any inspector or sub-inspector or other public servant or any person acting under the authority of the director or any inspector or sub-inspector or other public servant for anything done under this Ordinance or in good faith intended to be done under this Ordinance.

Government not to be Liable for Loss or Damage

19. The Government shall not be responsible for any loss or damage which may occur in respect of any plantation, plant or package to which this Ordinance applies and which shall be damaged, destroyed or lost by or in the course of any act or operation done or undertaken for the purposes of this Ordinance.

Schedule I

Schedules

All such scale insects or mealy bugs (coccidæ) as are injurious to fruit trees or other trees or plants of economic value.

Schedule II

Fees

For fumigating or disinfecting plants shrubs or fruit trees

120 or less	5 m ms each.	Minimum charge	£E 0.500
121 to 240	3.5 m ms each.	ditto	0.600
241 to 360	3.0 m ms each.	ditto	0.850
361 and over	2.5 m ms each.	ditto	1.000

A New Genus and two new Species of Culicidæ from the Sudan

BY

FRED. V. THEOBALD, M.A., F.E.S.

Imperial Ottoman Order of the Osmanieh; Grand Medallist of the Société Nationale d'Acclimatation de France; Honorary Member Société de Pathologie Exotique, Association of Economic Entomologists U.S.A., Royal Horticultural Society, etc.; Vice Principal of the S.E. Agricultural College, Wye.

Genus: *Diceromyia*, nov. gen.

Head clothed with narrow curved scales and numerous upright forked scales except at the sides where they are flat; female palpi short, slightly swollen apically; antennæ pilose, basal segment with scales and hairs; palpi of ♂ slightly longer than the proboscis, thin, no hair tufts, last segment very small; antennæ plumose, scaly on two basal segments; proboscis showing traces of a joint on apical half. Genus *Diceromyia*

Thorax with narrow curved scales; prothoracic lobes with scales and long chætæ; scutellum with flat scales, narrow-curved ones on each side of mid lobe, posterior border bristles of mid lobe in double line. Abdomen normal. Male genitalia with short broad basal lobe with very long stalked flat scales on the inner side, a tuft of curved hairs at the apex and forked claspers (*vide* Plate X., fig. 3; also fig. 18).

Wings with normal venation, densely scaled with Mansonia scales, broad spatulate ones and thin linear ones.

This genus comes near *Newsteadina*, Theobald, but differs in (1) the ♀ palpi being short and not longer than half the length of the proboscis, (2) in the absence of long hairy scales on the basal segments of the ♂ antennæ and (3) in the presence of flat scales on most of the scutellum.

From *Orthopodomyia*, Theobald, it also differs in the longer ♂ palpi and much shorter ♀ palpi and also in squamose characters.

The male genitalia are very marked.

Mansonia (?) nigra, Theobald (*Second Report, Wellcome Tropical Research Laboratories*, Khartoum, p. 80, 1906), also apparently belongs to this genus.

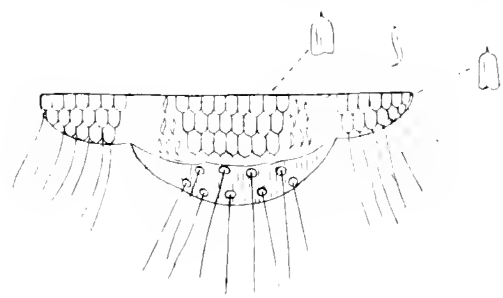
Diceromyia africana, nov. sp.

(Plate X.)

Thorax dark brown with dark scales, pleuræ with white puncta. Abdomen deep brown, with lateral short white median lines, in some cases reaching across the segments. Head dark with two pale spots; proboscis black with a white band. Legs dark brownish-black, with basal white bands and bases of femora pale, femora and tibiæ mottled. Wings thickly scaled with dark brown and some scattered pale scales. *Diceromyia africana*

♀ Head black with dark and some pale curved scales, the latter forming two more or less distinct spots, black upright forked scales rather numerous, flat white and then black scales at the sides; clypeus dark with some small flat scales; proboscis black with a broad white band and black hairs; antennæ dark brown with paler rings, basal segment dark with some flat yellow scales; palpi black, short.

Thorax almost black, clothed with narrow curved bronzy scales, some showing dull golden reflections in certain lights, some almost creamy ones at the sides in front of the wings; chætæ deep brown with golden-brown reflections; pleuræ black with patches of flat white scales; scutellum black, the mid lobe with flat and narrow curved creamy scales, the lateral lobes with them black; chætæ dark; metanotum black; prothoracic lobes with ochreous scales and long chætæ. Abdomen dark, ornamented as follows: basal segment black scaled all over except for a median basal white spot, hairs dense and golden, second segment with a basal median creamy spot, and traces of a white spot on each side near the base and a few scattered yellow scales, third to sixth segments with prominent white lateral spots near the base of the segments, with scattered yellow scales amongst the black ones, rest dark with some scattered yellow scales, border-bristles golden.



Dæomyia africana,

Legs dark blackish-brown, femora, tibiæ and to some extent the first tarsals with scattered creamy scales, base and venter of femora pale in the hind legs, all the tarsal segments with basal white bands, in the fore and mid the last two tarsi are unbanded; femoral and tibial hairs dark in some lights, paler in others; fore and mid ungues equal and uniserrate, hind equal and simple.

Wings with dense brown scales and some scattered white ones, many of modified Mansonia type, others almost pyriform, and beneath them lateral linear scales on the apical areas of the veins; first fork-cell longer and slightly narrower than the second fork-cell, their bases nearly level, stem of the first fork-cell not quite half the length of the cell, stem of the second fork-cell rather more than half the length of the cell, posterior cross-vein nearly three times its own length distant from the mid cross-vein.

Length: 3·5 mm.

♂ Head with grey narrow curved scales and black upright forked scales, flat black and creamy white ones at the sides of the head, some very broad upright scales in front, almost like long stalked flat scales, chætæ black.

Antennæ with brown plume hairs, pallid, the basal segment large, globular and dark with small flat creamy scales, the second segment with dense creamy scales; proboscis black with a creamy median band, above which it appears to be slightly angulated; palpi slightly longer than the proboscis with three white bands, and a minute white apical segment, a few long brown spines on the penultimate segment. The clypeus is black and minutely hairy and has longer spine-like hairs at the end. Thorax black with narrow curved pale golden and bronzy scales, of two sizes, chætæ dark, some with golden reflections; prothoracic lobes dark with small flat and narrow curved creamy scales and long chætæ; scutellum black with black and creamy flat scales and creamy narrow curved ones to the mid lobe, flat black ones to the lateral lobes, chætæ black; metanotum black.

Abdomen as in the ♀; genitalia, very marked with long dense scales on the inside of basal lobe, a marked apical tuft of hair and small bifid claspers. Legs banded and marked as in the ♀; fore and mid ungues unequal and uniserrate.

Wings with mottled dark and white scales, some of the large scales of Mansonia

PLATE X

1

2

3

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7

[illegible] n. sp.

1. Wing of ♀ to show scales
2. Head of
3. Genitalia of ♂
   (a) forked clasper
   (b) inner scale tuft
   (c) apical tuft
4. Wing of ♀
5. Wing of ♂
6. Head of ♀
7. Apex of ♂ palpus

type, others spatulate, lateral linear ones on the apical areas of the veins; fork-cells short, the first submarginal longer and narrower than the second posterior, its base slightly nearer the apex of the wing, its stem nearly two-thirds the length of the cell, stem of the second posterior also about two-thirds the length of the cell, posterior cross-vein nearly twice its own length distant from the mid cross-vein.

Pneomyia africana, ♂

Length: 3·5 to 4 mm.

Habitat: Nasser, Sobat River.

Time of capture: July, 1907.

Observations: Described from three ♀'s and three ♂'s, three specimens being nearly perfect. Collected by Dr. Wenyon. A very marked species clearly coming in a new genus. It bears some resemblance, however, to *Mansonia* (?) *nigra*, Theob. (*vide Second Report*, p. 80, 1906), which was taken on the Blue Nile.

It differs, however, in (i) the palpi of the ♀ not having two white bands; (ii) the abdomen not having irregular apical white bands; (iii) the tarsals of the first and second pairs of legs only having three, not four, bands; (iv) the ungues of fore and mid legs being uniserrate and not simple as in *M. nigra*. There are also (v) differences in wing venation and the wing scales, the sixth vein not having large heart-shaped scales.

Types in collection of the writer.

Culex sudanensis, nov. sp.

(Plate XI.)

Culex sudan. Thorax tessellated with golden-brown and deep brown, showing traces of linear arrangement. Proboscis unbanded. Abdomen black, with broad basal creamy-white bands, but two segments with yellow apical bands; very hairy in the male. Legs brown, with narrow basal pale bands. Wings normal.

♀ Head black, with pale narrow curved scales, pale upright forked scales in the middle, dark ones at the sides, flat lateral scales mostly dark, some creamy ones bordering the eyes and at the extreme sides, median chætæ golden, lateral ones black; proboscis, palpi and antennæ brown, the palpi with dull creamy apical scales. Thorax black, clothed with pale golden brown narrow-curved scales arranged somewhat in lines, the spaces between with scanty scales, thus giving a darker lined appearance, the scales becoming pale, almost creamy before the scutellum, which is also clothed with narrow-curved pale scales; chætæ brown, with golden-brown apical reflections; prothoracic lobes dark, with narrow curved pale scales; metanotum brown; pleuræ dark, with patches of flat white scales.

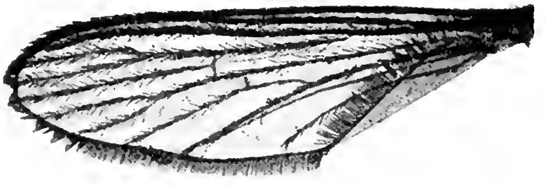
Abdomen black, with prominent creamy-white basal bands, the last two segments with apical yellow bands as well; posterior border-bristles pale golden; genital lobes black and long, hairy.

Legs dark brown, femora and tibiæ with some scattered pale scales and pale golden hairs, metatarsi and first two tarsals of fore legs, first three of the mid and all the hind with narrow pale basal bands; knee spots yellow; fore and mid ungues equal and uniserrate, hind ?

PLATE XI

1

2



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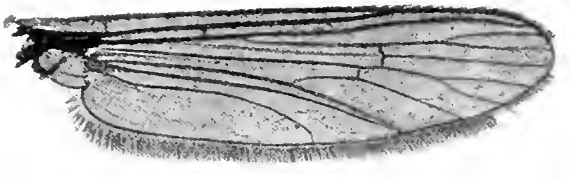


4

5

6

[illegible] n. sp.

1. Head of ♀
2. Apex of ♀ abdomen
3. Wing of ♀
4. Wing of ♂
5. Genitalia of ♂
6. Genitalia of ♂ under pressure, the spine [illegible]

Wings with short fork-cells, the first slightly longer and narrower than the second, its stem more than half the length of the cell, its base slightly nearer the apex of the wing, stem of the second fork-cell about three-fourths the length of the cell: posterior cross-vein not quite twice its own length distant from the mid.

Length: 3·5 mm.

♂ Similar to ♀, but the abdomen very hairy. The basal lobes of the genitalia are long and hairy and the long claspers are minutely bifid, the true termination of the clasper is hairy on the inside, and the other arm is formed by a stout chæta longer than the other projection.

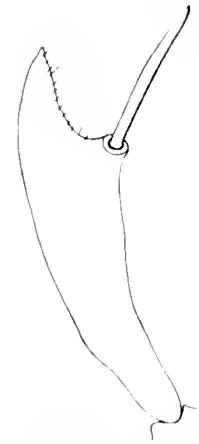
Fore and mid ungues unequal and uniserrate, hind equal and simple.

Wings with short fork-cells, the first longer and narrower than the second, its stem about two-thirds the length of the cell, its base very slightly nearer the apex of the wing, stem of the second fork-cell nearly as long as the cell; posterior cross-vein nearly twice its own length distant from the mid.

Length: 3·5 mm.

Habitat: Sudan (Harold H. King).

Observations: Described from 3 ♀'s and 1 ♂.



Culex sudanensis, ♂.

The male genitalia are very marked; no basally banded legged species of this appearance has before been found in the Sudan. One ♀ showed the abdominal basal bands narrower than in the type specimen and there are evidently basal white lateral spots which are hidden when the insects are dried up.

Types in the collection of the writer.

The Finches and Weaver Birds of the Sudan

being Notes on the Group containing the Birds Injurious to Grain Crops

BY

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Superintendent, Sudan Game Preservation Department

Introduction

A good deal of attention has lately been called to the damage done to growing grain crops in the Sudan by vast flights of small birds, but we have little or no information as to the relative abundance, distribution, habits, and destructiveness of the different species by which the damage is done in different districts. To obtain this, some knowledge of the group of birds containing the destructive species is required, and, as there is little easily accessible literature on the local avifauna, a general sketch of the grain and seed-eating finches of the Sudan may be useful at the present time. This paper includes all the finches that I know of as occurring within our limits, though I believe that only a very small proportion of them will be found to be appreciably destructive to agriculture. As far as my knowledge goes the damage seems to be done entirely by the Sparrows *(Passer)*, and the extremely abundant Weaver Birds of the genera *Hyphantornis*, *Xanthophilus*, *Quelea*, and, in a smaller degree, *Pyromelana*. The full list here given may perhaps, however, lead to the recognition of others as criminals, especially in the remoter districts.

Utility as insect killers

It should not be forgotten that the birds which congregate on the crops, and do so much damage at harvest time, feed their young almost entirely upon insects during the breeding season, and their immense numbers must make them an important factor in keeping down insect life. Their utility in this respect, however, seems to be somewhat discounted by the fact that, while they visit the cultivated districts to do damage, they retire to forest and marsh country away from the cultivation at the period when they become useful as insect killers. The whole question of the relation of birds to agriculture in the Sudan would repay study, and in this it is hoped that the present paper may be of assistance.

Part I

The Families, Sub-Families, and Genera

All the destructive species belong to the Fringilline, or Finch-like section of the Passerine Birds. In this group the bill, though varying in shape and proportionate size, is strong and conical, with smooth unnotched cutting edges to the mandibles, and with the nostrils placed close to the forehead; the wing has nine or ten primaries; the tail consists of twelve feathers; the legs and feet are strong, with the tarsus (the part of the leg between the "knee" and the foot) covered with scales in front and plain behind.

The group falls naturally into two families:

1. *Fringillidæ*, represented in the Sudan by Buntings, Sparrows, Serin Finches, and some others.

II. *Ploceidæ*, containing the Weaver Birds, Waxbills, Widow Finches, and Bishop Finches, etc.

In the *Fringillidæ* the wing has *nine* primaries only, the first (outer) feather being about the same length as the second.

In the *Ploceidæ* there are *ten* primaries in the wing, the first of which is very small, not nearly so long as the second. The base of the bill extends back like a wedge into the feathers of the forehead.

A glance at the outermost wing feather of a bird, or a count of the primaries, will therefore show to which of these families it belongs—the first step to "running it down."

Recognition

[*Note.* The word "primaries" may here require explaining. The wing of a bird folds like a Z. The "upper arm" (a strong single bone, the *humerus*), is directed backwards; next is the "forearm," a long joint composed of two bones (the *radius* and the *ulna*) forming the stem of the Z; then comes the "hand," formed of several small bones, and directed backwards again—the bottom of the Z. The large flight feathers which spring from the *hand* are the *primaries*, and those which spring from the *forearm* are the *secondaries*. They form a continuous series, but the joint between the forearm and the hand is the dividing point between them.

Most of the *Fringillidæ* (Finches) found in the Sudan are resident, only a small proportion of the species being cold weather visitors. Most are of gregarious habits, and feed principally on grain and seed; in the breeding season, however, they feed their young mostly upon insects, though partly on semi-digested seed. All except the Sparrows and Rock-Sparrows make open cup-shaped nests. They moult once in the year, in autumn, and have a partial change of colour in spring, due to the falling off of worn feather tips. (A good instance of this style of change is afforded by the cock of the common Sparrow; in winter the black throat feathers are edged with whitish; in the spring these edges are worn off, leaving the throat mark pure black.) The eggs of the *Fringillidæ* vary greatly, but are usually coloured and spotted or streaked.

The *Ploceidæ* (Weavers) are all residents. All are gregarious, especially those of the genera *Hyphantornis* and *Quelea*, some of which congregate in flocks literally of millions. They build covered nests, and their eggs vary greatly, being white, uniformly coloured, or spotted. They feed on grain or seeds and insects. Most of the sub-family *Ploceinæ* breed in colonies, making beautifully woven nests suspended from trees or reeds. These are often retort-shaped, with the entrance at the bottom of a hanging tunnel.

The *Estrildinæ* pair off in the breeding season, making small domed nests in grass or bushes, and not breeding in colonies. The *Viduinæ* build woven nests, often placed in grass or reeds. Many of them are polygamous, a small proportion of brightly plumaged males attending to a colony of nesting females.

Family I. *Fringillidæ*

Family I. *Fringillidæ*

The locally occurring birds of this family are divided into two groups or sub-families:

1. *Emberizinæ* (Buntings).
2. *Fringillinæ* (Sparrows, Serin Finches, etc.).

The *Emberizinæ*, or Buntings, of which the English Yellow-hammer is a well-known type, may be readily recognised by the form of the bill, in which, when closed, the cutting edges of the mandibles do not quite meet together in the middle. There is also a sharp angle on the under surface of the lower mandible, close to the chin. The Buntings build open nests on or near the ground, and their eggs are generally marked with irregularly scribbled lines.

The *Fringillinæ* are typical Finches, in which, unlike the Buntings, the cutting edges of the mandibles fit closely together when the bill is closed, and the pronounced angle on the under edge of the lower mandible, characteristic of that sub-family, is absent or slight. The very destructive Sparrows come in this group. The Finches of this sub-family make open nests, with the exception of the Sparrows, which build domed ones. The eggs are generally speckled.

1. Sub-family: *Emberizinæ*

Sub-family *Emberizinæ*

The African Buntings are divided into two genera:

Emberiza (Typical Buntings). In these there is a white pattern on the outer tail feathers.

Fringillaria (Rock Buntings), in which there is no white on the outer tail feathers.

2. Sub-family: *Fringillinæ*

Sub-family *Fringillinæ*

This is a larger section, and in the Sudan the following genera must be recognised:

Erythrospiza (Desert Trumpeter Bullfinches). Small red-billed birds, with a rosy-pink tinge in the plumage, brightest on wings and tail.

The birds in the following genera have no red in the plumage.

Serinus (Serin Finches). Small finches with a short bill, much swollen at the base, the upper mandible about as deep as the lower. Plumage, in the Sudan species, yellow and green, or grey with a white rump.

Poliospiza (Seed-eaters). In these the bill is moderately long, with the upper mandible deeper than the lower. The nostrils are covered with plumes. The top of the head is streaked with whitish.

Passer (Sparrows). The bill is moderately long, with the upper mandible deeper than the lower, and the nostrils covered by plumes. The wings are of moderate length, falling short of the end of the tail by more than the length of the tarsus (the bare shank of the leg). The first wing feather is small and narrow, the next three longest and nearly equal in length. The upper plumage is often partly chestnut-brown. A black throat patch characterises the males of several species. The crown of the head is always uniform in colour, and not streaked, as in the Seed-eaters, which the Sparrows somewhat closely resemble.

Petronia (Rock Sparrows). These are very similar to the Sparrows of the genus *Passer*, but in proportion to their size, have a much longer wing, which falls short of the end of the tail by less than the length of the tarsus. The nostrils are exposed, and not covered by plumes. A small patch of yellow on the throat is characteristic of the genus.

Family II. *Ploceidæ*

Family II *Ploceidæ*

This, the Weaver Bird family, is divided into three groups or sub-families:

1. *Viduinæ*, containing the Indigo Finches, the Whydahs or Widow Finches, the Bishop Birds, and the Dioches.
2. *Estrildinæ*, the Cut-throat Finches, Sociable Weavers, Silverbills, Mannikins, Waxbills, Fire-finches, and Pytelias.
3. *Ploceinæ* (the typical Weaver Birds), containing the Grosbeak Weavers, White-headed Weavers, Buffalo Weavers, Weaver Sparrows, Anaplectes, Spectacled Weavers, Slender-billed Weavers, Masked Weavers, and Golden Weavers.

These sub-families may be recognised as follows:

In the *Viduinæ* and the *Estrildinæ* the first primary, or outermost feather of the wing is very small, narrow, and sharply pointed, not reaching beyond the end of the primary coverts (the series of feathers on the upper surface of the wing which overlap the bases of the flight feathers).

In the *Viduinæ* the sexes are nearly alike in winter, with the plumage of the back striped, but in the summer the males assume a strikingly distinct breeding plumage, frequently with enormously developed tail feathers, or extremely brilliant colours.

In the *Estrildinæ* the sexes are nearly alike at all seasons. The plumage of the back is never striped. The minute first primary is sickle-shaped. There is no extraordinary seasonal development of the tail feathers in the males.

In the *Ploceinæ* the first primary is larger, reaching beyond the primary coverts, and is not sharply pointed. The tail is square or rounded. Males resemble females in winter, but assume a brighter plumage in the breeding season.

Sub-family *Viduinæ*

1. Sub-family: *Viduinæ*

The following genera are represented in the Sudan:—

Hypochera (Indigo Finches). Birds of small size, in which the adult males are uniform glossy blue-black. Females and young males are mottled-brown, with the centre of the crown of the head pale buff. The bill, whitish in colour, is short and conical, as wide as deep at the base, with the nostrils almost hidden by the nasal plumes. The tail is shorter than the wing, with the central pair of feathers slightly shorter than the others. Wing with the first feather very minute, not longer than the bill.

Vidua (Whydah or Widow Finches). In this genus the males in breeding condition have the four central tail feathers extremely long, and are of a handsome, unmottled, dark or pied plumage, with the bill black or red. Females, young, and males in non-breeding plumage are brown, mottled on the back with black, and with a buff eyebrow stripe. Tail square, shorter than the wing.

[*Note.*—In neither of the two above genera is there a frill on the neck in breeding males, nor is there any bright-red or yellow in their plumage.]

Coliuspasser (Great-tailed Whydahs). In this, and the next, group of Whydah Birds the tails are graduated or rounded, and not square, at all seasons. In *Coliuspasser*, but not in *Urobrachya*, the tail of males in breeding plumage is longer than the wing. In some of the South African species it is developed to a much more extreme length than in the one occurring in the Sudan. In our species (*Coliuspasser macrurus*) breeding males are velvety-black, with the upper part of the back and the shoulders bright chrome-yellow. The females and young are brown, mottled with black; males not in breeding plumage resemble them, but have the shoulders always bright chrome-yellow.

Urobrachya (Fan-tailed Whydahs). Very closely allied to *Coliuspasser*, but the rounded tail is always shorter than the wing. In the Sudan species (*Urobrachya phœnicea*) the breeding males are black, with the shoulders orange-red. Females and young are extremely like those of *Coliuspasser macrurus*: non-breeding males are very similar to those of that species, but have the shoulders orange-red instead of chrome-yellow.

Pyromelana (Bishop Birds). Called in the Sudan "Dhurra Birds." In these the tail is square, and not rounded. The males in the breeding season assume a brilliant livery of black and scarlet, or black and yellow, with thick upper tail coverts as long as the tail. Females, young, and non-breeding males are mottled-brown.

Note.—In *Coliuspasser*, *Urobrachya*, and *Pyromelana* the neck feathers of breeding males form, or can be erected into, a frill round the neck. Plumage of breeding males is black and bright-red, or black and yellow.

Quelea (Dioches, or Red-billed Weavers). In these the bill is strong, cone-shaped, and bright-red. The tail is square and short. The back plumage is mottled *always* with black stripes, as these are retained in the breeding dress of the male, which then differs from the females and young in acquiring some black or red on the head or throat.

Of the genera of the above family, *Pyromelana* and *Quelea* (especially) seem to be the only mischievous ones. *Hypochera* and *Vidua* seek their food mostly on the ground, scratching for fallen seeds with curious little backward jumps. *Coliuspasser* and *Urobrachya* are mostly birds of marsh or high grass rather than frequenters of cultivation.

2. Sub-family: *Estrildinæ*

This group contains nine genera represented in the Sudan, in recognising which the following notes may assist:— Sub-family *Estrildinæ*

Amadina (Ribbon Waxbills, or Cut-throats). Bill very conical and broad at the base, swollen and rounded. Plumage brown, much barred or banded, with a crimson bar on the throat of males. Tail short and rounded.

Philetairus (Sociable Weavers). Nostrils exposed. (In all the other genera of *Estrildinæ* these are covered by the feathers of the forehead). Tail short and square. (In the other genera it is graduated or rounded). The Sudan species is plain pale-brown, with some black on the wings and tail and the crown of the head light grey.

Uroloncha (Silverbills). Bill short, stout, and swollen, its basal edges rectangular when looked at from above; leaden or dull silver-coloured. Tail fan-shaped, with the two central feathers longest and narrowing into points.

Ortygospiza (Bar-breasted Manikins). Finches of very small size. Tail short and rounded, about half the length of the wing, the outstretched feet reaching beyond it. Culmen (the upper ridge of the bill) nearly straight.

Spermestes (Bronze Manikins). Differ from *Ortygospiza* in having the culmen curved, and in the extended legs not exceeding the tail. Head, and a patch on each shoulder, bronze-green in the Sudan species.

Uræginthus (Cordon Bleu Waxbill). Of small size. Graduated tail longer than the wing. Plumage blue and brown in the Sudan species, with a crimson patch on each side of the head in males.

Estrilda (Waxbills). Of small size. Very like the last genus in shape, but with the tail shorter than the wing. Second wing feather shorter than the fifth. The upper tail coverts (the feathers covering the base of the tail) always red, *unless* there is a crimson band through the eye.

Lagonosticta (Fire-finches). Of small size like the Waxbills, but with the first long feather in the wing becoming very narrow at the end, owing to the cut-away shape of the inner web. There are generally characteristic small white spots on the breast or sides.

Pytelia (Pytelias). Larger birds than the Waxbills and Fire-finches, with the first long wing feather narrowing at the end in the same way. Upper plumage greenish or grey: lower surface closely barred. Outer edges of the wing feathers red or yellow.

3. Sub-family: *Ploceinæ*

Sub-family *Ploceinæ*

Spermospiza (The Blue-bills). Bill blue with the tip orange. Sides of the chest glossy crimson. Breast black in males, marked with conspicuous pairs of spots or bars in the females.

Sporopipes (Scaly-fronted Weavers). Of small size. Nostrils not exposed. Tail square, with the central feathers slightly shortest. Feathers of forehead scale-like in appearance, with black centres and white edges.

Amblyospiza (Grosbeak Weavers). Stout, heavily built Weavers with an immensely thick bill, the base of which extends back in a ridge on the forehead beyond the eyes. Males with a white patch on the base of the wing feathers.

Dinemellia (White-headed Weavers). Birds rather like large Sparrows, with head and breast mostly white; a white patch on the wing feathers: feathers above and below the tail red.

Textor (Buffalo Weavers). Large strongly-built Weavers of black plumage.

Ploceipasser (Weaver Sparrows). Stout Sparrow-like Weavers, with a conspicuous broad pale eyebrow stripe, and white ends to the wing coverts which form two distinct bars on the base of the closed wing.

Anaplectes (Scarlet Weaver Sparrows). Birds of sparrow-like size and shape, with head and breast vermilion in the males. Bill red.

Malimbus (Malimbes). Black Weaver Birds with the crop crimson.

Hyphanturgus (Spectacled Weavers). Bill rather slender. Back *uniform olive-green.* A black line through the eye. Throat black in males, this colour not extending on to the sides of the face. Sexes otherwise similar.

Sitagra (Slender-billed Weavers). Smaller birds than the last, with the bill also slender. Back *green with dusky stripes.* Males with forehead, sides of head, and throat black. Females with no black on head.

Hyphantornis (Masked Weavers). Weavers with a considerably stouter bill. Males with black on the sides of the head, and females without it. Plumage of back greenish with dusky stripes, black and yellow, or yellowish-chestnut, never uniform green.

Xanthophilus (Golden Weavers). Very similar to *Hyphantornis*, but with no black on the head. Lower parts clear golden-yellow. Upper parts olive-yellow.

PART II

NOTES ON THE SPECIES

Family: *Fringillidæ*

Sub-family: *Emberizinæ*

Genus: *Emberiza*

Family *Fringillidæ* Sub-family *Emberizinæ*

1 *Emberiza flavigastra*, Rupp. (Golden-breasted Bunting). Length, 5·7 inches; wing, 3·2. Head striped with black and white; back nearly plain chestnut; lower surface mostly bright-yellow; under tail coverts white. Some white on the wing coverts. I have found this bird not uncommon on the Blue Nile above Wad Medani, the upper Atbara and Setit, and at El Obeid in Kordofan. Resident.

2. *Emberiza affinis*, Heugl. (Swainson's Golden-breasted Bunting). Length, 5·3 inches; wing, 2·75. Similar to the last except that it has no white on the wing coverts. I have met with it occasionally between Wau and Chak Chak in the Bahr-El-Ghazal, and have specimens from Raffile. Resident.

3. *Emberiza hortulana*, Linn. (The Ortolan). Length, 6·2 inches; wing, 3·6. Above brown with dusky streaks; throat pale-yellow; a patch on the crop and most of the head olive colour; rest of underparts pale-rufous. Winter visitor to the northern Sudan. Abundant at Erkowit, and sometimes at Khartoum.

4. *Emberiza cæsia*, Cretzschm. (Cretzschmar's Bunting). Length, 6 inches; wing, 3·2. Very similar to the Ortolan, but with crop and head grey, not olive, and throat rufous. Winter visitor, very common over the northern Sudan.

Genus: *Fringillaria*

5. *Fringillaria striolata*, Licht. (Striolated Rock Bunting).

6. *Fringillaria septemstriata*, Rupp. (Red-winged Rock Bunting).

These are smaller Buntings of rock-frequenting habits. There is no white on the tail. The head is striped with black and white in adults, and brown with black streaks in the young. Back brown streaked with black. Under surface rufous, and wing feathers partly rufous-chestnut.

F. striolata has black on the throat and crop. The chestnut on the wing feathers does not quite cross the inner webs. Length, 5·1 inches; wing, 2·75. Rocky localities from Shendi north. I have it from Port Sudan. Resident.

F. septemstriata has the crop rufous, the black of the throat not extending on to it. The chestnut on the wings completely crosses the inner webs of the primaries for part of their length. Length, 5·5 inches; wing, 3·1. Rocky localities in the northern Sudan. I have it from the Setit, Blue Nile, and Chak Chak. Resident.

I have never seen any of the above Buntings settling on the heads of growing grain. They feed mostly on the ground, and seem to do no damage.

Sub-family: *Fringillinæ*

Genus: *Erythrospiza*

7. *Erythrospiza githaginea*, Licht. (Desert Trumpeter Bullfinch). Length, 4·8 inches; wing, 3·4. Sandy-brown, washed with rose-pink. Bill red. A resident desert bird, ranging south to 18° N. in the Bayuda Desert. Frequents cultivation near desert, clustering on mustard and heads of small grain or seed. Not numerous enough to do serious damage. Sub-family *Fringillinæ*

Genus: *Serinus*

8. *Serinus nigriceps*, Rupp. (Abyssinian Black-headed Serin). Length, 4·8 inches; wing, 2·7. Yellow beneath, and olive and yellow above; head and throat jet-black in males. Recorded from Dongola. I know nothing of it.

9. *Serinus icterus*, Bonn. et Vieill. (Yellow-fronted Serin). Length, 4·2 inches; wing, 2·7. Plumage green and yellow. Common in the Bahr-El-Ghazal and on the Upper Blue Nile. Resident. A forest finch mostly. Probably does no damage.

10. *Serinus leucopygius*, Sundev. (White-rumped Grey Serin). Length, 4 inches; wing, 2·6. Grey with white rump. Common and widely distributed over most of the Sudan. Attacks growing grain, but does not collect in very great numbers, and the damage it does is probably slight.

Genus: *Poliospiza*

11. *Poliospiza canicapilla*, Du Bus. (Senegal Seed-eater). Length, 5·2 inches; wing, 2·9. Brownish-grey, the crown streaked with whitish. Very scarce. I have only met with it once, between Wau and Chak Chak. A seed-eater from Jebel Ahmed Aga, too young to identify, perhaps also belongs to this species.

Genus: *Passer*

The following Sparrows more or less resemble the common House Sparrow, with black on the throats of the males. The females have not the black throat, and are duller than the males.

12. *Passer hispaniolensis*, Temm. (Spanish Sparrow). Length, 6 inches; wing, 3. Crown of head, chestnut. Sides streaked. Has been recorded from the Nile at Ambukol and Merowe, and from the Upper Blue Nile. A winter visitant. I have never met with it, but Mr. M. J. Nicoll, of the Giza Zoological Gardens, writes me that he shot it at Merowe this winter, and saw it in hundreds.

13. *Passer italiæ*, Vieill. (Italian Sparrow). Length, 5·8 inches; wing, 3·1. Crown chestnut. Sides not streaked. According to Heuglin it occurs on the Blue Nile, but this wants confirmation.

14. *Passer rufidorsalis*, Brehm. (Sudan House Sparrow). Length, 4·7 inches; wing, 2·7. Crown, grey. Ear coverts whitish, with no black. This is a small, brightly-coloured race, or sub-species, of the common House Sparrow, and its habits are the same. It is extremely abundant at Khartoum, and along the Nile northwards to Berber and Dongola. Its northward range appears to be checked by the Nubian Desert, and I think the Sparrow at Halfa belongs to a different form, more like the Egyptian bird. Emin obtained it on the Upper Nile as far south as Lado, but it appears to be very scarce on the White Nile. It does not seem to extend to the Red Sea coast; I found the few Sparrows frequenting houses at Port Sudan were *Passer diffusus*. I do not know how far it extends up the Blue Nile. Its present range will probably spread as villages grow into towns. It would be interesting and useful if people would record its presence or absence in different out-stations at the present time, as it is most destructive to crops, and apparently steadily increasing in numbers.

15. *Passer cordofanicus*, Finsch. (Kordofan Sparrow). Length, 5·6 inches; wing, 3. Crown, grey. Ear coverts, *grey*. Heuglin met with them in Central Kordofan, but only at the beginning of the rains. Probably resident. I have never come across it.

16. *Passer shelleyi*, Sharpe (Shelley's Sparrow). Length, 5·6 inches; wing, 2·75 Very like *P. cordofanicus*, but with half of the ear coverts pure white, and half jet-black. I have a male and two females from Mongalla. The only other known specimen is a male obtained by Emin at Lado. Apparently extremely rare.

The following Sparrows have no black on the throat of the male.

17. *Passer simplex*, Licht. (Desert Sparrow). Length, 5·2 inches; wing, 3. Crown and upper parts unmottled rufous-sandy. Kordofan and the northern deserts of the Sudan to between Berber and Suakin. I have never met with it. Resident.

18. *Passer diffusus*, Smith (Grey-headed Sparrow). Length, 5·5 inches; wing, 3·4. Crown, head and neck, grey. Most of back, chestnut; beneath, whitish-grey. This is a Bush Sparrow rather than a House Sparrow in its habits, and is met with in large numbers far from human habitations or cultivation. In towns where the common House Sparrow has not established itself, however, as at Port Sudan, this species to some extent adopts the habits of the latter, and frequents buildings. It is a very widely distributed bird in bush-covered country, and I have specimens from Port Sudan, the Setit, the Atbara, Gallabat, El Obeid and the Mazrub Wells in Kordofan, Wau in the Bahr-El-Ghazal, Roseires on the Blue Nile, the lower White Nile, and Mongalla. I have no information as to its attacking crops, though

it is a species which, from its numbers and wide distribution, would be a very destructive one if it did so.

19. *Passer crassirostris*, Heugl. (Thick-billed Sparrow). Length, 6·6 inches; wing, 3·8. Very similar to *P. diffusus*, but rather larger, with a much stouter bill, and greyer underneath. It was discovered at Fazogli, on the Blue Nile, in 1867, but does not seem to have been noticed in the Sudan since, though it has been found in East Africa. It would be interesting to find it again in the neigbourhood of Roseires.

20. *Passer emini*, Hartl. (Emin Pasha's Sparrow). Length, 4·8 inches; wing, 2·45. A small Sparrow in which the males are almost entirely dark chestnut-brown. Rare. I have it from Meshra-El-Rek and Mongalla only.

21. *Passer luteus*, Licht. (The Yellow Sparrow). Length, 5 inches; wing, 2·5. Head, neck and breast, yellow; most of back, chestnut. A very abundant, widely-spread, and destructive Sparrow, ranging between about 12° and 20° N. It is common at Khartoum in the summer, making a large stick nest in lime trees. It is abundant on the lower parts of the Blue and White Niles, and ranges north of Berber. In April, 1903, I saw it in hundreds of thousands at Bara in Kordofan. Every thorn zareba round cultivation was literally yellow with them. On that occasion Silverbills in smaller, but very large numbers were feeding on the crops in company with them.

Genus: *Petronia*

Both these Rock-Sparrows have a small patch of yellow on the throat.

22. *Petronia dentata*, Sundev. (Lesser Rock-Sparrow). Length, 4·75 inches; wing, about 3. A smallish brown Sparrow with mottled back. Quite a bush sparrow in its habits. Common, in moderate numbers in the Bahr-El-Ghazal; I have it from Raffile, Wau, and Chak Chak. It also occurs on the Zeraf and on the Upper Blue Nile. I do not know of it damaging crops.

23. *Petronia pyrgita*, Heugl. (Heuglin's Rock-Sparrow). Larger, length, 5·7 inches; wing, 3·2. Back, greyer and not mottled. This must be quite a rare bird, and I have never been able to obtain it. Mr. Charles Rothschild collected two examples at Shendi, and I remember seeing a specimen obtained at the Haraza Hills, Western Kordofan, by Captain (now Major) H. N. Dunn, R.A.M.C., in October, 1902.

Family: *Ploceidae*

Sub-family: *Viduinae*

Genus: *Hypochera*

24. *Hypochera ultramarina*, Gm. (Indigo Finch). Length, about 4·5 inches; wing, 2·45. Males in breeding plumage glossy-blue-black, with wings and tail dark-brown, and a little white under the wing. Bill whitish. Females and non-breeding males mottled-brown above, with centre of crown buff. A widely distributed and tame little bird, inclined to frequent houses and villages, and to visit "zeers" for water. Often associated with the little crimson Fire-finch. I have it from Khartoum, the Blue and White Niles, Gedaref, and Wau, and it ranges some distance north of Khartoum. It builds an untidy sparrow-like nest, often in holes in buildings. Family *Ploceidae* Sub-family *Viduinae*

25. *Hypochera wilsoni*, Hartert. (Wilson's Indigo Finch). Very similar to the last, but with the wings and tail much paler brown. A more southern species. I have it from Mongalla only.

Genus: *Vidua*

26. *Vidua principalis*, Linn. (White-breasted Whydah). Breeding male: length, 11·5 inches; wing, 2·8; longest feathers in tail 9 inches. Jet-black above, with a

white collar and whitish rump. Tail feathers very long and narrow, black. Underparts white. Bill red. Females (length 4·75 inches) are rufous-buff, with a mottling of dark centres to the feathers, and the centre of the crown buff between two blackish stripes. Males in winter are similar to them. Ranges as far north as Shendi, but is much commoner farther south. I have it from Fachi Shoya on the White Nile to Mongalla and Lado, and from the Zeraf; from Wau and Chak Chak, and Roseires. It is described as breeding in colonies, building woven nests suspended in trees or high grass.

27. *Vidua paradisea*, Linn. (Paradise Whydah). Length, about 5·5 inches; wing, 3; but in the breeding male two very long and broad black tail feathers, set edgeways, are assumed, bringing its length up to 15 or 16 inches. Breeding males have the head, throat, and upper plumage black, with a pale yellow collar round the neck; breast glossy mahogany colour, shading into buff. Females and non-breeding males are reddish-brown above, streaked with black. Head with the centre of the crown buff between two broad black stripes, beneath which are broad buff eyebrows. Beneath buffy-white.

Fairly common and widely distributed. The long-tailed males are conspicuous objects, but are in small proportion to the females; the species appears to be polygamous. I have met with it from the Setit on the east to El Obeid on the west, and from Roseires to the White Nile and Mongalla. Its long tail has given it the Arab name of "Abu Seif"—the sword-bearer.

Genus: *Coliuspasser*

28. *Coliuspasser macrurus*, Gm. (Yellow-mantled Whydah). Breeding male: length, 7·6 inches; wing, 3·2. Velvety black, with bright chrome-yellow on the back and shoulders, and a longish fan-shaped tail. Females and young males, 5·3 inches; wing, 2·6, mottled dark brown, with paler edges to the feathers, and a buff eyebrow. Adult non-breeding males similar, but with a chrome-yellow patch on the bend of the wing. Common in the Bahr-El-Ghazal, frequenting open grassy plains near rivers or "khors." I have it from Raffile, Kojali, Chak Chak, Pongo and Chell Rivers, etc., but not in the beautiful breeding plumage, which is assumed in the rains only.

Genus: *Urobrachya*

29. *Urobrachya phœnicea*, Heugl. (Heuglin's Fan-tailed Whydah). Length, 6·3 inches; wing, 3·4; females rather smaller. Breeding males black, with a patch of orange-red and cinnamon on the bend of the wing. Females and non-breeding males very similar to those of *Coliuspasser macrurus*, but with some orange-red on the bend of the wing. Common on marshes and plains of high grass near water. I have it from the White Nile south of Kaka, along the Bahr-El-Ghazal to Meshra, the Jur River, the Sobat, and from the Dinder. Flocks fly low over the grass, with a rather heavy flight.

All the above genera of the *Viduinæ* feed principally upon grass seeds, and I do not think they are at all injurious to cultivation. The birds of the next two genera appear to be very mischievous.

Genus: *Pyromelana*

30. *Pyromelana franciscana*, Isert. (Franciscan Bishop-bird). Known as the "Dura bird" in the Sudan. Length, 4·8 inches; wing, 3·4. Breeding males scarlet and velvety-black, the top of the head and underparts from the chest downwards being of the latter colour, and the throat, neck, and back scarlet.

1. Adult
2. Adult, out of plumage
3. Adult, in plumage

Females and non-breeding males mottled blackish and pale brown, with a buff eyebrow. The red-and-black breeding males must be familiar to every resident in the Sudan; they are, however, in small proportion to the brown-plumaged birds. I believe they are polygamous, as only two red males used to appear at a little colony of some 8 or 10 nests which I knew of at Khartoum. The nests are woven of grass, placed in high grass or dura, and contain pale blue eggs. It is found from Dongola southwards over a great part of the Sudan. I have it from Khartoum, the White Nile, Blue Nile, Gedaref, Kordofan, Bahr-El-Ghazal, and Mongalla. Though destructive and abundant it does not occur in any such immense numbers as the red-billed *Quelea* referred to in the next genus.

31. *Pyromelana flammiceps*, Swains (Fire-crowned Bishop-bird). Length, 5·2 inches; wing, 3. Very like the last, but a trifle larger, and with the black and scarlet differently distributed. The crown of the head is scarlet, the chin and throat black, instead of vice versa. Does not range nearly so far north as the last. I have it from Mongalla only. Females like those of the last.

32. *Pyromelana ladoensis*, Reichen. (Lado Yellow-crowned Bishop-bird). Length, 4·3 inches; wing, 2·2. Breeding males: crown of the head and back bright canary-yellow. Sides of head, a broad collar round the neck, and under surface velvety-black. Females and out-of-plumage males very like those of other *Pyromelanas*. Abundant at Lado, where Emin discovered it. Mr. Hawker obtained it on the White Nile near Kodok, but in ten years I have never come across it.

33. *Pyromelana xanthomelas*, Rüpp. (Ruppell's Black and Yellow Bishop-bird). Length, 5·5 inches; wing, 3. Breeding male black, with the lower half of the back and some markings on the wings bright yellow. Females mottled blackish-brown. Non-breeding males similar, but retaining yellow on back and wings. Antinori obtained it on the Upper White Nile, which is all I can find regarding its occurrence in the Sudan.

Genus: *Quelea*

34. *Quelea æthiopica*, Sundev. (Buff-fronted Dioch). (Plate XII.). Length, 4·7 inches; wing, 2·7. Bill stout and strong, *bright red*. Plumage of the back streaked, with blackish centres to the feathers and pale edges *at all seasons*. Non-breeding males and females with the crown of the head brown with dusky centres to the feathers, and *a pale eyebrow stripe*: beneath whitish buff. Males in breeding plumage develop a black "mask" on the face, extending from the eyes down to the throat; the top of the head and the underparts are buff, or buff more or less strongly tinged with pale claret colour.

This is quite one of the most destructive birds in the Sudan, and, owing to its immense numbers, one of the most serious enemies of agriculturists. It is widely spread in the Kassala, Sennar and Kordofan Provinces, on the White Nile, Zeraf, and Upper Nile as far as Lado, collecting in vast flights of hundreds of thousands, or millions even, on ripening grain crops. It breeds in large colonies, hanging its woven ball-shaped nests on acacias, "Sessabans," etc.

35. *Quelea erythrops*, Hartl. (Dark-throated Red-headed Dioch). Length, 5·1 inches; wing, 2·55. Bill black in males, dark brown in females. Entire head and throat crimson, shading into blackish on the chin. Plumage otherwise very similar to the last. Heuglin obtained a specimen somewhere in the neighbourhood of Rumbek, which is all I know of its occurrence in the Sudan.

36. *Quelea cardinalis*, Hartl. (Cardinal Dioch). Length, 4·3 inches; wing, 2·3.

Bill black, as in the last, to which it is very similar, differing principally in having the back of the crown streaked with blackish, and the whole throat pure crimson with no blackish chin. It has also a smaller bill. Emin found it numerous at Lado, and I have a male from Mongalla. It apparently occurs only quite in the south of the Sudan.

Sub-family: *Estrildinæ*

Genus: *Amadina*

Sub-family *Estrildinæ*

37. *Amadina fasciata*, Gm. (Cut-throat Finch, or Ribbon Waxbill). Length, 5·1 inches; wing, 2·6. Pale rufous-brown, with close angular black bars, *the male* with a crimson band across the throat. Common and widely distributed in moderate numbers. I have it from Gallabat, the upper Atbara and Setit, the Blue Nile, and Kordofan. Heuglin obtained it on the White Nile, and Emin at Lado. In the heat of the day they drink in flocks at the mud "hôds" made by Arabs at their wells to water cattle.

Genus: *Philetairus*

38. *Philetairus arnaudi*, Bp. (Arnaud's Sociable Weaver). Length, 4·7 inches; wing, 2·6. Pale brown, with some black markings on wings and tail, and the crown of the head whitish-grey. These Weavers occur only in the south of the Sudan. I have specimens from Mongalla and Rejaf. They are extremely sociable in their breeding habits, crowding their nests, which are made of coarse grass with a hanging entrance tunnel, into a mass on the same bough. The birds of an allied South African species work together to make a large roof-like shelter for the common good, to the under side of which their nests are attached in a mass. I am not aware if the same habit has been recorded in our bird.

Genus: *Uroloncha*

39. *Uroloncha cantans*, Gm. (Silverbill). Length, 4·3 inches; wing, 2·1. Bill lead colour. Upper parts pale brown, with narrow indistinct darker bars. Feathers of the forehead and throat rather scale-like. Rump and tail blackish-brown. Underparts whitish. The Silverbill is common and widely distributed, in some localities occurring in very large numbers. On the East I have it from Talgwareb station, but have not noted it on the Red Sea coast; it occurs right across the country from Roseires to Western Kordofan, ranging north of Shendi, and south along the White Nile. At Bara, in Kordofan, in April, 1904, I saw it in thousands in company with the Yellow Sparrow, and I think it is to some extent mischievous to crops. I have found it nesting at almost any time of the year, in thatched roofs, palm trees, and bushes.

Genus: *Ortygospiza*

40. *Ortygospiza atricollis*, Vieill. (Bar-breasted Manikin). Length, 3·6 inches; wing, 2. Above brown. Forehead, cheeks, and throat black. Centre of chest rufous. Crop and sides boldly barred with black and white. A tiny finch obtained by Emin at Rejaf, and by von Heuglin on the Bahr-El-Ghazal.

Genus: *Spermestes*

41. *Spermestes cucullatus*, Swains. (Bronze Manikin). Length, 3·7 inches; wing, 1·9. Above brown, the rump barred with grey. Crown of head and a patch on each shoulder bronze-green. Throat bronze-brown. Centre of breast white; sides barred brown and white, with a patch of bronze-green on each. Another very diminutive grass finch. I have it from Tembura and from between Wau and Chak Chak, which are, I think, the most northern records for it.

Genus: *Uraeginthus*

42. *Uraeginthus bengalus*, Linn. (Cordon Bleu Waxbill). *Estrilda phoenicotis* is a common synonym. Length, 4·5 inches; wing, 2. Above brown, with the rump and tail blue. Sides of head and underparts blue, excepting the centre of the abdomen and the under tail coverts, which are pale brown. The *males* have a conspicuous patch of crimson on the cheeks. The Cordon Bleu is common in the Kassala and Sennar Provinces; in Kordofan, in the Bahr-El-Ghazal, and on the White Nile and Upper Nile. It is a pretty and harmless species, feeding on small seeds. It makes an egg-shaped nest of grass in a bush, and lays white eggs.

Genus: *Estrilda*

43. *Estrilda occidentalis*, Fraser and Jard. (Fraser's Waxbill). This is little more than a sub-species of the Common Waxbill, *Estrilda astrild*. Length, 4·3 inches; wing, 1·75. Above, including the rump, brown, closely crossed with narrow dark bars. Tail dark brown. A crimson stripe through the eye, and face below that white. Breast tinged with pink; sides brownish with dusky bars; abdomen and under tail coverts black. Bill wax-red. Often met with on the Blue and White Niles, in small flocks.

44. *Estrilda cinerea*, Vieill. (Common Black-rumped Waxbill). Length, 3·4 inches; wing, 1·8. Above brown, with narrow indistinct darker barring. Rump and tail black, with white edges to the outer tail feathers. A crimson stripe through the eye. Cheeks and underparts pinkish-buff; centre of abdomen pink. Bill wax-red. Sennar, Kordofan, White Nile, Upper Nile, and Bahr-El-Ghazal. I have it from Wau, Chak Chak, and Roseires.

45. *Estrilda rhodopyga*, Sundev. (Sundevall's Red-rumped Waxbill). Length, 4 inches; wing, 1·8. Above brown, finely barred with dusky. A stripe through the eye, and the rump, crimson. Wings and tail brownish-black, with some crimson on the margins. Cheeks and throat buffy white. Beneath brownish, tinged with pink. Bill red. Occurs on the Blue and White Niles. I have often seen flocks of these Waxbills in Khartoum in the winter and spring. Emin found it common at Lado.

46. *Estrilda subflava*, Vieill. (Northern Zebra Waxbill). Length, 3·8 inches; wing, 1·7. Upper parts olive-brown. A stripe through the eye and the rump and upper tail coverts crimson. Most of the under surface bright reddish-orange, with the sides strongly barred with olive. Occurs on the Nile from Kaka to Lado. My specimens are from Bor and Lado.

47. *Estrilda paludicola*, Heugl. (Heuglin's Pale Waxbill). Length, 4·2 inches; wing, 1·8. Above brown with very faint barrings, and the top of the head grey. Rump crimson. Cheeks greyish. Underparts buffy. Heuglin discovered this little Waxbill at Meshra-El-Rek, and Emin procured it at Lado. I found it abundant in khors between Chak Chak and Dem Zubeir.

48. *Estrilda nigricollis*, Heugl. (Grey Black-faced Waxbill). Length, 4·4 inches; wing, 1·9. General colour leaden-grey; rump crimson; tail black, with some crimson on the margins. Sides of the head and the upper throat jet-black. Beneath pinkish-grey, with some small white spots on the sides. Bill bluish-grey. Heuglin discovered it in the Bahr-El-Ghazal near Wau. (I have followed Captain Shelley in putting this and the next species into the genus *Estrilda*. They seem to me to go more naturally into *Lagonosticta*).

49. *Estrilda larvata*, Rupp. (Rüppell's Black-throated Waxbill). Length, 4·5 inches; wing, 2·1. Male with the upper parts slaty-grey; the crown and nape washed

with vinous-pink. Rump, and some edgings to the tail feathers, crimson. A "mask," including the sides of the head and the whole throat, black. Front of chest vinous-red: sides the same, with small white spots. Centre of chest and abdomen black. The female is a browner bird, with no black on the face, and only faintly tinged with vinous. Antinori obtained it on the Upper White Nile and in Kordofan. I found it numerous at Gallabat in April, 1903, and also have a pair from Roseires.

Genus: *Lagonosticta*

50. *Lagonosticta melanogastra*, Hengl. (Heuglin's Black-bellied Fire-finch). Length, 4 inches; wing, 1·9. Mostly crimson. Centre of breast, abdomen, thighs, and under tail coverts black. No white spots on the breast. In the female a great deal of the crimson is replaced by ashy or brown. Heuglin discovered it in the Bahr-El-Ghazal. Emin procured it at Lado, and Antinori in Kordofan and Sennar. I have never met with it.

51. *Lagonosticta butleri*, Grant (Butler's Fire-finch). Length, 4·4 inches; wing, 2·2. Known only from two females which I obtained at Chak Chak. Above earthy-brown; rump and tail washed with crimson. Chin and throat grey; chest grey with a pinkish tinge, and a few small white spots. Remainder of underparts pale pinkish-brown.

52. *Lagonosticta brunneiceps*, Sharpe (Brown-naped Fire-finch). Length, 3 inches; wing, 2. Upper parts brown washed with crimson, and brightening into crimson on the forehead, sides of the crown and rump. Face and underparts crimson, shading into brown under the tail. A few white spots on the sides of the chest. Female mostly brown, with the rump crimson. Widely distributed from Dongola and Berber southwards on the Blue and White Niles, and in the Kassala and Kordofan Provinces. A charmingly pretty and fearless little bird, frequenting gardens, and entering verandahs freely to drink from "zeers."

53. *Lagonosticta rufopicta*, Fraser (Bar-breasted Fire-finch). Length, 3·7 inches; wing, 1·85. Above dark brown, rump dull crimson. Forehead and underparts pinkish-crimson, shading into brown on centre of chest and abdomen. The chest marked with very small white bars. Occurs on the Upper Nile and in the Bahr-El-Ghazal. My specimens are from Bor and Kenisa.

54. *Lagonosticta rhodopsis*, Heugl. (Heuglin's Dusky Fire-finch). Length, 3·8 inches; wing, 1·85. Dusky, ash-coloured, rump crimson, tail black. Eyebrows, cheeks, and chin washed with rosy. Known only from Heuglin's description of a pair from the Bahr-El-Ghazal. It has been suggested that they may have been only immature examples of *L. brunneiceps*.

Genus: *Pytelia*

55. *Pytelia phœnicoptera*, Swains (Black-billed Red-winged Pytelia). Length, 4·8 inches; wing, 2·3. Above brownish-grey, rump scarlet; tail black, with margins washed with red. Wings brown, with crimson on outer edges of the quills and bend. Face, chin, and throat grey; remainder of underparts grey with white bars, widest towards the tail. Bill black. Recorded from the Bahr-El-Ghazal by Heuglin, and from Lado by Emin. Apparently rare.

56. *Pytelia lineata*, Heugl. (Red-billed Red-winged Pytelia). Length, 4·7 inches; wing, 2·3. Very like the last, but with the bill red. An Abyssinian bird, occurring between the Upper Blue Nile and the Atbara. Scarce. I have one pair from Roseires.

57. *Pytelia citerior*, Strickl. (Senegal Red-faced Pytelia). Length, 4·6 inches; wing, 2·2. Above yellowish-olive, with the top of the head grey, the rump scarlet,

and the tail black washed with crimson. In the male a scarlet "mask" covers the forehead, sides of face, and part of throat. Rest of throat and crop bright "old gold" colour. Breast and sides barred with olive-brown and white, centre of abdomen whitish. The females are duller, lacking the scarlet mask and the golden-yellow crop. This red-faced finch, which frequents thorn bush, and is generally met with in pairs or only small parties, occurs from Kassala and Sennar across the Sudan to Kordofan and the Bahr-El-Ghazal. I am not quite certain how far south it goes on the White Nile. From Shambe south, the next species appears to take its place.

58. *Pytelia soudanensis*, Sharpe (Sudan Red-faced Pytelia). A southern ally of the last, very closely resembling it, and differing principally in the white bars on the lower surface becoming pairs of white spots on the breast, and in the dark bars being bolder.

To distinguish the range of these two closely-allied forms as well as I am able to, I give the localities of my specimens of both:

P. citerior, Roseires, Rahad River, Gedaref, 20 miles west of Omdurman, El Obeid, Wau, Pongo River, Chak Chak.

P. soudanensis, Shambe, Bor, Mongalla.

The whole of the *Estrildinæ* feed principally on grass seeds, and, with perhaps the exception of the Silverbill, seem to do no damage.

The next group contains some very destructive birds.

Sub-family: *Ploceinæ*

Genus: *Spermóspiza*

59. *Spermospiza ruficapilla*, Shelley (Red-headed Blue-bill). Length, 6·3 inches, wing, 2·8. Head, front of neck, and sides of throat, bright glossy crimson; upper tail coverts duller crimson. Rest of the plumage dark slate-grey, the underparts with spots and bars of white. Bill blue with orange edges. Sub-family: *Ploceinæ*

Discovered by Emin in the Bahr-El-Ghazal, and apparently only obtained once since, in East Africa.

Genus: *Sporopipes*

60. *Sporopipes frontalis*, Daud (Spotted-fronted Weaver). Length, 4·5 inches, wing, 2·5. Above ashy-brown; feathers of the forehead, and of a moustache, scale-like, black with tiny white points. Back of the head cinnamon, with black centres to the feathers on the crown. Underparts white, tinged with brown. Common, but not in large flights, in Kordofan and on the Upper Nile. I have it from El Obeid and Mongalla. Builds an untidy sparrow-like nest, which the family resort to at night long after the young have flown.

Genus: *Amblyospiza*

61. *Amblyospiza melanota*, Heugl. (Heuglin's Grosbeak Weaver). Length, 7·3 inches, wing, 3·8. Male: forehead, as far back as the base of the bill extends, and a patch on the bases of the wing feathers, white. Upper parts mostly deep blackish-chocolate, becoming a more cinnamon-brown on the head and neck. Beneath dark greyish, with paler edges on abdomen and towards tail. Females are mostly dull brown above with paler edges to the feathers, and beneath white streaked with dark brown; without the white forehead and wing patch of the males. Upper Nile. Emin found it abundant at Lado. I have it from Kenisa, Gigging, and Rejaf. These Weavers *look*, from their immense bills, as though they would work havoc among any grain crop; but, as a matter of fact, they appear to

live mostly on berries and large forest seeds, beetles, termites, and locusts. They roost and breed in reed beds, resorting to forests to feed, and, in spite of their clumsy-looking bills, are said to construct beautifully-woven nests.

Genus: *Dinemellia*

62. *Dinemellia dinemelli*, Rüpp. (White-headed Weaver). Length, 8·2 inches; wing, 4·7. Head, neck, and breast white; above brown, with the rump and upper tail coverts washed with vermilion; lower abdomen and under tail-coverts also vermilion. Upper Nile. Recorded from Lado by Emin, and from the Bahr-El-Ghazal by von Heuglin. I have not met with it. There is a coloured illustration of this bird in Sir Harry Johnston's book on Uganda. It frequents open country in flocks, and breeds in colonies, making huge untidy nests of thorns, lined with grass, at the top of high acacias.

Genus: *Textor*

63. *Textor albirostris*, Vieill. (White-billed Buffalo Weaver). Length, 8·6 inches; wing, 4·8. Entire plumage glossy-black, with the concealed bases of the feathers whitish, and a trace of white edging on the wings. Bill whitish in young birds, black in older ones. Occurs in Sennar, Kordofan, on the White Nile and Sobat, and at Lado. My specimens are from Bara, Kosti, and Tawela. These birds construct enormous masses of sticks and thorns, in each of which several nests are placed, on the tops of high acacias. These conspicuous structures must often be noticed by travellers on steamers passing the neighbourhood of Kosti, and they are quite big enough to be taken for the nests of vultures or marabous. They are sometimes 6 or 8 feet across, and the material used would almost fill a cart. The birds are not in very great numbers, and they appear not to attack crops.

Genus: *Plocepasser*

64. *Plocepasser melanorhynchus*, Rupp. (Black-billed Sparrow Weaver). Length, 7 inches; wing, 4. Above brown, with the rump and tail coverts white, and a good deal of white on the wing. Top of the head, and a line from the lower mandible down each side of the neck, black; a very broad white eyebrow stripe from above to behind the eye. Underparts white. Bill black. General appearance very sparrow-like. Upper Nile as far north as the Sobat. My specimens are from Mongalla and Gigging, at both of which stations it is abundant, and, from its white rump, conspicuous. Nests which I found placed in colonies on the outer branches of thorny trees were very solid bundles of coarse grass, about a foot in length, woven so that the stiff stems projected outwards. The weight of these nests for their size, was remarkable, and the manner in which the sharp grass stems projected made them as inconvenient to carry in the hand as hedgehogs. I have not noticed the bird on crops.

65. *Plocepasser superciliosus*, Rupp. (Chestnut-crowned Sparrow Weaver). Length, 6·4 inches; wing, 3·4. Upper parts brown, with some whitish margins on the wings. Crown of the head chestnut, with a conspicuous buffy-white eyebrow. Sides of the head brown, with a whitish stripe from the lower mandible below the cheeks. Throat white, with a black line on each side of it. Underparts buffy-grey. Bill brown. Another very sparrow-like bird. Widely distributed on the Blue and White Niles, in Kordofan, and in the Bahr-El-Ghazal. My specimens are from Roseires, El Obeid, Raffile, Wau, and Chak Chak. Common in bush or forest. I have not seen it attacking crops. My specimens from Roseires have the bill markedly stouter than those from the Bahr-El-Ghazal.

Genus: *Anaplectes*

66. *Anaplectes melanotis*, Lafr. (Red-winged Anaplectes). Length, 6 inches; wing, 3·2. Male with top of the head, neck, throat, and breast vermilion; rest of upper parts brown, the back washed, and the wings and tail edged, with vermilion. A broad black patch on each side of the face. Abdomen whitish. Females brown, whitish below, with wings and tail washed with red. Occurs on the Upper Nile, in the Bahr-El-Ghazal, and in southern Sennar, but seems to me to be very scarce. I have a male from Raffile, and I saw it once or twice between Wau and Chak Chak.

Genus: *Malimbus*

67. *Malimbus nitens*, Gray (Gray's Malimbe). Length, 6 inches; wing, 3·4. Black, with the lower part of the throat and the crop bright crimson. The black on the head, neck, upper back, and breast is intense and glossy; elsewhere duller. Apparently just extends into the south of the Bahr-El-Ghazal, as Bohndorff obtained it in the Nyam-nyam country.

Genus: *Hyphanturgus*

68. *Hyphanturgus ocularius*, Smith (Smith's Spectacled Weaver). Length, 6·2 inches; wing, 3. Male: front half of crown, sides of head, and underparts bright olive-yellow; upper parts uniform unstriped yellowish-olive-green. Chin and throat and a narrow line from the bill through the eye, black. Female similar, but without the black throat. (This and the next species have longer and more slender bills than the other Weavers which follow). I have a single male of this Weaver from Tembura, in the Bahr-El-Ghazal, which is the only record I can find of its occurrence within Sudan limits.

Genus: *Sitagra*

69. *Sitagra luteola*, Licht. (Lichtenstein's Slender-billed Weaver). Length, 4·7 inches; wing, 2·5. Male with a jet-black "mask" covering the frontal half of the crown, sides of the head, and throat. This mask is bordered by bright canary-yellow, which extends down the sides of the neck and over the whole under-surface of the bird. Back yellowish-olive, with dusky centre streaks to the feathers. Wings margined with pale yellow. Female browner-greenish above, with no black on the face, and paler beneath.

This pretty little Weaver Bird is common and widely distributed on the Blue and White Niles, in Kordofan, and in the Bahr-El-Ghazal. My specimens are from Roseires, Bara, Mazrub, Wau, the Zeraf River, Bor, Mongalla, Lado, etc. It does not congregate in very large flights, and, though I have seen it on crops occasionally, I do not think it is responsible for much damage.

It weaves beautiful little oval nests, with a tubular entrance, suspended from acacia trees. I have found them singly and in small colonies. On the Upper Nile the fibre of the Doleib palm alone is used, and then the nest is so elastic that when crushed in the hands it springs back into shape like an India-rubber ball. At the same time it is so thinly woven as to be quite transparent, and the sitting bird, or the white eggs, can be seen in it distinctly from beneath. North of the range of the Doleib palm its nests are made of grass, and in this material are much less artistic structures.

Genus: *Hyphantornis*

70. *Hyphantornis heuglini*, Reichenb. (Heuglin's Masked Weaver). Length, 5·5 inches; wing, 2·8. Male with a black "mask" covering the sides of the head and the whole throat. Crown of head, sides of neck, and entire under-surface "old

gold" yellow, inclining to a tinge of chestnut round the black of the throat. Back yellowish-olive-green, with dusky centre streaks to the feathers; wings blackish, margined with yellow. The female is ashy-brown above, with broad dark centres to the feathers, and an indistinct buff eyebrow; beneath buff, with a tinge of yellow on the throat. Inhabits the Bahr-El-Ghazal, where Heuglin discovered it, and the Upper Nile. I have a male from Kojali. A rare Weaver, frequenting open forest or scattered trees, and unlikely to cause any damage to agriculture.

71. *Hyphantornis abyssinicus*, Gm. (Abyssinian Black-faced Weaver). Length, 6·9 inches; wing, 3·5. Male: a black mask covering the frontal two-thirds of the crown, the whole sides of the head and the throat. Back of the head chestnut, shading into bright golden-yellow on the nape. Most of upper surface bright golden-yellow, with jet-black mottlings on the shoulders. Wings blackish, broadly margined with yellow. Underparts bright yellow, tinged on the breast with chestnut, this colour margining the mask and shading gradually into the yellow. Bill black. Female: head greenish-olive; back ashy-brown, with dusky centres to the feathers; rump and tail olive. Wings brown, margined with pale greenish-yellow. This fine Weaver inhabits the southern Bahr-El-Ghazal, the Upper Nile, and the Upper Blue Nile. I have eight specimens from Mongalla, and six from Roseires, at both of which places it appears to be common, but I do not know whether it attacks crops.

72. *Hyphantornis badius*, Cass. (Cassin's Chestnut Weaver). Length, 5·5 inches; wing, 2·9. Male: whole head and throat black. Sides of neck, crop, and breast dark chestnut; sides chestnut mixed with yellow; centre of abdomen and under-tail coverts yellow. Tail olive and yellow. The female has the head above olive, with a buffy eyebrow stripe; the back pale brown with broad black centres to the feathers on the upper part of it; wings blackish, edged with pale yellow. Throat and abdomen white; chest and flanks tinged with yellowish buff.

My specimens of this Weaver are from Bor, Kenisa, and Roseires. Heuglin records it from the White Nile, Sennar, and the Atbara. It does not appear to be a very abundant species.

73. *Hyphantornis dimidiatus*, Salvad. and Antin. (Antinori's Black-headed Weaver). Length, 5·7 inches; wing, 2·8. Male: entire head and throat black; crop and breast chestnut, shading into canary-yellow on the rest of the under surface; neck and back yellow, shaded with olive; tail brown, washed with olive; wings blackish-brown, the feathers margined with bright yellow. Female: above uniform pale yellowish-olive; wing feathers margined with olive and pale yellowish buff; eyebrows, sides of head, chin, and throat pale yellow; rest of under surface white, the sides tinged with ashy.

A southern bird, which Emin found on the Upper Nile as far North as Wadelai. In 1871, Antinori obtained a specimen in a garden at Kassala. Between these widely distant points it does not seem to have been noticed, which is remarkable.

74. *Hyphantornis vitellinus*, Licht. (Vitelline Masked Weaver). Length, 5·5 inches; wing, 2·8. Male: a black "mask" on the sides of the forehead, sides of the head, and upper throat. Rest of head and underparts golden-yellow, shading into chestnut towards the forehead and just below the black throat. Most of back uniform olive-yellow, with the rump bright yellow. Tail olive-brown, washed with yellow. The female has the top of the head and upper back ashy-brown with broad dark centres to the feathers, and a slight wash of yellow on the rump. Some buff margins on

PLATE XIII

[illegible]

1. Adult [illegible] 2. Adult [illegible] plumage
3. Adult [illegible] plumage

[illegible]

the wing feathers; underparts buff, shaded with yellowish on the cheeks and throat. Heuglin found this Weaver feeding on grain crops at Berber, and on the Blue and White Niles. Rothschild and Wollaston found it common at Shendi, and Emin got it at Wadelai, but on the intervening portion of the White Nile the common Masked Weaver appears to be *H. tæniopterus*.

75. *Hyphantornis tæniopterus*, Reichenb. (Reichenbach's Masked Weaver). (Plate XIII.). Length, 5·4 inches; wing, 2·7. Male: front half of forehead, front half of face, chin, and throat black; back of head, sides of neck, and underparts bright yellow, shading into chestnut on the front of the head, and all round the black "mask." Back nearly uniform greenish-yellow, with the rump brightest. Wings blackish, margined with pale yellow. Tail olive, washed with yellowish. Female: crown and tail olive; back ashy-brown, the upper part of it with broad black centres to the feathers, the rump plain. Wings brown, edged on outer feathers with greenish, and on the inner feathers with yellowish-white. A faint pale eyebrow; sides of face brown; lower parts whitish, more or less strongly tinged with brown.

Reichenbach's Weaver ranges through the country bordering the White Nile from Khartoum to the Uganda frontier. It appears to be the most abundant Weaver in the country, and it congregates in flocks which must, literally, often number millions. Few travellers on the White Nile can have failed to notice the immense flights of these birds, which look at a distance like great drifting clouds of smoke, and which pass overhead with a roar of innumerable wings like the rush of a hurricane. This species and *Quelea æthiopica* are the most destructive birds on the White Nile, and as cultivation extends along that river their ravages are likely to become very serious. The woven grass nests of this Weaver are suspended in papyrus, reeds, or trees. The eggs exhibit a most remarkable amount of variation. I have them uniform brown, uniform olive-green, pale green speckled with olive, whitish freckled with red, densely freckled with red throughout, etc.,—in fact all my clutches might be taken for eggs of different species. My specimens of the bird are from Khartoum, Kodok, Taufikia, Kenisa, Shambe, and Kojali.

Danger to crops from *Hyphantornis tæniopterus* and *Quelea æthiopica*

Genus: *Xanthophilus*

76. *Xanthophilus galbula*, Rupp. (Ruppell's Golden Weaver). Length, 5 inches; wing, 2·8. Male: forehead, fore part of face, and chin chestnut, shading into bright golden-yellow on remainder of head and entire under surface. Back olive-yellow, with faint dusky centres to the feathers; rump plain yellow. Wings blackish, with yellow margins. Tail yellowish-olive. Female: above ashy-brown, with dark centres to the feathers of back; head tinged with olive; rump plain olive. Wings plain brown, margined with pale yellow and whitish. Beneath brownish-white, tinged with yellow on the throat and chest.

This is another extremely abundant and destructive species, ranging over the Upper Blue Nile districts and the Eastern Sudan to the Red Sea coast. It appears to extend only a short distance up the White Nile. My specimens are from the Dinder, Gedaref, Erkowit, Suakin, and Port Sudan. On the country between Gallabat and Gedaref I have seen it in vast flights, like locusts for multitude. Near the Blue Nile I once passed a breeding-place where the bushes for half a mile along a path, and for a hundred yards each side of it, were literally laden with their nests. There must, at the lowest computation, have been hundreds of thousands of them. In smaller numbers it is always to be noticed breeding, in the summer, in the gardens at Gedaref and Suakin, and in the ravines all over the Erkowit plateau and the

Red Sea hills, where the beautiful yellow plumage of the male makes it a very noticeable bird.

The descriptions of the males given in the last four genera of Weaver Birds apply only to the full breeding plumage. At other times of the year the males almost exactly resemble the females, and the different species are then by no means easy to distinguish. This will be gathered from the similarity in the descriptions of the females. I shall be very glad to identify any destructive birds sent to me with notes as to locality, abundance, and the kind of crops on which they were found feeding. A simple method of preserving them sufficiently well for identification is to pour a few drops of carbolic acid down their throats, and to suspend the birds by a thread through their nostrils until thoroughly dry, when they can be wrapped in paper and packed in a small box. Numbered labels corresponding to any notes should be tied to their legs.

A simple method for preserving specimens

This paper has extended to a length for which I must beg indulgence, but the number of species dealt with is considerable. I have made the list of our finches as complete as I am able to, and I think it includes all the species which may by any possibility be found to do any kind of damage to grain crops. I have made free use, especially in the first part of the paper dealing with descriptions of the families, sub-families, and genera, of Captain G. E. Shelley's *Birds of Africa*, and of the late Dr. A. C. Stark's excellent first volume on Birds in the *Fauna of South Africa* series, and in conclusion I must acknowledge my indebtedness to these writers.

Additional Note on a Species of Lark

(Melanocorypha bimaculata)

DESTRUCTIVE TO RIPENING DURA

I am surprised to find that in my notes on birds injurious to agriculture ought to have been included the large Eastern Calandra Lark *(Melanocorypha bimaculata)*.

Until quite lately I was unaware that any kind of Lark did damage to growing grain. Their feet are not sufficiently prehensile to enable them to cling to the upright ears or stalks, and I have never before seen any species hovering against the grain heads and extracting the grain without settling. This I find the Eastern Calandra Lark does. Settling on the ground among the dura it flutters up to the level of an ear and hovers poised against it while it extracts a grain. Having secured one it drops to the ground, swallows it, and immediately flutters up for another. The bird does not settle on the dura at all.

An instance of grain destruction by Larks

Vast flocks of this large Lark lately collected on a meagre dura crop between Khartoum and the White Nile, and did a great amount of destruction. I think it would be a low estimate to say that 50 per cent. of the crop was destroyed. In places one could gather hundreds of ears without one single grain left in them. Other birds (Common and Yellow Sparrows, with a few Red-billed Weavers) were also attacking the crop in large numbers, but the dense flights of this big Lark seemed to me to be doing most of the damage.

Melanocorypha bimaculata is a large handsome Lark with a very strong and finch-like bill. In examining 14 examples lately I found the length of the bird, from point of bill to end of tail, varied from 7 to $7\frac{1}{2}$ inches, the length of wing from $4\frac{1}{4}$ to $4\frac{3}{4}$, and the greatest expanse across the wings from $13\frac{1}{2}$ to $15\frac{1}{4}$ inches. The weight of these birds ranged from

65 to 75 grammes, and averaged a little over 69. They had been feeding entirely on dura, and were, like all birds just about to migrate at this season, exceedingly fat. The colour of the bird is pale brown above, with blackish-brown centres to the feathers on the crown and most of the back, the rump and upper tail coverts being without this dark mottling. The wings are dark brown, with pale buff edgings. The feathers of the square and rather short tail are dark brown edged with buff, and all except the centre pair are broadly tipped with white. There is a black line through the eye, and a whitish eyebrow above it. The ear coverts are brown, the cheeks and throat white. On the crop are two heavy black markings, forming an interrupted band across it. The rest of the lower parts are whitish washed with brown. The bill is dark horny-brown with the base of the lower mandible yellow.

This is a Palæarctic bird, breeding in northern Asia and Asia Minor, and migrating in the winter to N.E. Africa as far south as Abyssinia and the Blue Nile. Probably its immigrations vary a great deal in magnitude. During this winter and the two preceding ones it has been very abundant near Khartoum, but for some years previously I never noticed it, and, if present, it must, I think, have been in smaller numbers. Variation in different years

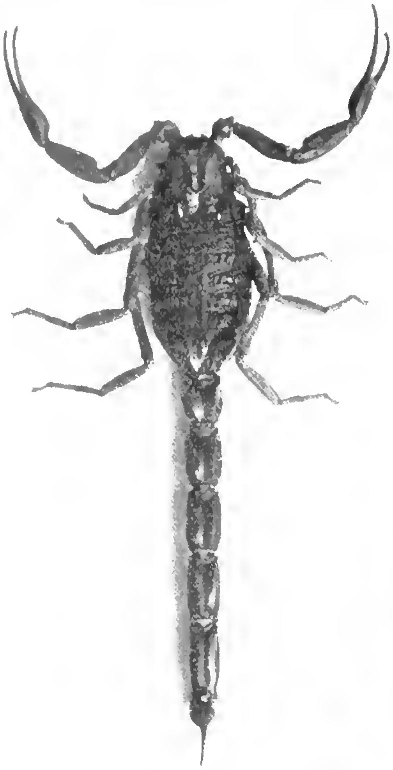
Mr. Hawker obtained specimens at Wad Shalai on the White Nile in 1901, but only saw one flock, and Messrs. Witherby and Rothschild, who made collections in the Sudan in the same year, did not meet with it.

Rüppell recorded it from the Dongola Province.

It seems a most destructive visitor when in large numbers.

The flight of the bird is usually buoyant and undulating; when flying into a strong wind it goes more steadily, and rather like a starling. It constantly utters a loud cheery trill when on the wing.

PLATE XIV



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BUTHIDAE

1. [illegible] (Khartoum)
2. [illegible]
3. [illegible] (Wady Halfa)
4. *Buthus occitanus* (Alexandria, Egypt)
5. [illegible]
6. *Buthus minax* (Mongalla)

[illegible]

Scorpions and Allied Annulated Spiders of the Anglo-Egyptian Sudan

BY

Professor Franz Werner

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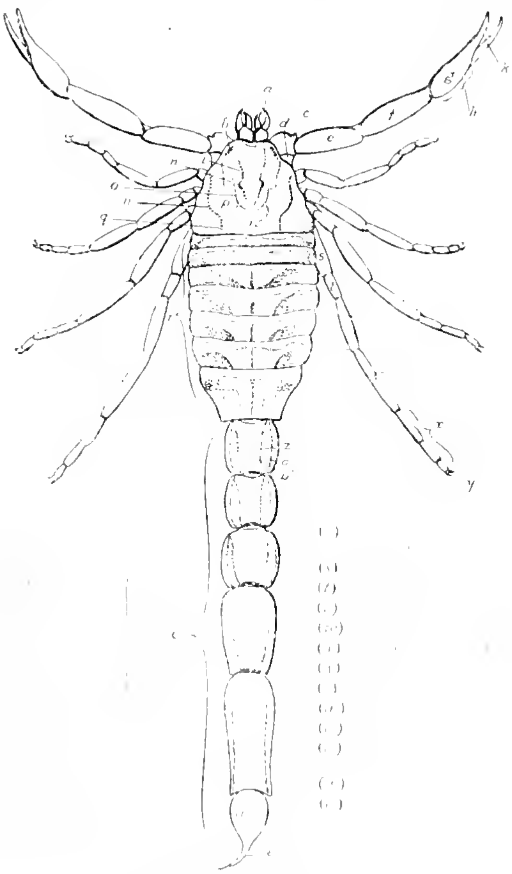
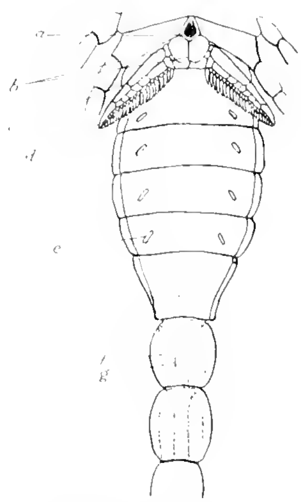
Having treated in the foregoing Report[1] the poisonous snakes of the Sudan, I shall try now to deal in the same manner with another group of animals, which are feared with more or less reason and which have been the subject of my investigations during the time which I passed in the Sudan (Winter, 1905).

The scorpions form, in the widest sense, a very distinct and unmistakable group of the *Arachnoidea* or spiders, and are characterised as belonging to them by having two pairs of articulated mouth-parts and four pairs of likewise articulated limbs, by the fusion of the head and thorax to a "cephalothorax," by the limbless abdomen and by the complete absence of gills, all members of this group breathing air directly by means of so-called "lungs," which consist of four pairs of invaginations of the skin, opening

A distinct group of the *Arachnoidea*





[1] *Third Report, Wellcome Tropical Research Laboratories*, Gordon Memorial College, Khartoum.

externally by oblique slits on the under side of the abdomen (Fig. 21, *e*). Each of these lung-sacs contains a number of parallel lamellæ protruding from the wall of the sac.

Anatomical characters

Three parts are to be distinguished in the body of scorpions. The first is the cephalothorax (Fig. 20, *p*), bearing the mouth-parts and limbs and covered above with a kind of shield; on this the eyes are arranged in three groups, one (composed of 2 to 5 eyes) on each side of the anterior margin and one (formed of two eyes on a small prominence) in the middle. The second piece, broadly united with the cephalothorax, to form the trunk of the animal, is the præabdomen, called shortly "abdomen" (Fig. 20, *c*). It consists of seven segments, the two first connected ventrally (Fig. 21) with the genital apparatus, the third to the sixth each bearing a pair of the above-mentioned slit-like "stigmata" of the breathing organs. The third piece is the tail-like postabdomen or "cauda" (Fig. 20, *c'*), consisting of six segments with a poison-sting at the end of the terminal vesicular segment. This cauda is the most characteristic external feature of scorpions and distinguishes them at once from all allied forms of annulated spiders.

The under side of the trunk shows, at the second ventral plate of the præabdomen, a pair of comb-like appendages (Fig. 21, *c*), likewise most characteristic of the scorpions. The number of comb-teeth or comb-lamellæ is valuable for distinguishing the species, as it is constant within certain limits. Somewhat in advance of these combs, the teeth of which bear sense-organs, we find a pair of genital valves, touching each other in the median line and in advance of them the "sternum," a triangular (Fig. 21, *a*) or pentagonal (Fig. 27) plate situated just in the median line.

The first pair of mouth-parts are the small mandibles, slightly prominent under the front margin of the cephalothorax. The terminal joint is scissor-like and the two branches of it, called the movable and the immovable mandibular fingers, are frequently found armed with tooth-like prominences.

Divisions of the maxillary palp

The second, a very much better developed pair, are the large, limb-like maxillary palps, armed with powerful scissors at their ends. These make the animal somewhat resemble a crayfish, with the difference that the latter has the *inner*, but the scorpion the *outer* "finger" of the scissors movable. The maxillary palp is formed (1), by the basal joint (the coxa), with its margin directed to the median line adapted for chewing; (2), the trochanter, a ring like short joint; (3), the femur and (4), the tibia, long, the joints acting somewhat like the upper and fore-arm of man, and provided, as a rule, with more or less strong longitudinal ridges; (5), the "hand" with its two "fingers."

The same divisions are to be distinguished when we investigate the four pairs of walking limbs of the thorax, which are nearly equal to one another in every respect, with the single exception, that they become gradually a little longer, as one passes from the first to the fourth pair. Coxa, trochanter, femur, tibia, all resemble those of the maxillary palps; but the end of the foot is formed by a series of three tarsal joints, the terminal one provided with a pair of more or less curved claws, the base of which is provided with a walking-spine (Fig. 24, *w*). Free movable spines at the base of the terminal joint are called basal spines (Fig. 24, *b*) and a tarsal spine (Fig. 24, *t*) is found at the penultimate joint in the scorpions of the genus *Buthus*.

The scorpions are strictly terrestrial animals of nocturnal habits, hiding during the day-time under stones, logs, the bark of trees, or in holes in the sand or soil. All are predaceous, feeding on small insects which are seized with the scissors of the maxillary palps and held above the cephalothorax; then the cauda is bent upwards in a vertical plane sufficiently far to enable the scorpion to observe his prey with his eyes and to choose, therefore, the exact point where his sting is to be introduced into its body.

It is a widely distributed belief that a scorpion, if surrounded by pieces of burning coal, kills itself by means of its sting, if it cannot see any way of escape. But often as this story has been repeated, it is not confirmed by any exact experiments; on the contrary, such experiments have shown that the scorpion only succumbs to the heat, and that the movements of the "cauda" are merely executed with the intention of driving away the unknown assailant. Naturally, the scorpion's poison has not any action on itself, just as a viper may bite its own body without any ill effect beyond the wound inflicted by its fangs.

All scorpions are viviparous, and the young are similar to the mother in every respect, with the exception that they are of a whitish colour, and are carried on the mother's back during the period following birth.

Habits and distribution

The group is distributed over all the warmer parts of the globe, becoming more scarce as regards both species and individuals from the equator towards the poles. According to Kraepelin the northern limit of distribution is situated in the old world between the 70° and 75° N. lat.; in North America between the 35° and 70°. On the other hand, they are found everywhere in the southern hemisphere, with the exception of South Patagonia, New Zealand and the antarctic islands.

They are more numerous as regards both species and individuals in dry countries, where the rainfall is slight. This is clearly demonstrated by their distribution over the Anglo-Egyptian Sudan, where the arid tracts of the North are inhabited by more species than the districts of the Upper Nile, where a single species is somewhat common. In accordance with their favourite habitats, scorpions do not exhibit any vivid colouring but only various modifications of a brown hue varying from a very light yellow (met with especially in species living in deserts) to a yellowish- and reddish-brown and dark brown to blackish with a bluish gloss. Where there are dark markings on the dorsal surface they are likewise brownish to black.

Scorpions are not only the oldest known Arachnids, but are amongst the earliest inhabitants of our planet, as they have been found in deposits of the Silurian period, and in a shape scarcely different from that of the scorpion of to-day. *Proscorpius osborni* and *Palaeophonus nuncius* are known from the Upper Silurian, *Eoscorpius* and *Cephalophthalmus* from the Carbonian.

Concerning the question as to whether scorpions are dangerous to man by reason of their sting, F. Dahl has given a short account of the various opinions held by authors. There is no doubt that the scissor-like chelicerae, the first pair of mouth-parts of the animal, do not contain poison-glands, and that therefore the scorpion's *bite* does not cause any dangerous effect. On the other hand the inflated, vesicle-like (but hard) last segment of the postabdomen contains two poison-glands, the ducts of which end separately and anteriorly to the point of the terminal, very acute and more or less curved sting. As a result, therefore, the scorpion meets his enemy with erected tail curved over his body, and a sting from it is deadly for the smaller warm-blooded animals up to the size of a dog, rarely, also, for man.

The poison and its virulence

As the older method of proving the virulence of the poison, *i.e.* simply to make the scorpion sting the animal, was not at all exact, experiments were made by injecting the poison directly into the blood-vessels in known quantities. This was possible, as it has been shown that the scorpion ejects its poison if treated with the electric current. In this way three to ten drops of poison could be obtained, the first perfectly clear, the following more milky, and, after a delay of 15 to 20 days, a fresh quantity of poison could be obtained. Hence it was possible to carry out exact experiments with a weighed quantity of the pure poison, and such experiments with the large scorpion of North-West Africa, *Buthus (Prionurus) australis L.*, showed that already 0·1 mgm. of its poison was sufficient to cause the death of a guinea-pig of 500 to 600 grammes within $7\frac{1}{2}$ hours, while a dog of 15 to 20 kilogrammes died within 10 hours after having received 1-1·5 grammes of the poison. Insects and spiders, the regular food of scorpions, proved especially susceptible to the scorpion's poison: on the other hand, frogs proved to be rather insensible to it, and, still more, fishes and molluscs. The virulence of the scorpion's poison diminishes after repeated stinging, the animal becoming exhausted; and there is no doubt that the poisons of different species of scorpions possess very different degrees of potency.

Symptoms of scorpion-sting

The symptoms of scorpion-sting may be described as follows: violent local pains combined with inflammation and local swelling, extension of the pain to the neighbouring parts of the body, sleeplessness and a feeling of cold. The pain disappears after one to three days. The writer, who was stung by the yellow scorpion of Asia Minor (*Buthus gibbosus*, Brullé) near Ephesus at about 7 a.m., had violent pains in the wounded finger and inflammation, but no swelling. Large vesicles appeared on the skin of the finger, which remained irritable for several hours, but at noon no pain whatever remained although no remedy was employed.

The greatest number of well authenticated fatal results from scorpion-sting comes from North Africa; other cases have been reported from the West Indies, Mexico and South Africa; on the other hand, in some countries inhabited by many scorpions, cases of lethal scorpion-sting are quite unknown.

The references to scorpion poison quoted above are taken from Prof. F. Dahl's essay in the *Naturwissenschaftliche Wochenschrift*, XIX. No. 7, 1903, p. 97-99.[1]

I have thought it unnecessary to give elaborate descriptions of the Sudanese species of scorpions. The literary references given will enable students to make themselves fully acquainted with the species shortly described here.

As, however, the characters selected to distinguish them are such as can be easily recognised with the naked eye or with a good pocket lens, and are, moreover, constant, I am convinced that these descriptions are sufficient for the recognition of all the species hitherto obtained in the Anglo-Egyptian Sudan. Naturally, this applies only to the present state of our knowledge, as probably more species will be discovered, especially in the vast territories of the southern Sudan. Still, in any case, they will remain useful for the identification of the commoner and larger, and therefore, doubtless, more dangerous species.

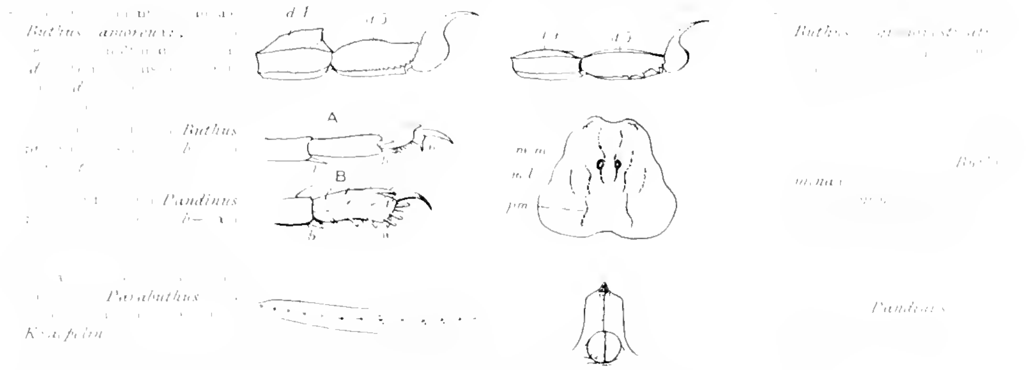
Works of reference

For an introduction to the study of scorpions, I refer the reader to the work of K. Kraepelin, "Scorpiones und Pedipalpi," in *Das Tierreich*, Berlin VIII., 1899, and for special references to the Sudanese Fauna, to A. Birula's paper on the Scorpiones and Solifugæ collected by myself in the Winter of 1905 (*Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften* in Wien, CXVII., 1908). All necessary literature is quoted in these two publications. Interesting new forms have been described since this paper was written, by Mr. S. Hirst in *Annals and Magazine of Natural History*, Series 8, Vol. VII., February, 1911.

The two main divisions of scorpions represented in the Sudan are easily distinguished by their external characters. In the *Buthidæ*, the sternum is triangular and the *hands* of the maxillary palps are more or less elongate. In the *Scorpionidæ* the sternum is pentagonal and the *hands* are very broad in such members of this family as have been

[1] For further information see references given under "Scorpion Sting" in the *Review Supplements* to the Third and Fourth Reports of these Laboratories.—A. B.

found hitherto in the Anglo-Egyptian Sudan, and belong to the strictly African genus *Pandinus*. The genera of *Buthidæ* are three, and they may be distinguished as follows:



1. Immovable mandibular finger without any tooth on the lower margin ... *Nanobuthus*
   Immovable mandibular finger with two teeth on the lower margin 2
2. Cephalothorax with distinct keels formed by small granula; dorsal plates of the abdomen with three longitudinal keels, at least the hindmost ones ... ... *Buthus*
   Cephalothorax without granular keels; abdomen with a single median keel, or not keeled at all ... ... *Parabuthus*

I will now give a description of the species of scorpions occurring in the Anglo-Egyptian Sudan.

1. Genus: *Buthus*, Leach

Genus *Buthus*

Immovable mandibular finger with two teeth-like prominences on the lower margin; the last two pairs of limbs with tarsal spurs; abdomen with three longitudinal keels; cephalothorax with distinct granular keels; oblique granular rows on the maxillary fingers with 1 to 2 lateral basal granulæ; basal median lamella of the combs not dilated in any sex; cauda distinctly keeled below in all segments.

This genus, represented in Southern Europe, Northern and Tropical Africa, and Western Asia to India, is represented in the Anglo-Egyptian Sudan by five species that may be distinguished by the following key, according to K. Kraepelin's excellent memoir, "Scorpiones und Pedipalpi" in *Das Tierreich* (VIII., 1899).

1. Fifth caudal segment of the adult with sharp, prominent dorsal keels, bordering a concave dorsal surface ... ... *B. (Prionurus Androctonus) amoreuxi* Sav.
   Fifth caudal segment of the adult with the dorsal keels missing or granular, surmounted by the convex lateral parts of the dorsal surface 2
2. Front of cephalothorax smooth; supraciliary ridges smooth; keels of cephalothorax very obsolete; keels of dorsal plates of the abdomen smooth, like its whole upper surface ... ... *B. (Buthacus) leptochelys*, Hemprich and Ehrenberg
   Front of cephalothorax granular; supraciliary ridges granular, or becoming granular towards the anterior end; keels of cephalothorax distinct, granular; keels of dorsal plates of the abdomen granular, like the upper surface 3
3. Posterior median keels of the cephalothorax confluent with the median lateral keel, forming with their fellows a lyre-shaped figure (Fig. 20); poison bladder nearly smooth 4
   Posterior median keels of the cephalothorax confluent with the middle median keel, thus forming a parallel-sided area (Fig. 25); poison-bladder granular 5
4. First two dorsal plates of the abdomen like the following, with three distinct, straight, smooth keels; movable finger not twice as long as hind-hand *B. (B.) occitanus* L.

First two dorsal plates of the abdomen with five keels, the lateral ones oblique, the outer ones directed obliquely backwards and outwards; all keels granulate. Movable finger twice as long as hind-hand ... *B. (B.) quinquestriatus*, Hemprich and Ehrenberg

5. Supraciliary ridges distinctly granular; number of comb-teeth less than twenty; small species (30–46 mm.) ... ... *B. (Buthus) acutecarinatus*, E. Simon

Supraciliary ridges entire, at least in front of the eyes; number of comb-teeth more than twenty; larger species (48–67 mm.) .. . ... *B. (Hottentotta) minax*, L. Koch

Buthus (Prionurus) amoreuxi, Savigny (Plate XIV., fig. 3; Fig. 22)

Buthus amoreuxi

Savigny, T. C., *Description de l'Egypte*, Ed. 2. 1827, Vol. 23, p. 411; Atlas Pl. 8, figs. 2, 2 a., 2 Z. *(Scorpio amoreuxi)*

Hemprich and Ehrenberg, *Verh. naturf., Fr. Berlin*, I., B 29, p. 356; *Symb. Phys. Zool.* II., 1829; Arachnoidea, Scorpiones, No. 6, tab. II., fig. 2a f. *(Androctonus [Prionurus] citrinus)*

Pocock, R. T., *Journ. Linn. Soc. Zool.*, Vol. 25. 1895, p. 306 *(Prionurus citrinus)*

Birula, A., *Bull. Acad. Imp. Sc., St. Petersbourg*, XIX., No. 3, p. 110 *(Buthus amoreuxi)*; *Sitz. Ber. Akad. Wiss., Wien*, CXVII., 1908, p. 134 *(Buthus [Prionurus] amoreuxi)*

This entirely yellow scorpion is the largest of all Sudanese *Buthus*, and reaches nearly 125 mm. in total length. The strong, raised upper keels of the thick cauda and the relatively thicker hands distinguish this species from all other *Buthus* of the country.

It is a strictly desert form, like its larger western congener *B. (P.) australis*, L. Its distribution is restricted to the Nile Valley, from Cairo to Wady Halfa. I know of it from no other locality in the Sudan than this latter one, where it is not uncommon. As this species is nearly related to the North-West African *B. australis*, which is said to be the most dangerous of all scorpions, causing sometimes even the death of man, it is possible that the Sudanese species may be equally venomous.

Buthus (Buthus) quinquestriatus, Hemprich and Ehrenberg (Plate XIV., figs. 1, 2; Fig. 23)

Buthus quinquestriatus

Savigny, T. C., *Description de l'Egypte*, Vol. 22, 1827, p. 710; Atlas, Pl. 8, fig. 1 *(Scorpio occitanus)*

Hemprich and Ehrenberg, *Verh. naturf., Fr. Berlin*, I., 1829, p. 353 *(Androctonus [Leiurus] 5-striatus)*; *Symb. Phys., Zool.*, II.; Arachnoidea, Scorpiones, 1829, No. 1, tab. 1, figs. a-f. *(Androctonus [Leiurus] quinquestriatus aculeatus)*

Birula, A., *Sitz. Ber. Akad. Wiss., Wien*, CXVII., 1908, p. 124

This is by far the commonest scorpion of the Central Sudan, and is frequently met with in Khartoum gardens under stones and logs. The Sudanese specimens are, at least in adult specimens, distinguished from those from Egypt by the coloration of the fifth caudal segment, which is not dark, as in the Egyptian specimens, but yellowish, like that of the whole animal. The cephalothorax is sometimes, but apparently not frequently in Sudanese specimens, shaded with black, and the back of the abdomen is indistinctly trilineate in this case. Supraciliary ridge granular in front, as well as all the other keels of the abdomen and the cauda. Lower lateral keels of fifth caudal segment with larger, somewhat triangular prominences towards their hinder end. Tibia of maxillary palp, with two granular keels above, about as broad as the hand.

This species is distributed all over eastern North Africa (Egypt, Sinai, Borders of Red Sea, Syria; doubtfully also in Algeria, where I have never found it). It reaches a length of 95 mm., but all the Sudanese specimens of my own collections are smaller. I have collected it at Wady Halfa, Khartoum, and in the desert near Gebel Araschkol, west of El Dueim, but not southward of this point. Captain Flower collected the species on the Blue Nile.

Buthus (Buthus) occitanus, Amoreux (Plate XIV., fig. 4; Figs. 20 and 21)

Kraepelin, "Scorpiones und Pedipalpi," in *Das Tierreich*, VIII., 1899, p. 26

I know a single locality for this species in the Sudan, where it was found on the shores of the Red Sea (Dooroor, near Suakin). It was collected here by the late Dr. J. Anderson. Besides the distinguishing characters already given in the synoptic table, I wish to remark that it is distinguished from the foregoing species by the following ones: supraciliary ridge smooth, granular in front and behind, dorsal and upper lateral keels of the cauda nearly obsolete.

This is a widely distributed species, ranging from Senegal to Morocco and over the whole of northern Africa, being restricted in Egypt apparently to the coast; and from there extending to Somaliland, Arabia and Syria. It occurs also in South-Western Europe and reaches about 80 mm. in total length.

Buthus (Buthus) acutecarinatus, E. Simon (Plate XV., fig. 3)

Simon, E., *Ann. Mus. Genova*, XVIII., 1883, p. 245, Pl. VIII., fig. 18.
Birula, A., *Bull. Acad. Sc., St. Pétersbourg*, XXIII., 1906, No. 1–2, p. 139, Sér. V., 1905; *Sitz. Ber. Akad. Wiss., Wien*, CXVII., 1908, p. 129 *Buthus acutecarinatus*

The smallest *Buthus* of the Sudan, not reaching 50 mm., my largest specimen from Khartoum 33·5 mm. Coloration yellowish, granular keels of truncus blackish. Movable finger more than twice as long as hind hand. This little species is distributed from the Cyrenaica to Egypt, Arabia, Syria, Abyssinia and Eritrea; its range in the Sudan is throughout the whole Nile Valley, as it is known from Wady Halfa (collected by the Swedish Expedition), Khartoum and from Gondokoro, Uganda, beyond the southern limit of the Anglo-Egyptian Sudan. Dr. Anderson collected it at Dooroor, 60 miles north of Suakin, Captain Flower in the Sennar Province and Dr. S. K. Mâloûf on the Atbara. It is by no means common.

Buthus (Butharus) leptochelys, Hemprich and Ehrenberg

Hemprich and Ehrenberg, *Verh. naturf., Fr. Berlin*, I., 1829, p. 355 (*Androctonus [Leiurus] leptochelys* and *A. [L.] macrocentrus*). *Symb. Phys., Zool.* II., Arachnoidea, Scorpiones, 1829, No. 3 (*A. [L.] leptochelys*), No. 7, tab. I., figs. *a—e* (*A. [L] macrocentrus*) *Buthus leptochelys*
Simon, E., *Exploration de la Tunisie*, Arachnides, 1855, p. 51 (*Buthus arenicola*)
Birula, A., *Sitz. Ber Akad. Wiss., Wien*, CXVII., 1908, p. 170

A rather rare species, known from North Africa (Eastern Algeria and Tunis to Lower Egypt) and the Red Sea littoral. It was found at Dooroor, near Suakin, by the late Dr. J. Anderson. This light yellow scorpion is distinguished by its smooth surface from all its Sudanese congeners. As further characters of specific value, I may add that the lower lateral keels of the fifth caudal segment are provided with lobiform teeth near their posterior end, and that the poison vesicle is perfectly smooth. Hand not so thick as tibia, fingers once-and-a-half as long as hind hand. Total length not more than 60 mm.

Buthus (Hottentotta) minax, L. Koch (Plate XIV., figs. 5, 6; Fig. 25)

Koch, L., *Aegyptische und Abyssinische Arachniden*, etc., Nurnberg, 1875, Taf. 1, fig. 2, p. 4 (*Buthus minax*) *Buthus minax*
Pavesi, P., *Ann. Mus. Genova*, XX., 1883, p. 96 (*Buthus isseli*); XV., 1895, p. 495 (*B. hottentotta*)
Kraepelin, K., "Scorpiones und Pedipalpi," in *Das Tierreich*, VIII., 1899, p. 22 (*Buthus hottentotta minax*)
Birula, A., *Sitz. Ber. Akad. Wiss., Wien*, CXVII., 1908, p. 141

This is the *Buthus* of the Sudan proper, and is not met with north of Khartoum; even in this locality it may only be occasionally found, as it is frequently carried on the steamers on the Upper Nile amongst the wood fuel. I took two of my specimens on board steamers, one at Mongalla, near the southern limit of the Sudan. I found it rather common at Gondokoro, under the decayed logs of the Southern Dôm-Palm (*Hyphene coriacea*). The Swedish Expedition found it at Khartoum and Kaka (White Nile). It has been recorded also from the Lado (*Paresi*), Abyssinia and Eritrea.

The coloration of this species shows a greater tendency to brown than is present in any other *Buthus* of the Sudan, but it is always more or less yellowish-brown, with blackish keels. The largest specimen I have collected measures 67 mm. of total length: it is a female, and the largest male is distinctly smaller. The sexes are distinguished externally by several characters, as shown by Birula. The movable finger is never twice as long as hind hand.

2. Genus: *Parabuthus*, Pocock (Fig. 26)

Genus *Parabuthus*

Immovable finger of the mandible with two teeth at the lower margin; cephalothorax without granular keels; abdomen with a single indistinct median dorsal keel. Oblique granular rows of maxillary fingers with paired external and single internal lateral granules. Basal median lamella of the combs broadly dilated in the female.

A single species is known from the Sudan.

Parabuthus hunteri, Pocock

Pocock, *Journ. Linn. Soc.*, XXV 1895, p. 309

Parabuthus hunteri

Distinguished by having the posterior two caudal segments and the poison vesicle deep greenish-black to greenish-brown, even in the young. Tail much more slender than in the allied *P. liosoma*, Hemprich and Ehrenberg, from Arabia, which has the end of tail and the vesicle reddish-brown.

Found at Dooroor and Suakin. Mr. S. Hirst regards this species as a mere sub-species of the Arabian *P. liosoma*, and records a large male specimen from Omdurman. Reaches 100 mm. in total length.

3. Genus: *Nanobuthus*,[1] Pocock

Genus *Nanobuthus*

Immovable mandibular finger, toothless below; no granular keels on the cephalothorax; abdomen with median keel and feeble lateral keels. Oblique granular rows of maxillary fingers missing in basal third; five rows of oblique rows, every one of which is continued at its base as a short transverse row of three conical teeth.

Nanobuthus andersoni, Pocock

Pocock, *Journ. Linn. Soc.*, XXV 1895, p. 314

Nanobuthus andersoni

Body (truncus) infumated above, posterior and lateral margins of dorsal segments ferruginous. Limbs and tail pale yellow, base and end of tail somewhat infumated. Small species, as already indicated by its generic name[1]; measuring only up to 28 mm. It has been found hitherto only at Dooroor, near Suakin, by the late Dr. John Anderson.

Genus: *Pandinus*, Thorell (*Scorpio*, Pocock) (Figs. 24, B; 27)

The species of this genus are easily distinguished from all Sudanese *Buthidae*, as already (*page* 182) explained, by the five-sided sternum (Fig. 27) and the very broad hands of the maxillary palps; they are further distinguished from all other of the *Scorpionidae*, to which they belong, by the following characters: No prominence whatever under the sting of the poison-vesicle; upper surface of hand round, without keel; lower surface of the first four caudal segments with two median keels; three eyes on each side of the front

[1] The dwarf *buthus*.—A B.

border of the cephalothorax; posterior margin of tibia of maxillary palp with rather a sharp, smooth keel, preceded by numerous trichobothria (sense-pits, minute round grooves with a hair in the middle) arranged in 2 to 4 rows.

To this group belong some of the giants of the whole group; the genus is nearly entirely restricted to Tropical Africa.

The three species known hitherto from the Sudan may easily be distinguished as follows:—

1. Ventral combs with 13–14 lamellæ; limbs and body dark brownish or greenish-black ... ... *P. imperator*
Ventral combs with 17–22 lamellæ 2

2. Femur of maxillary palp granular below; upper surface of hand with more or less distinct traces of keels ... ... *P. exitialis*
Femur of maxillary palp smooth below; upper surface of hand without any keels ... ... *P. pallidus*

Pandinus pallidus, Kraepelin (Plate XV., fig. 2)

Kraepelin, *Mitt. Mus. Hamburg*, XI. 1894, p. 60; (*Scorpio*); "Scorpiones und Pedipalpi" in *Das Tierreich*, VIII. 1899, p. 120

Pandinus pallidus

Yellowish to greenish-brown, hands more reddish-brown, limbs pale yellow. Dorsal keels of the short cauda with acute denticulation; hand of maxillary palp nearly as broad as length of movable finger, its upper surface with smooth, isolated (or, in the var. *gregorgi*, reticular) prominences; 17 to 21 lamellæ in the ventral combs.

This species has been found only in Somaliland and Kordofan; the Kordofan specimen, measuring 10·7 centimetres to tip of tail excluding poison fang, was collected by Bimbashi Williams, late of the Sudan Veterinary Department. It belongs to the var. *gregorgi*, Pocock (*Ann. Mag. Nat. Hist.* (6) XVII. 1896, p. 432) which is not very different from the type.

Pandinus exitialis, Pocock

Pocock, *Ann. Mag. Nat. Hist.*, Series 6, Vol. II., p. 240 (*Scorpio*)
Kraepelin, *Das Tierreich*, VIII. 1899, p. 119; *Zool. Jahrb. Syst.* (1903), XVIII., p. 567
Hirst, *Ann. Mag. Nat. Hist.*, Series 8, Vol. VII. 1911, p. 219.

Pandinus exitialis

Blackish-brown, limbs yellow. Femur of maxillary palp granular below; upper surface of hand with distinct longitudinal keels (four complete and a short inner keel in a specimen from the Blue Nile). Lower surface of hand with two longitudinal granular rows near the outer margin. The species was originally described from Shoa. Captain S. S. Flower found a small male, measuring 85 mm. in length, at Abu Haraz, Blue Nile.

A variety *sudanicus* described by Mr. Hirst at the same time as this specimen, seems to me nearly related to *P. pallidus gregorgi*. In comparison with *exitialis* the hand is much smoother, nearly the entire surface of the lobe (the produced part of hind hand) being furnished with low anostomony ridges instead of isolated tubercles. These ridges are smaller and narrower than in *gregorgi*, but it is easily distinguished from this form by having the lower side of femur of maxillary palp granular instead of smooth.

The only known specimen of this variety is a female, 111 mm. long, from Jebel Mal, 12 miles south of El Obeid, Kordofan, collected by Captain (now Major) H. N. Dunn, R.A.M.C.

Pandinus imperator, C. L. Koch (Plate XV., fig. 1)

Kraepelin, "Scorpiones und Pedipalpi," in *Das Tierreich*, VIII. 1899, p. 122

Pandinus imperator

Dark green or piceous; vesicle reddish-brown; limbs leather-brown to dark brown or green; hands sometimes reddish-brown. Dorsal keels of the strong cauda granular. Hand of maxillary palp as broad as length of movable finger, with isolated, roundish, sometimes reticularly confluent, smooth prominences. The var. *subtypicus* Kraepelin (*Mt. Mus. Hamburg* XI. 1894 p. 69) is distinguished by the following characters: Lower median keels of first and second caudal segments completely absent. Dorsal plates of abdomen nearly smooth; only 13 to 14 lamellæ in ventral combs.

This enormous scorpion, which attains a total length of 175 mm., is represented in the tropical part of the Sudan (Gour country) by the above mentioned var. *subtypicus*. It is well distinguished from the West African typical form.

LIST OF SUDANESE SCORPIONS

Species	Total length in mm.	Number of oblique granular rows of mandibular fingers	Number of lamellæ of the combs	
			From	To
Buthus (*Prionurus*) *amoreuxi*, Sav. ...	123	13–14	29–34 (male)	21–25 (female)
Buthus (*Buthacus*) *leptochelys*, H. & E.	60	—	23	27
Buthus (*Buthus*) *quinquestriatus*, H. & E.	93	12	32	36
Buthus (*Buthus*) *occitanus*, Amor.	80	13	30–33 (male)	25–28 (female)
Buthus (*Buthus*) *acutecarinatus*, E. Simon...	33·5 (47)	11	17	18 (25)
Buthus (*Hottentotta*) *minax*, L. Koch	67	14	21	23
Parabuthus hunteri, Poc.	100	—	—	—
Nanobuthus andersoni, Poc.	28	5	16	17
Pandinus pallidus Krpln. (*gregoryi*, Poc.) ..	107	—	17	21
Pandinus exitialis, Poc. (*sudanicus*, Hirst) .	111		21	22
Pandinus imperator, C. L. Koch (*subtypicus*, Krpln.)	—	—	13	14

Pedipalpi

A group of curious annulated spiders, somewhat allied to the scorpions and restricted to the tropical parts of both hemispheres, is represented by a single species in the Sudan. From the scorpions, to which some (but not the Sudanese one) bear a superficial resemblance, they are easily distinguished by the fact that the first pair of limbs is very slender elongate, even flagelliform (hence the German name "Geissel-Spinnen," flagellated spiders,) that there is not a cauda of five strong segments with a poison-vesicle and poison-sting at the end, but a slender filiform elongate postabdomen consisting of many annuli or no postabdomen whatever; and that comb-like appendices of the ventral side are wholly absent. The single Sudanese species belongs to the Tribe *Amblypygi* with broad reniform cephalothorax, without caudal filiform postabdomen and with elongate maxillary palp, the hand of which is provided with a movable claw; and with an extremely elongate whip-like, multi-annulated terminal portion of the first pair of limbs.

Distinctive characters of the Pedipalpi

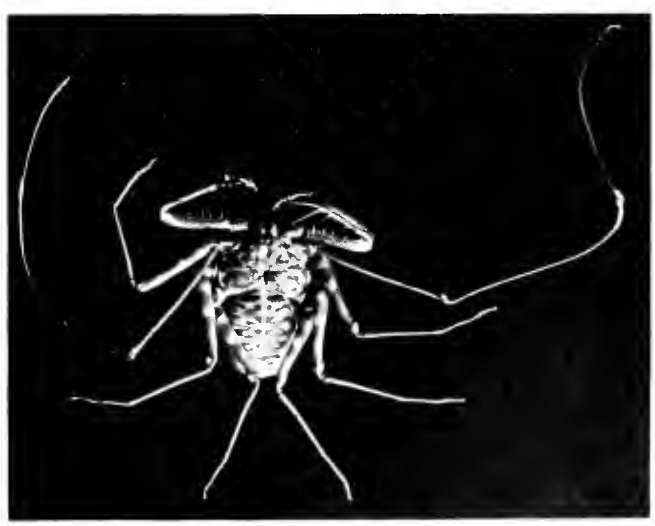
As far as we know, the pedipalpi are oviparous, the newly hatched young undergoing no metamorphosis. They are predaceous animals like the scorpions, with about the same limits of distribution, but are absent in the countries bordering the Mediterranean, as well as in Australia. They live somewhat like the scorpions, but perhaps keep even more concealed, some actually being found in caves.

PLATE XV

1

2

3



4

1. *Pandinus imperator* (British E. Africa)
2. *Pandinus pallidus* (Kordofan)
3. *Buthus acutecarinatus* (Khartoum)
4. *Damon variegatus* (British E. Africa)

All illustrations are natural size

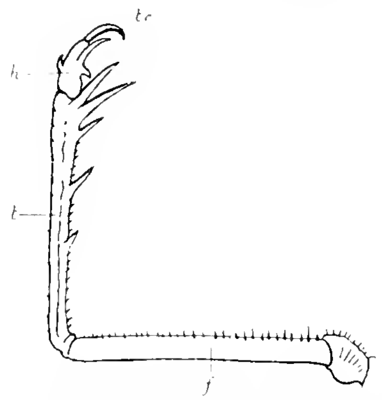
Genus: *Damon*, C. L. Koch

Genus *Damon*

Tibia of fourth limb consisting of two pieces; hand of maxillary palp bearing, below the strong spine directed distally, another strong spine directed backwards.

Damon variegatus (Perty) (Plate XV., fig. 4; Fig. 28)

Kraepelin. "Scorpiones und Pedipalpi," in *Das Tierreich*, VIII 1899, p. 239



[illegible] *Damon variegatus*
(*f*—[illegible] *t*—[illegible] *h*—[illegible])

Cephalothorax yellowish-red to reddish-brown, blackish in the radiating furrows, and with yellow spots at the margins; each segment of the abdomen with two spectacle-like black oval spots with yellow centre; limbs distinctly annulated.

This species is widely distributed over Africa, from Cape Colony to Natal, Transvaal, Lake Nyasa, Zanzibar to the Sudan (14° N. lat.). It is also known from Homran, Arabia. Like the second species of the genus, it is probably carried to other countries, possibly in wood, and has been found in South America. It attains a total length of about 25 mm.

SOLIFUGÆ

A very distinct group of annulated spiders, characterised as follows: cephalothorax followed by three free thoracic segments and an abdomen consisting of ten segments, not followed by a tail-like postabdomen. Mandibles scissor-like, maxillary palps limb-like, provided with a vesicular adhesive organ at the distal end. Basal joints of the fourth pair of limbs with three or five pedunculated triangular appendices (malleoli) (Fig. 35B).

These spider-like, hairy, ugly-looking arachnoids are all very alike in their external features and very difficult to distinguish. In coloration they are rather similar to the scorpions, yellowish to blackish-brown.

Distribution of *Solifugæ*

The *Solifugæ* are probably all oviparous; the newly-hatched young are only in a few points (as the number of the malleoli, development of the spines of the limbs) different from the adults. All *Solifugæ* are rapacious nocturnal animals feeding on insects, especially on termites, and living in arid parts of the warmer regions of the earth. They reach their northern limit between the 40° and 45° N. lat., but are absent in Italy, China and Japan, nor are they represented in the Malay Archipelago with a single exception. They are distributed all over Africa, and are especially rich in species in Cape Colony, which Kraepelin believes to be the centre of their distribution. They are found in America, in the Southern United States to Washington Territory, through Mexico, central and northern South America. They have even been found in the Cordilleras of Chile and the Argentine, but never in the eastern States (Brazil, Paraguay, Guiana, Eastern Venezuela).

Solifugæ are feared as much as, or still more than, scorpions wherever they occur, at least in North Africa. Their rapid movements, the powerful mandibles, the great size of the hairy body, are terrifying to Europeans as well as to natives, though no poisonous apparatus whatever can be detected.

Though I have collected *Solifugæ* in Algeria as well as in Egypt, Asia Minor and the Sudan, I have never been bitten by any of the specimens, and therefore do not know from personal experience whether they should be handled with care or not; but in every case it would be well to take precautions, although the smaller species are said to be unable to perforate even the comparatively thin human skin.

Of nearly two hundred known species, only very few have been found in the Sudan. Their extreme quickness, nocturnal habits, and the difficulty of ascertaining their hiding-places, result in the smaller species especially being rare in collections. Indeed, many of them have been described from but a few specimens, or a single one, and from only one sex. The only species of which I have personal knowledge is *Galeodes arabs*, which is the largest and commonest of them all, and is found not infrequently in Khartoum. No exact locality is known for most of the other species, but three at least are certainly found in the Sudan, the others only indicated as from "Nubia" or "Borders of Red Sea."

The families of *Solifugæ* represented in the Sudan may be distinguished as follows:—

Galeodidæ

Stigmata of second and third abdominal segment covered by a plate finely denticulated at its posterior margin. Tarsus of maxillary palp articulated with metatarsus. Claws of limbs hairy in the adult. Ocular prominence only with two setæ at anterior margin, second and third leg, with two, fourth leg with three, tarsal joints, besides the metatarsus.

Solpugidæ

Stigmata of second and third abdominal segment free, or covered by lateral folds; tarsus of maxillary palp immovably connected with metatarsus; claws of limbs naked; two or more setæ at anterior margin of ocular prominence; number of tarsal joints very variable.

In the *Galeodidæ* we have three genera to distinguish:—

Galeodes

First leg with two small curved terminal claws; pedicle of malleoli, mostly longer than plate.

Paragaleodes

First leg without terminal claws; pedicle of malleoli mostly shorter than plate.

Othoes

First leg without terminal claws; claws of second, third and fourth pairs of legs very long.

In the *Solpugidæ* we may distinguish one genera probably occurring in the Sudan:—

Rhagodes

Terminal (tenth) abdominal segment very large, forming part of back; anal opening perfectly ventral, horizontal; ventral mandibular finger with a single basal tooth, preceded by very small teeth.

The three remaining genera have the following points in common:

Terminal (tenth) abdominal segment circular or elliptic, not protruding much from the preceding segment; anal opening vertical, in the middle of abdominal segment. Ventral mandibular finger, at least in the female, nearly always with two principal teeth.

Solpuga

Second and third leg with four, fourth leg with six or seven tarsal joints, besides the metatarsus (ocular prominence with numerous fine setæ at anterior margin; metatarsus of maxillary palp not spinous ventrally in both sexes).

Dæsia

Second and third leg with two, fourth leg with four tarsal joints (metatarsus of maxillary palp ventrally only spinous, without cylindrical setæ).

Gluviopsis

All legs with a single tarsal joint, that of fourth leg elongate; ocular prominence, with two principal setæ at anterior margin, and some smaller ones.

Galeodes

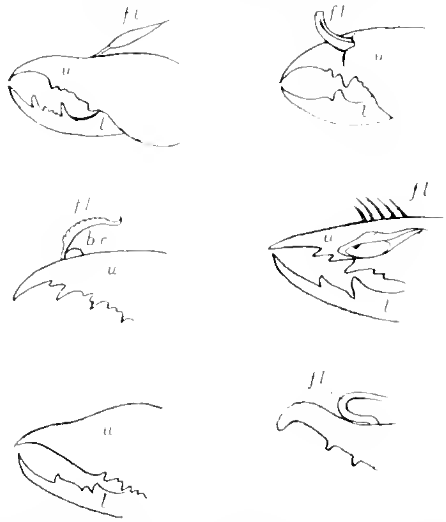
Rhagodes

Solpuga schweinfurthi

Gluviopsis rufescens

Daesia ehrenbergi

Solpuga dentatidens

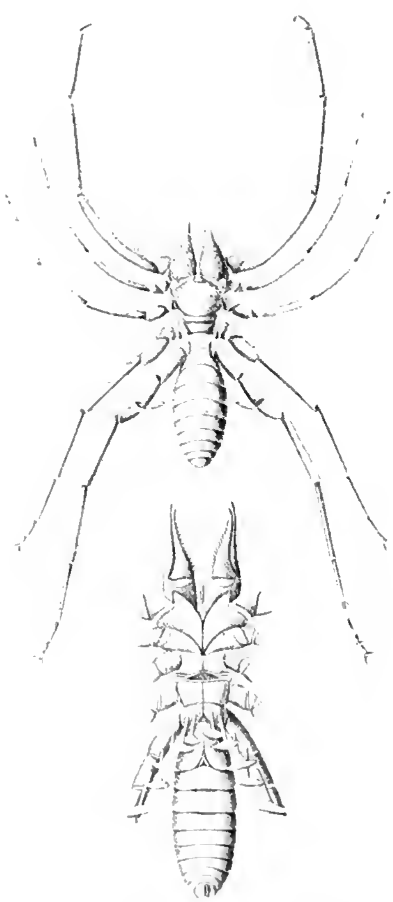


The males of most *Solifugæ* are provided with a curious appendix of the dorsal mandibular finger called the "flagellum." It varies extremely in shape in the various genera and species; but I only give figures and no descriptions. (Figs. 29, 30, 31, 34.)

Galeodes arabs

A

B



Galeodes arabs
(*Organisation du règne Animal*)

1. Genus: *Galeodes*, Ol.

G. arabs,[1] C. L. Koch (Fig. 29, 35)

Kraepelin, "Palpigradi und Solifugæ," in *Das Tierreich*, XII., 1901

Cephalothorax yellowish-brown, reddish-brown anteriorly and laterally; mandible yellowish with two reddish longitudinal stripes; abdomen with or without distinct median darker stripe. Tibia and base of metatarsus of maxillary palp somewhat infumated; greyish-black (metatarsus nearly to distal end) in young specimens; legs yellow.

The largest specimen collected by myself is 52 mm. in total length (from anterior margin of cephalothorax to posterior end of abdomen). Therefore this is the largest species of *Solifugæ* in the Sudan. It is distributed over the greater part of North Africa from Algeria to Egypt; Syria, Asia Minor, Arabia, Sudan (Khartoum, Werner, 1905; Omdurman Swedish Expedition 1901; Wady Halfa, Surgeon-Major (now Lt.-Colonel) Penton and Captain S. S. Flower), and is relatively common in human dwellings.

The allied *G. araneoides* (Pall.) is recorded by Tullgren from the Sudan (Shendi), but as he only had an opportunity of examining a young specimen, I am not convinced of the correctness of this identification.

[1] This is the *Abu Shabat* of the Arabs

2. Genus: *Paragaleodes*, Kraepelin

P. scalaris, C. L. Koch

Kraepelin, l.c., p. 25

Cephalothorax and mandibles somewhat infumated, densely yellow-hairy in the female, white-hairy in the male, like the sides of the free thoracic segments, abdomen, the maxillary palps and legs; only tibia metatarsus and tarsus of fourth limb intensively yellow-hairy in both sexes. *Paragaleodes arabs*

Length of body (see remarks under the foregoing species) 35 mm.

Arabia, Egypt, borders of Red Sea; no exact indication of locality for the Sudan.

3. Genus: *Othoes*, Hirst

O. floweri, Hirst

Ann. Mag. Nat. Hist., Series 8, Vol. VII, February, 1911, p. 221

The genus *Othoes* is distinguished from the genus *Galeodes* not only by the absence of claws to the first leg and the extremely long claws of the following legs, but also by having the fine hairs at the end of the first leg bifurcated terminally. In the only known species the second and fifth teeth of the immovable mandibulary finger are the longest, the posterior of the two intermediate teeth is exceedingly small; between the two large teeth of the movable finger there are likewise two smaller teeth, the posterior one being minute. *Othoes floweri*

Colour of body, mandibular fingers and legs, pale yellow; a fine blackish line along the anterior margin of the head-plate, and the ocular tubercle is also black but it has an ill-defined longitudinal yellowish streak in the middle. Patella and tibia of maxillary palp and the tarsus slightly darkened; basal segments of this appendage, pale yellow.

The single (female) known specimen, the total length of which is 22·5 mm., was found at Wady Halfa by Captain S. S. Flower.

4. Genus: *Rhagodes*, Pocock (Fig. 30)

Rh. melanocephalus, E. Simon

Simon, E., *Ann. Soc. ent. France*, 1879 (5), IX., p. 122 (*Rhax*)

Cephalothorax black, free thoracal segments whitish-yellow, scarcely black-spotted. Abdomen with black longitudinal stripe on either side to the posterior end, tenth segment entirely black; median dorsal and ventral line of abdomen with broad yellow band to end of ninth segment. Mandible blackish-brown, maxillary palp and first leg yellow, only metatarsus black, tarsus reddish-brown, following legs yellow. *Rhagodes melanocephalus*

Length of truncus, 20 mm.

Known only from Nubia.

5. Genus: *Solpuga*, A. Lichtenstein

S. dentatidens, E. Simon (Fig. 34)

Simon, E., *Ann. Soc. ent. France*, 1879 (5), IX., p. 115, Pl. III., figs. 9, 10 (*Galeodes*)
Pocock, *Ann. Mag. Nat. Hist.*, 1896 (6), XVIII., p. 185
Kraepelin, l.c., p. 69

Cephalothorax and mandibles light yellowish-red, abdomen yellow, maxillary palp dark yellowish-red, its metatarsus and tarsus dark brown, legs yellowish-red. *Solpuga dentatidens*

Length of truncus, 25 mm.

Known only from the White Nile and Somaliland.

S. schweinfurthi, Karsch (Fig. 31)

Karsch, *Arch. f. Naturg.*, 1880, XLVI., I., p. 239, Pl. X., fig. 12
Kraepelin, l.c., p. 69

Solpuga schweinfurthi

Cephalothorax clay-yellow: mandible of same colour, frequently with reddish stripes; ocular prominence with yellow median line; abdomen with narrow dark median dorsal line, bordered with lighter or (in old females) nearly unicolour light. Maxillary palp and legs yellow.

Length of truncus, 32 mm.

Found in the Gour country by Schweinfurth.

6. Genus: *Daesia*, Karsch

D. ehrenbergi, Karsch (Fig. 33)

Karsch, *Arch. f. Naturg.*, 1880, XLVI., I., pp. 270, 237, Pl. X., fig. 23

Daesia ehrenbergi

Mandible pale yellow, cephalothorax yellow in the middle, infumated laterally; ocular prominence black. Abdomen yellow, with indication of dark median band; maxillary palp rarely light coloured, femur yellow, tibia reddish-brown, metatarsus and tarsus brown, legs yellowish, only femur and tibia of fourth darker.

Length of truncus, 28 mm.

Distributed over Egypt, Palestine and Cyprus; recorded also from Nubia (Dongola).

7. Genus: *Gluviopsis*, Kraepelin

G. rufescens, Pocock (Fig. 32)

Pocock, *Ann. Mag. Nat. Hist.* (6), XX., 1897, p. 271 (*Blossia*)
Kraepelin, *Mitt. Mus. Hamburg*, XVI., 1899, p. 236; l.c., p. 105

Gluviopsis rufescens

Mandible, cephalothorax and dorsal plates of abdomen yellow to reddish-brown; maxillary palp reddish-brown, or femur and tibia bicolorated (yellow and black); ventral region yellow; first and second leg yellow, of the third and fourth the greater basal portion is reddish-brown.

Length of truncus, 15 mm.

Borders of Red Sea and Eastern Mediterranean.

It must be borne in mind that these descriptions are only sufficient for the recognition and distinguishing of the species mentioned above, which are known or expected to occur in the Sudan. These species, however, only represent types of such genera as are expected to occur in the Sudan, and their descriptions are therefore unsatisfactory for any specialist, who would devote himself to an exact and intensive study of this very neglected group. I hope, however, that these notes will incite someone in the Sudan to devote himself to a more extensive collecting of *Solifugæ*, and there is no doubt that that vast and especially favourable country will prove to be rich in species of this group and afford facilities for valuable scientific work for a long time to come.

Notes on Two Specimens of Spitting-Snakes from Southern Rhodesia

BY

Henry Curtis, F.R.C.S

London

The two specimens in question were brought to England by the writer in 1906, on his return from Bulawayo, Southern Rhodesia, having been captured after causing injury to the eyes of patients of Dr. Strong, of Bulawayo, on different occasions.

Clinical History

Dr. Strong has had several cases under his care at Bulawayo, arising as the result of the patients disturbing the snake in the garden, or while out shooting, or when climbing a kopje. In one case the only noticeable features were merely temporary pain, photophobia, and hyperaemia of the conjunctiva.

Cases illustrating the injury to the eyes by ejected venom

In the case affected by the smaller snake now referred to, the victim incautiously stooped down while belabouring it with a stick, his face and eyes being invitingly near the snake. The first thing noted was an acid taste in the mouth, and, directly after, a sudden sharp burning pain in the eyes as the caustic fluid reached the eyeballs. The pain and photophobia required the use of an eye-shade for more than a week. Cocaine is, of course, a very effective anodyne.

This instance, as Dr. Lefeuvre remarks, seems to show that the fluid is scattered as it is ejected, and not aimed, as some say, directly at the eyes.

In the third case under Dr. Strong's care—a child of about seven years—there was violent purulent ophthalmia, but this may have been contributed to by dirty habits and surroundings and the use by the parents of copper sulphate in rather strong solution.

The eyes of the patient attacked by the larger snake were washed out with warm milk with at least no ill effects.

Dr. W. Lefeuvre, who before coming to Bulawayo had had twelve years' experience in the Karoo, writes: "I have only come across instances of spitting in the cobra and Ring-hals[1] *(Sepedon)*. A captive cobra in a cage, when teased through the glass front, repeatedly struck at the glass with his head, raising his nose and mouth as he did so, at the same time ejecting a yellowish custardy-looking liquid, quite different from the clear viscous poison peculiar to the poison gland and ejected through the fangs." [Mr. Boulenger, to whom I submitted this statement, however, draws the opposite inference and considers that the fluid here described was the venom itself.]

Geographical distribution

As to the geographical distribution, Dr. Lefeuvre found no essential difference between the cobra in Southern Rhodesia and that at the James River, 160 miles from Cape Town. Cape boys and Dutch farmers avoid going too near when dealing with snakes, which are quickly seized by means of a forked stick, used to firmly press the

[1] In the *Field* newspaper for February 20, 1909, is a record of recovery from the effects of venom injected into the eyes of a patient, the snake being the Ring-hals.

neck to the ground, in which position attempts at spitting would not be likely. When in the Karoo, Dr. Lefeuvre himself had never had to treat a case on whom a snake had spat, but had heard from Dutch farmers that they had had to do so. Where snakes are less common, as in Southern Rhodesia, people are apt to be less cautious.

Identification

The famous authority on Snakes, Mr. G. A. Boulenger, of the Natural History Department of the British Museum, has been kind enough to examine and report on these specimens, both of which prove to be *Naia nigricollis*. The larger is shown in the drawing, of natural size, by Lady Dorothy Stanley. The illustration serves to bring out some of the points in identification mentioned in Mr. Boulenger's letter to the *Field* of February 1, 1908, quoted *in extenso* hereafter. The larger snake, of a dark leaden colour, measured 6 feet $9\frac{1}{4}$ inches, the smaller 3 feet $4\frac{3}{4}$ inches. Both terminated in narrow whip-like tails. It is interesting to note here that in the *Third Report of the Wellcome Tropical Research Laboratories*, Khartoum, Dr. Franz Werner, in a paper on the Poisonous Snakes of the Anglo-Egyptian Sudan, refers to the black-necked cobra, *Naia nigricollis*, which had been brought in from Gondokoro, and which in his presence "spat or rather ejected its venom" at his friend Dr. Sassi "after some chewing movements of the jaws."

Venom

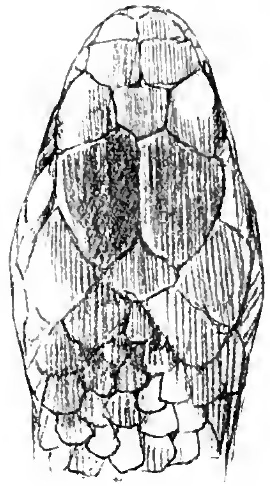
The snakes, through my ignorance, were unfortunately preserved in a mixture of formalin and spirit, and were therefore rendered useless as regards experiments with the venom. Dr. C. J. Martin, F.R.S., Director of the Lister Institute, London, who has done much experimental work in connection with the snakes of India, etc., informs me that formalin combines with the venom to form a compound rendering it useless for experimentation. This should be remembered by travellers sending home specimens for investigation.

Venom, *not* saliva, ejected by "Spitting-snakes"

The term "*Spitting-Snake*" is clearly a misnomer, as also the use of the word "Saliva" for the fluid ejected. The perusal of many accounts makes it clear that this fluid is the venom, not the saliva. Indeed, but little saliva is secreted except during actual mastication, and a consideration of the anatomy of the labial glands providing the saliva in snakes makes it certain that no mechanism exists for its expulsion to a distance in the way generally described. The snake, to eject its venom, requires to be in the erect position, with its head drawn back, and so poised as to allow the fluid to be ejected forward and upwards—a condition impossible when its capture is effected, as it is done by Boer farmers by means of a forked stick pressing the snake's neck firmly into the ground.

During the first half of 1908, numerous contributions to the subject of Spitting-Snakes appeared in the *Field* newspaper, letters or notes being published on January 11, 18, February 1, 15, March 21, 28, and April 18. The most important letter, dealing with many of the points previously raised, was by Mr. Boulenger, and it is so valuable that I reproduce it here.

PLATE XVI



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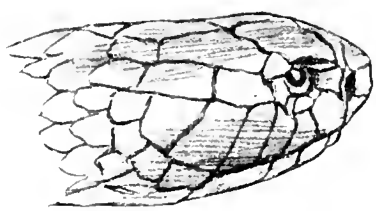

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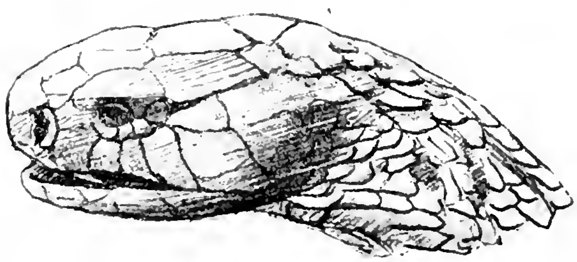


3

Naia nigricollis (RHODESIA)

Head seen from above, and right and left sides

All illustrations are natural size

SPITTING-SNAKES[1]

SIR,—The correspondence which has appeared in the last numbers of the *Field* confirms a fact which has been known for a long time to travellers in tropical and South Africa. Whenever the spitting-snake has been scientifically determined it has proved to belong to the genus *Naia* (cobras) or to its near ally *Sepedon*, of which a single species, *S. hæmachates*, the ring-hals of Cape Colony, is known.

But only certain species of cobras appear to be endowed with this curious habit. It has never been observed in the Indian cobra, *Naia tripudians*, the type species of the genus, although an Eastern form, inhabiting Southern China and the Malay Peninsula and Archipelago, has received, probably not without reason, the name of *Naia sputatrix*. In Africa we have six species of *Naia*:

1. *N. haie*, inhabiting the countries bordering the Sahara, and extending, though rare, to East Africa as far south as the Transvaal. It occurs also in Palestine and in Arabia.

2. *N. flava*, from Cape Colony.

3. *N. melanoleuca*, from West Africa (Guinea to Angola), and Central Africa, eastwards to Uganda.

4. *N. nigricollis*, from the whole of tropical Africa, from Senegambia and Nubia, to Angola and the Transvaal; occurring also in Arabia.

5. *N. anchietæ*, from Angola and Ovamboland.

6. *N. goldii*, from the Lower Niger and Cameroon.

The two latter are rare, and no observations have been made on them in the live state.

Naia haie, the common cobra of Egypt, has never been observed to spit poison. Hy. S., quoting Sir Andrew Smith, gives *N. haie* as the scientific name of the South African spitting-snake, but Sir Andrew Smith was mistaken in his identification, and the snake he had in view is *N. flava*, a quite distinct species.

As *Naia melanoleuca* and *N. nigricollis* occur together in most parts of Africa where the spitting has been witnessed, and as both are regarded by the natives as "spitters," it is not possible to decide at present whether they agree in this respect, but, so far as my own information goes, the habit has been authentically established in the latter only. The snakes brought home by Mr. Lort Phillips and Dr. Donaldson Smith, as having spat at them, belong to *N. nigricollis*. Professor Barboza du Bocage, the veteran Portuguese zoologist, tells us in his *Herpetologie d'Angola* (p. 133) that a *cuspideira* (spitting-snake) sent to him from Angola, and which he kept alive for several months, during which it often displayed its power of ejecting poison at a considerable distance, was a *N. nigricollis*. Dr. A. Bavay, in the *Bulletin* of the French Zoological Society for 1895, has published some interesting observations on the "Serpent Cracheur de la Cote occidentale d'Afrique," without, however, having been able to settle the question of the species.

He is inclined to refer the snake to *N. haie*, but the description applies better to *N. nigricollis*, which is common in Dahomey, where the observations were made by M. Le Naour. In his recently published book, *Les Venins*, Dr. Calmette suggests that the Dahomey snake may have been a *Sepedon hæmachates*, overlooking, however, the fact that that snake is not known to occur in West Africa. Dr. Calmette rightly objects to the habit being ascribed to *N. haie*, of which he has kept numerous specimens in his laboratory without ever witnessing any attempt on their part to shoot out poison. I think it is now well established that *N. haie*, is not endowed with this faculty any more than the common *N. tripudians* of India. That closely related species should behave so differently is very remarkable, and this again shows how important it is to correctly determine the species, or to preserve specimens for future identification, when making observations on the habits of animals.

For the present, therefore, only three species are known, on trustworthy authority, to spit poison. These are: *Sepedon hæmachates*, *Naia flava*, and *Naia nigricollis*; to those *N. melanoleuca* must probably be added.

It would be interesting to make further observations on this subject with due reference to the species, the correct identification of which may be facilitated by the following synopsis: *Sepedon* is at once separated from the cobras proper by its keeled dorsal scales, which, as in our common viper or adder, bear a raised ridge along the middle. The cobras, *Naia*, have smooth scales. *N. haie* and *N. anchietæ* differ from the other species in having a series of small shields separating the eye from the large shields bordering the upper lip. The former has a large hood (the inflatable neck) with twenty-one or twenty-three scales across it, and there are nineteen or twenty-one scales in a series across the body, whilst in the latter the neck is scarcely dilatable and bears seventeen rows of scales like the body. In the other species one or two of the large shields of the upper lip border the eye; in *N. flava*, *N. melanoleuca*, and *N. goldii* the sixth or the seventh of those shields is the largest in vertical diameter, whilst in *N. nigricollis* the third is the deepest. In *N. flava* the rostral shield (capping the end of the snout and bordering the mouth) is as deep as broad, and there are twenty-three scales across the neck; in *N. melanoleuca* the rostral shield is considerably broader than deep, and the scales across the neck number twenty-three to twenty-nine. In *N. goldii* the rostral shield is broader than deep, the scales across the neck number only fifteen, and the eye is much larger than in the other cobras, its diameter being two-thirds its distance from the end of the snout. Attention to these few points should enable anyone to correctly name a dead cobra, even a dry skin; and the value of future observations on habits would be greatly enhanced by such a discrimination.

G. A. BOULENGER.

There is a noteworthy divergence of views expressed in the following letter, appearing in the *Field* of April 18, 1908. So far as I am aware, no reply was published:—

SPITTING-SNAKES

SIR,—In an article on this subject in your issue of Feb. 1, Mr. Boulenger states that the spitting habit in snakes, on scientific investigation, has only been proved to belong to the South African ringhals (*Sepedon hæmachates*) and certain African species of cobra (*Naia*). He further remarks that it has never been observed

[1] From the *Field*, February 1, 1908

in the India cobra *(Naia tripudians)*. In this he is mistaken. It has been observed in Asiatic colubrines, and various vipers too. I have myself on more than one occasion seen a cobra of the species *tripudians* strike at an Indian juggler and emit poison. In the *Journal of the Bombay Natural History Society* (vol. xiii., *page* 376) Mr. Goring Jones reported a cobra at Mandalay striking at Lieut. Gibson, who was bending down near the snake. He was not actually struck, but had poison ejected into his eye, much swelling and pain following. A hospital assistant of mine in Fyzabad, United Provinces, India, related to me one morning how he and others had found a cobra *(N. tripudians)* which had taken refuge in the crevices of some old masonry. In trying to dislodge it a jet of poison was propelled towards them. Again the title *sputatrix* applied to one form of Asiatic cobra now considered but a variety of *N. tripudians*, one can hardly suppose, suggested itself to Boie (*Isis*, 1827, *page* 557) unless evidence had been forthcoming of its capability to discharge its poison forcibly.

In 1905, Father Dreckman, S. J., an enthusiastic ophiologist, wrote to me that a gravid Russell's viper *(Vipera russellii)*, which he had in captivity, had struck at him and ejected venom into his eye. The wire netting guarded him from a more dangerous result. He suffered acute pain, and had a red eye for a week, though he immediately washed the part as thoroughly as he could.

Miss Hopley, in her book on snakes (*page* 351), says of the Indian saw-scaled viper, "When the poison gland is full, and the snake angry, you may see the venom exuding from the point of the fang, and by a forcible expiration the reptile can eject it. I have seen this in the little *Echis carinata*."

So much for Indian vipers, but the evidence does not stop here. I notice in Cassell's *Natural History* (vol. iv., *page* 66), Audubon is quoted to the effect that he saw a rattlesnake in a wire cage strike at the bars, and the poison was sent several feet towards him.

From these reports there can be little doubt that vipers eject their poison like their colubrine allies, and it seems to me probable that all the Toxicophidia have this power, though some appear to manifest it more frequently than others. I have for many years supposed this to be the case, so much so that I refrained from entering into my notebook several other incidents of the kind that have been reported to me by various observers.

Personally, I think the term "spitting" a misnomer. Spitting implies a labial or lingual action, and as far as I am aware snakes have no labial muscles; certainly they can neither purse nor pout the lips. The tongue, too, with its bifurcation and finely-pointed tips, is not a suitable organ for performing such an office. The word "spitting" is no more applicable than the word "coughing" venom; in fact, the latter is less wide of the mark. Until Mr. H. Lyster Jameson's letter in the *Field* of Jan. 11, I had always regarded the so-called "spitting" of snakes as the outcome of the sudden check offered to the forward thrust in striking when the snake had reached its full power of extension. Any poison hanging on the fangs is shaken off by the check, and carried forward by the vehemence of the forward thrust. I still believe that this accounts for some of the poison ejected, but it now occurs to me that a spray of 150 minute drops such as Mr. Lyster Jameson observed is more likely to be caused by a sudden blast of air expelled from the rima glottis. This orifice lies well behind the fangs, and during excitement snakes inflate and deflate their lungs with great vigour. "Ejection" of venom appears to me to fit the actual facts better.

F. WALL, C.M.Z.S., Major, Indian Medical Service.

Dibrugark, Assam, March 12.

As a slight contribution to the geographical distribution of "Spitting-Snakes" in Africa, the following extracts from the works of Cameron, Stanley and Johnston may be of some interest. With regard to Sir Harry Johnston's statements it may be said that Mr. Boulenger does not agree that the *Causus* viper should be included in the category of spitting-snakes. Such divergent views on the part of distinguished experts and travellers indicate the desirability of further records of first-hand and scientifically accurate reports. Desirability of further observations.

Commander V. Lovett Cameron, R.N., C.B., D.C.L. Speaking of the littoral region met with between Bagamoya (on the East coast, just opposite Zanzibar) and the Useghara mountains, the dividing range between the lowlands and the interior, the writer says[1]:—

"Snakes are not numerous, and the greater part are not venomous, though the *Cobra capello* exists and is much dreaded. There is also a snake which is said to be able to project its saliva to a distance of two or three feet, and when that saliva falls on man or beast a lingering and painful wound results."

Sir H. M. Stanley, G.C.B., says,[2] under date April 10, 1880, Mgangila:—

"Snakes are frequently met with in this road-making. In the neighbourhood of the Congo the slate-coloured spitting snakes are most numerous. Vivi platform was at first infested with a large number of these. They robbed us of our laying hens, and devoured the chicks, and then coiled themselves under the lower shelves of the magazine and menaced our store-men with their venom, which they ejected in a stream from a distance of six feet. The poison must be exceedingly powerful, and especially painful to the eyes, judging from its ill-effects, which lasted eight or ten days."

[1] *Across Africa*, 1885 Edn., p. 503.
[2] *The Congo and the Founding of its Free State*, 1885, Vol. I., p. 204.

Sir Harry Johnston, K.C.M.G., K.C.B., says in his work on *George Grenfell and the Congo*, 1908:—

Vol. I. *page* 228 "There are in the Congo region at least seven examples of viperine and cobra snakes whose venom is fatal.

page 279 "Above the Ndunga Rapids the Congo (Isangila-Manyanga portion) is pent up in a gusty windy trough between steep, sterile slopes. Here, as Stanley remarks, Nature has begrudged life, animal as well as vegetable. The somewhat sterile down-country away from the river-banks abounds with snakes to a degree unusual in Congo-land—chiefly spitting cobras (*Naia*) and deadly tree cobras (*Dendraspis*), *Causus* vipers and puff-adders.

page 928 "With regard to the reptiles of the Congo the poisonous snakes include many types that are common to the rest of West Africa. The genera *Naia* (Cobras), *Dendraspis* (Tree Cobras), *Causus* (Cape Vipers), *Bitis* (puff-adders), *Atheris* (Tree vipers), and *Atractaspis* (Egg-laying vipers) are all represented, the last-named by fourteen species.

page 950 "The reptiles of Fernando Po are almost all common to the adjacent parts of Africa . . . there are twenty-two snakes. Of these, so far as is known, only three kinds are poisonous—the rhinoceros puff-adder (*Bitis nasicornis*), the *Causus rhombeatus*, and the tree cobra (*Dendraspis neglectus or jamesonii*)."

The same author, in his work on *Liberia*, 1906, Vol. II., *pp.* 807–11, writes as follows:—

page 807 "The Reptiles of Liberia, so far as is known, offer no species restricted to that country in its geographical distribution, though there are here represented most of the forms peculiar to West Africa north of the Equator.

"Amongst the long array of Snakes at least ten are poisonous, though it is remarkable how very seldom any death is reported to occur from snake-bite in this country, or in any other parts of Africa, as compared with Asia, Australia and America.

page 808 "*Causus rhombeatus* is very common in Liberia, just as it is throughout Africa south of the Sahara. It is a small, slender viper, with the head distinctly marked off from the neck. The *Causus* viper is only about two feet in length, but very venomous and dangerous from its insignificant appearance and size. It is olive-brown in colour with V-shaped brown marks along the back, and a reversed V or arrow mark on the top of the flat head.

page 810 "The *Causus* viper, already referred to, has a habit (which may be observed when it is kept in captivity) of dribbling its venom from the points of the long fangs when it is angry and excited. This peculiarity has been much noticed by Europeans and natives in South and South-West Africa, where this little viper shares with the much larger Cobra the nickname of "spitting snake." The Cobras, of course, are not connected with the vipers at all. They are simply a group of colubrine snakes that have independently acquired the feature of a poison gland and a perforated fang. They may be told at a glance from the average viper by the narrow jaws. The skin on the sides of the neck in the common African form of *Naia haie* is dilatable into a hood, but this feature is not so striking as in the common Indian cobra or the hooded snake (*Sepedon*) of South Africa.

"The West African forms of cobra are regarded as separate species (*i.e.* from the Indian)—*N. nigricollis*, from the black markings on the back of the neck spreading into a general black tinge, and *N. melanoleuca*, in which the general colouring is in bolder contrast of black and white. These cobras are fairly common in Liberia, where they often attain a length of four to eight feet. *Naia nigricollis* is not infrequently seen in native villages, which it visits on account of the rats and other vermin that form its food. The snakes frequent the thatch more especially, and do not generally interfere with human beings unless first attacked. Even then, instead of striking with their fangs, they seem to prefer to eject the venom by compression of the muscles of the poison gland, so that, like the *Causus* viper, this serpent also bears the nickname of "spitting snake." I have never, myself, actually observed this ejection of the venom, nor, I believe, has the fact been certified by any scientific observer; but it is asserted to be the case all over Africa wherever cobras are found. The natives say that the snake aims at the eyes, and that if the venom enters the eye it causes a very severe inflammation, but nothing worse. One fact is certain (from my own observation): that these African cobras are very slow to strike with their fangs. I have once or twice nearly trodden on one, and the snake has rapidly withdrawn to a safe distance, and then adopted an attitude of menace."

A Note on the Sudan Spitting-Snake

BY

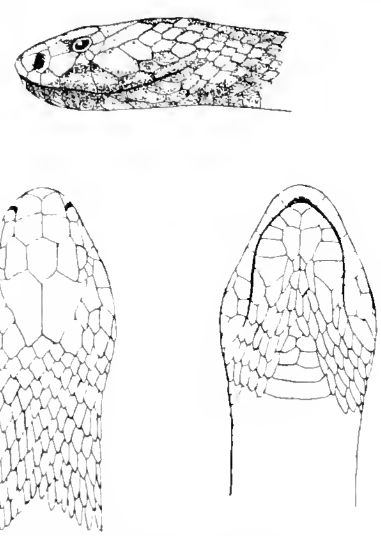
Sir Thomas R. Fraser, M.D., F.R.S.

So far as the very small quantity I received would allow, I have examined the specimen of the venom of the "Spitting-Snake," which was kindly sent to me by Dr. Andrew Balfour of the Wellcome Tropical Research Laboratories, Khartoum.

This specimen possesses the interest of being the actual venom ejected a considerable distance by the serpent. At the moment of ejection it had been received on a flat glass plate, held before the serpent, and then quickly dried on the plate which was sent to me. The serpent itself was not identified.*

I found that a dose of 0·0035 gramme per kilogramme, injected subcutaneously, was sufficient to produce death in white rats. The small quantity at my disposal was insufficient for the determination of the exact minimum lethal dose. The symptoms were similar to those produced by the venoms of the African cobra and of *Sepedon haemachates*, which I had lately examined,† and, as in the case of these venoms, no conspicuous blood changes were observed. On the whole, the probability is that it is the venom of the African cobra.

It is so well known that the Sepedon can eject venom to the distance of several feet, that in some parts of Africa it is popularly known as the "Spuw Slang" or Spitting-Snake. This habit of ejecting venom as a means of offence or defence appears, however, to be exercised also by the African cobra, whose venom, likewise, is chiefly neurotoxic. Venom thus ejected is not likely to produce general poisoning, or indeed, to do much harm unless it reaches the eyeball, where severe local effects may follow.



Naia nigricollis (Sobat)

Head, seen from side, from above and below. Adult length approx. 1.40 metre.

* It was almost certainly *Naia nigricollis*, the spitting cobra of the Sobat.—A. B.

† *Philosophical Transactions of the Royal Society*, Series B. Vol. 200, pp. 241-269 (in conjunction with Dr. A. G. Gunn).

Herpetomonas aspongopi

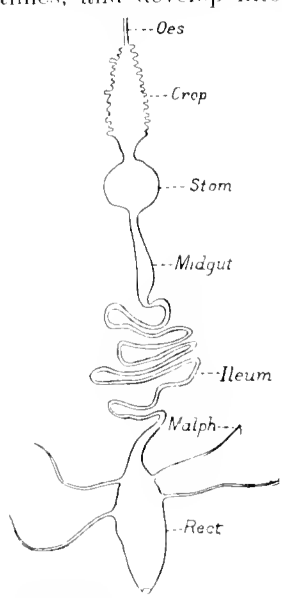
BY

W. M. Aders, Ph.D.

During the winter of 1908, when working in the Wellcome Tropical Research Laboratories at Khartoum, Dr. Balfour proposed that I should examine a number of parasites both of plants and animals in order to ascertain if the former were infested with any other species of parasite; in other words, to study what has been termed hyper-parasitism.

The first parasite examined was the "Melon Bug," *Aspongopus viduatus*, a large hemipterous insect which causes considerable damage to the melon crops in Khartoum. The adult female lays her eggs on the leaves of the melon plant. The eggs are green in colour and usually number from 12 to 15. The young larvæ in the winter months hatch out in about 12 days; they are bright crimson in colour, shed their skins several times, and develop into nymphs. The nymphs vary much in colour, some being of a bright red, whilst others are blackish. The bugs, if supplied regularly with fresh food, will live well in captivity.

The alimentary tract of the "Melon bug"



Aspongopus viduatus

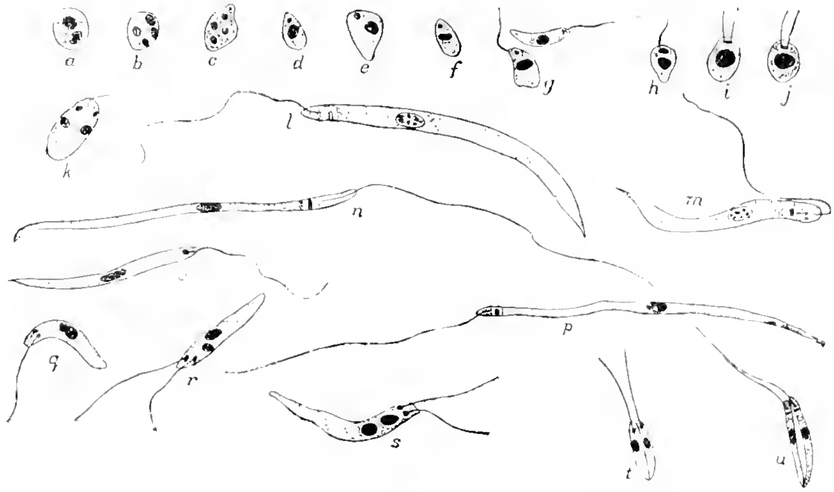
The alimentary tract (*vide* Fig. 36) of the adult *Aspongopus* consists of a short narrow œsophagus which opens into a large sacculated crop: this adjoins the large round stomach, directly behind which is another dilatation, the mid-gut: this is somewhat pear-shaped, and brightly coloured, and it is continuous with the small intestine, which is generally much coiled. At the junction of the small intestine and the colon, four long narrow Malpighian tubes arise, and the colon terminates directly in the rectum. The salivary glands are easily recognised as a pair of white glistening bodies, each consisting of five acini which open into the narrow œsophagus. In adult females the ovaries, which are large green grape-like bodies situated on either side of the body cavity, are very conspicuous. The whole of the abdominal organs are in close relation to the fat bodies and tracheal tubes. Seven out of 120 adults were found to be infected; many nymphs were examined but always with negative results.

Methods

The intestinal tract was removed and placed in a watch glass containing normal saline solution, a small piece of the crop was cut away and the contents placed on a slide and examined. In many cases swarms of herpetomonads were seen actively swimming about. Other pieces of the crop were now taken and their contents smeared out for staining. The films thus obtained were fixed in osmic acid vapour for a few seconds and then placed for ten minutes in absolute alcohol. I found Leishman's stain the best to use, as with Giemsa's it was very difficult to stain the flagella satisfactorily.

Structure and Life-Cycle of the Parasite

I shall commence by describing what I regard as the resting stage of the parasite. Bodies probably representing this stage were often found in the crop and on two occasions in the faeces. They are oval, round, or pear-shaped bodies (Fig. 37, *a*) measuring from 1 μ to 2 μ in length. Their protoplasm stains blue and in parts is very finely vacuolated. These round bodies contain two large nuclei somewhat diffuse in structure. Nearly the whole of the cell is taken up by the nuclei. A general enlargement of this resting body is the first stage towards further development. The two



Herpetomonas aspongopi. [illegible]

Magnification: $\frac{1}{12}$ oil immersion [illegible] × 940

large nuclei divide, thus forming four nuclei (Fig. 37, *b* and *c*). Immediately after this the cell divides by transverse fission. In this last stage one of the nuclei decreases in size and probably becomes the blepharoplast of the young immature parasite (Fig. 37, *d*, *e* and *f*). I have constantly found these bodies present in my preparations and believe that they are the resting stage of *Herpetomonas aspongopi*, but as they were only found in the faeces on two occasions it is possible that their significance may have been mistaken. The young immature parasite is generally pear-shaped, and however formed is easily recognisable (Fig. 37, *d* and *e*). Its nucleus stains pink and is situated at the rounder end of the parasite. The protoplasm stains blue and may appear somewhat vacuolated. When highly magnified, indefinite chromosomes can be made out, but it is not possible to count them. In the young parasites the blepharoplast measures about one-third the size of the nucleus; it is almost always circular in shape and stains deep red. Owing to its great affinity for the stain no inner structure could be demonstrated. There was no other structure visible in these young forms. In the next stage the young parasite appears larger. Its form is elongated and the flagellum grows out from the micronucleus (Fig. 37, *g* and *h*). Division by longitudinal fission may now commence (Fig. 37, *i* and *j*). The parasites now rapidly become elongated until the adult stage is reached. Resting stage

A typical adult parasite (Fig. 37, *l*, *m* and *n*) measures about 18 μ in length and from 2 μ to 3 μ in breadth at its widest part. Its posterior end is usually somewhat pointed, although I have seen a few with blunt ends. The body is cylindrical with a blunt anterior end. The protoplasm stains very evenly, there being no vacuolated areas. One unstained area is present around the blepharoplast. The nucleus is generally spherical in shape and is placed centrally, but occasionally it is situated behind. The nucleus shows great affinity for the red constituent of the Romanowsky stain, but in more or less decolorised preparations chromosomes can be distinctly made out. The blepharoplast is more rod-shaped than round: it stains very darkly and is situated at the anterior portion of the flagellate. In many parasites it has a double appearance suggesting commencing division. The flagellum measures about 13 μ in length; it consists of one stout filament which arises from an achromatic space somewhat anterior to the blepharoplast and passes out at the anterior end. The intra-cellular portion of the flagellum does not differ from the rest, and no basal granule could be detected.

Process of division

On examining a flagellate which is about to commence dividing (Fig. 37, *q*), it can be seen that the nucleus is somewhat enlarged; it does not stain so readily, and in some cases chromosomes are recognisable. The blepharoplast is thickened and somewhat elongated. It was not possible to ascertain if the second flagellum grew out of the micronucleus, or if it was formed by the splitting of the original flagellum. After close examination of many specimens it seems most probable that the new flagellum grows from the micronucleus (Fig. 37, *q*); at a later stage the blepharoplast splits transversely (Fig. 37, *r*) and the two halves become separated. The nucleus now becomes elongated and it undergoes division (Fig. 37, *r* and *s*). A line is seen which commences at the root of the blepharoplast and runs to the posterior end of the parasite. Along this line the parasite divides (Fig. 37, *t*), the anterior end of the parasite separating first, the cleavage later extending to the posterior end (Fig. 37, *u*). It is quite common to see all stages of division in the crop in good infections. The parasites evidently divide many times, as division was observable in quite small forms, and also in many larger forms which evidently gave rise to the long thin form (Fig. 37, *o* and *p*); some of these long forms measured as much as 32 μ. Dividing parasites were always found in the crop, less often in the stomach and mid-gut and very rarely in the rectum. As mentioned before, the bodies supposed to be the resting stages were found in the fæces on two occasions.

Salivary glands infected

In one melon bug the salivary glands were found to be swarming with parasites, many of which were dividing. Several of the drawings were made from parasites from these glands.

The method of infection

Very little can be said on this point as infected bugs were extremely rare. Patton's view that the liquid fæces are sucked up by other bugs seems by far the most acceptable hypothesis regarding the mode of infection. As mentioned before, a large number of larvæ and nymphs was examined but they were never found to be infected. In the few infected bugs which were studied, careful examination of the ovaries was made but no parasites were discovered.

Experiments

An emulsion of the contents of the crop of a bug, which contained many flagellates, was made in salt solution and injected into a gerbil: the result was negative, no infection taking place. An attempt was made to keep the flagellates in citrate of soda solution, but they all died quickly.

Concluding Remarks

Herpetomonas aspongopi is a true parasite of *Aspongopus viduatus*, the complete cycle of development taking place in the alimentary tract of the bug. The parasite is not transmitted hereditarily, but it probably is conveyed from host to host by the ingestion of faeces containing resting forms. No parasites were observed in conjugation, nor could male or female forms be distinguished.

Patton has drawn attention to the resemblance between *Herpetomonas lygaei* and the Leishman-Donovan body, and this flagellate also offers a similar resemblance, consequently it belongs to the same category. The flagellate stage is distinguished by the formation of a typical flagellum, and by division and multiplication of the flagellates. The non-flagellate stages closely resemble the Leishman-Donovan body, the parasite in the resting stage dividing into two parasites, which afterwards develop into two flagellated forms.

For some time past there have been considerable differences of opinion concerning the ancestry of haemoflagellates. According to Minchin's view the haemoflagellates were originally parasites of the intestines of vertebrates, whence they wandered into the blood stream, and were taken up later by bloodsucking insects, thus becoming parasites of a vertebrate and of an invertebrate host. This hypothesis applies to many forms of haemoflagellates, but, as Prowazek pointed out, *Herpetomonas muscae domesticae* is a true parasite of the house-fly; this insect is not a blood-sucker although its ancestors may have been, as a study of the mouth parts of the house-fly appears to indicate. *Herpetomonas aspongopi* is likewise a true parasite of *Aspongopus viduatus*, which is not a blood-sucker. Many of the Hemiptera are fierce blood-suckers, as, for example, the bed-bugs (*Acanthia*). The beak-like mouth parts of the bed-bugs bear a definite resemblance to the mouth parts of the plant-feeding bugs, therefore it might be claimed that the ancestors of the latter were originally blood-suckers, and that they had originally become infected with Herpetomonad forms from some vertebrate host.

I should like to thank Dr. Balfour and Captain Archibald, R.A.M.C., for their kind help and advice.

Fig. 38. Overseer's Stone Hut dug out
See milling stone of another kind in front

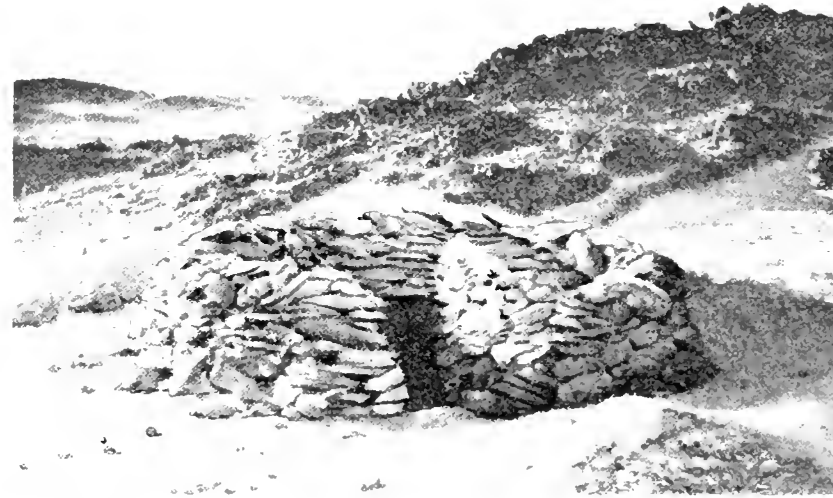


Fig. 39. Overseer's Hut nea[illegible]

Fig. 40. A Dam a[illegible] a Khor
Buried in sand and dug away by Dr. Eliot

Fig. 41. Overseer's Hut (same as Fig. 39) Plan from ba[illegible]
Note peculiar form of hut X(XX) X = furnace XX = hut

Ancient Gold Mining in the Sudan

BY

Stanley C. Dunn, F.G.S., A.R.S.M.

Sudan Government Geologist. Gordon Memorial College, Khartoum

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Traces of ancient mining are found all over the Sudan north of the 18th parallel of latitude, and there are 85 important old workings which can with certainty be imputed to the Egyptians or the Mediaeval Arabs prior to the tenth century A.D. It is possible that the climatic conditions were considerably different to those that now exist. The rainfall must have been far greater; not only are there many wells now dry but traces of reservoirs and even of cultivation, where now one or two storms of rain during the year is the maximum supply. Several attempts have been made in the past ten years to re-open some of the old workings, but owing to the difficulties of transport and the absence of water in sufficient quantities, only one mine, Om Nabardi, near number six station, is at present being worked.

I am greatly indebted to Mr. Arthur Llewellyn for his kind permission to utilise the report for the Egypt and Sudan Mining Syndicate, written in 1903. Additional information has been obtained principally from the works of Dr. Wallis Budge, Professor Sayce and Messrs. Breasted and Weigall.

There is abundant evidence that the mining industry of ancient Egypt covered a most extensive field, and dates from a remote antiquity.

Mr. Ernest A. Floyer, in a contribution to the *Journal of the Royal Asiatic Society* ("The Mines of the Northern Etbai," 1892), after a careful review of the evidence available, concludes that even before the times of the Ancient Egyptians, or in the earliest times contemporary therewith, although unknown to them, the mountains between the Nile and the Red Sea were searched and worked for gold by a people whose chief occupation was mining. It is supposed that these former inhabitants of the Etbai were a negroid race whose descendants at the present day dwell south of Kordofan, and work the copper mines of Hofrat-El-Nahas.

A primitive mining community

The Phœnicians visited this ancient people to trade for the gold of the mines before Egyptian oppression had driven them farther south; and for the Egyptian kings there flowed from this source a stream of gold the volume of which, accumulated in the course of centuries, is now beyond conception, enabling them as it did to supply the civilised world.

The earliest known reference to gold appears to date from the era of Menes, the first historical ruler of Egypt, who is supposed to have reigned about the thirty-eighth century B.C. It is an enactment by which the exchange ratio between silver and gold was fixed at $2\frac{1}{2}$ to 1, thus indicating that even at that far distant date the precious metals were in common use as means of currency. Silver remained the more precious metal until about 2000 B.C.

Floyer is of opinion that the first mines worked by the Egyptians themselves were in the Sinai Peninsula, and were opened under the rule of Senoferu at the close of the third or beginning of the fourth dynasty, a period contemporaneous with the building of the first pyramids.

The earliest inscriptions in the mines and quarries of Hammamat, in Upper Egypt, date from the fifth dynasty, a period at which Ancient Egypt reached the zenith of her civilisation. This place also bears inscriptions of the sixth dynasty and thence onward up to Ptolemaic times.

Earliest written record

The oldest known written record, other than rock inscriptions, dates from the twelfth dynasty (twenty-fifth century B.C.) and probably refers also to the mines of Hammamat. In it a high official of the crown relates how he escorted the gold from mines between Keneh and Kosseir to Koptos on the Nile (Sayce, *Gold in Ancient Egypt*).

In the fifteenth and sixteenth dynasties (seventeenth century B.C.), Egypt, being conquered by the Syrian Bedouins, was governed by a Semitic race, during which time the mines do not appear to have been worked. At the beginning of the eighteenth dynasty (fifteenth century B.C.), when Thutmosis had reconquered Nubia, the mines had evidently been reopened, for it is recorded that Thutmosis III. was in receipt of an annual tribute therefrom of 2,400 lb. of gold (about £132,000 value). If this large figure is correct, it is at any rate certain that by 1440 B.C. the annual tribute had sunk to from 600 to 800 lb. of gold, one-third of the sum. About 1416 B.C., Amenhotep III., in a war against the Nubians, took away from Napata a very large store of gold in dust, figures and ornaments.

The Turin papyrus

The Turin papyrus, brought by Drovetti from Thebes, dates from the nineteenth dynasty (fourteenth century B.C.). It describes mines then existing in the Wadi-Atika (now the Wadi Allagi) and is accompanied by a map which is probably the oldest known cartographical effort in existence. There is little doubt that it represents the mines of Dereheib, visited and described by Linant de Bellefonds in 1868, and reopened unsuccessfully by the "Dereheib and African Syndicate" in 1902 3. This mine is said to have been opened under King Setos I. (1360 B.C.) and in 1290 B.C. we are informed of the difficulties of reaching the mine and of working it owing to the lack of water in the desert. Setos I. is credited with the discovery of other mines in the Wadi Allagi, and is said to have constructed a broad road therefrom to the river Nile at Kubban, opposite Dekka. A well sunk by this king along the route was abandoned at 190 feet, having failed to discover water; but, on sinking being resumed by his son, Rameses the Great, water was struck at 202 feet.

As an indication of the enormous wealth of Ancient Egypt at this date, we may quote Diodorus, who states, on the authority of Hecateus, that a record on the tomb of Osymandyas at Thebes (supposed temp. nineteenth dynasty) gives the total produce of the gold and silver mines at (? to) that time as reaching the incredible amount of 32 millions of minæ, a sum equal to 133 millions sterling.

Royal interest in the mines

It is supposed that the dwindling of the gold supply from the Sudan up to the reign of Setos I. prompted this direct Royal interest in the Mines of the Wadi Allagi. At this date, also, the mines of the Eastern Desert, known for 1000 years, were worked systematically.

The Egyptian kings, however, prior to about 750 B.C., had not the power to take over the Sudan Gold Mines permanently and work them as a Government Monopoly. Piankhi, the first great king of Nubia, conquered Egypt about 750 B.C., and the Nubian rule lasted until its defeat, under Tamath-Amen, by the Assyrians about 663 or 662 B.C.

Nastasenen, King of Meroe, appears to have defeated the army of Cambyses about 520 B.C. and then raided the gold-mining desert natives between the Nile and the Red Sea, capturing, in five expeditions, 1,252,232 cattle, about 800 lb. Troy of gold, much gold dust and many gold figures.

The "Island" of Meroe, according to Diodorus, contains mines of gold, silver, iron, and brass; precious stones and ebony trees.

With the fall of the twentieth dynasty began a period of foreign domination during which Nubia regained her independence. It would appear that not until the beginning of the Ptolemaic period (fourth to first century B.C.) was the mining industry again prosecuted with anything like its former vigour. According to Mitchell, "*Reconnaissance des Anciennes Mines de Hammamat* (Cairo 1879), certain hieroglyphic inscriptions found in a temple at Hammamat, place the date of re-opening the mines under this period at about 240 B.C. in the reign of the III. Ptolemy Euregetes, under whom the foreign power of Egypt reached its proudest height. The annual output of the mines under the Ptolemies is said to have reached a value of five millions sterling, and Strabo tells us that down to the days of the XIII. Ptolemy (80 B.C.), the Royal revenue was between three and four millions, a great part of which, no doubt, must have come from the mines.

The mines under the Ptolemies

Agatharchides, Diodorus and Strabo, who lived during the first century B.C., described many of the mines very minutely and traced their history back to the times of the early Egyptian kings, but with the advent of the Roman period of occupation (40 B.C.) all further record ceases and the mines seem once more to have dropped into oblivion.

Towards the end of the ninth century of the Christian era, Roman rule having given place to Mohammedan ascendancy, the mines again received attention. Al Makrizi tells us in his account of the Beja (*Burckhardt's Travels*) that the Etbai and Butana are full of mines of silver, copper, iron, lead, loadstone, marcasite, emeralds, "and a very brittle stone, of which if a piece is rubbed with oil, it burns like a wick" (probably lignite).

In the reign of Ahmed Ibn-Talun, one Abderrahman el-Omari, a descendant of the Khalifas, reopened the mines at Um Geraiat, about eighty miles from Esneh on the Nile. Following this he worked mines farther south at Ceija, later still, at Jebel Essewed; and finally the more important gold mines of Dereheib. Accompanied by a hundred thousand men, this adventurer's career was one long record of pillage and oppression, which, after thirty years of bloodshed and treachery, ended in assassination by his own followers. History gives us no record of the result of this working of the mines; but the gold obtained must have been considerable even to admit of the maintenance of so great a number of men, the supplying of whom is said to have employed sixty thousand camels bringing provisions from the Nile, and wheat from Aidab on the Red Sea.

Abderrahman el-Omari

Sir J. Gardner Wilkinson, in his learned work on the Ancient Egyptians, makes reference to certain Cufic inscriptions found by M. Bonomi in the Eshuranib mines which point to their having been worked in the years 951 989 A.D. This date, if correct, brings us down to a period nearly 100 years later than the Khalifa-el-Omari. The same writer further states, though on what authority does not appear, that the mines continued to be worked till a much later period than the tenth century A.D., and that they were finally abandoned because the amount of gold obtained barely covered the expense of work.

It is unfortunate that no records of mining by the natives are obtainable between the tenth and nineteenth centuries.

No records between 10th and 19th centuries

The following notes are principally in Mr. Llewellyn's own words.

The ancient method of mining the ore and extraction of gold is described in fragments of the work of Agatharchides (140 B.C.), preserved for us by Diodorus, Siculus and others. It is doubtful whether the historian's description refers to the period of the Ptolemies or to an earlier epoch of the Pharaohs; but the things of which he speaks are in evidence at the old mines to-day; the iron cutters and stone mortars of the men;

the mills at which the women toiled; the tables of the skilled Selangeus; the furnace of the "cook"; the pots in which he fused his gold; the slags therefrom, and even the very charcoal of his fire; all are there save the miserable wretches who wrought the task, and of them there is no tale except the multitude of lowly mounds which mark the last resting place of man and woman and child.

How the mines were worked

Of these people Diodorus writes: "The Kings of Egypt condemn vast multitudes to the mines who are notorious criminals, prisoners of war and persons convicted by false accusation—the victims of resentment. And not only the individuals themselves, but even whole families are doomed to this labour, with the view of punishing the guilty, and profiting by their toil. The vast numbers employed are bound in fetters and compelled to work day and night without intermission, and without hope of escape; for they set over them barbarian soldiers who speak a foreign language, so that there is no possibility of conciliating them by persuasion or through familiar intercourse. No attention is paid to their persons, they have not even a piece of rag to cover themselves; and so wretched is their condition that all who witness it deplore the excessive misery they endure. No rest, no intermission from toil is given either to the sick or maimed; neither the weakness of age nor woman's infirmities are regarded; all are driven to their work with the lash, till at last, overcome with the intolerable weight of their afflictions, they die in the midst of their toil. So these unhappy creatures always expect worse to come than they endure at the present, and long for death as preferable to life."

The following is a free translation from Muller's text of Agatharchides' description. "The metal-bearing rocks which are called gold-bearing are intensely black, but among them is produced a stone than which nothing is whiter. Of these mountains, those which are rugged and have an altogether hard nature they burn with wood; and when they are softened by fire they experiment on them and cut the loosened stones into small pieces with an iron chisel.

"But the principal work is that of the artificer who is skilled in stones. This man shows to the diggers the track of the metal, and apportions the whole work to the needs of the wretched men in the following manner:—Those whole in strength and age break the places where shines the white stone with iron cutting hammers. They use not skill but brute force, and thus they drive in the rocks many galleries, not straight, but branching in all directions like the roots of a tree, wherever the stone pregnant with gold may diverge.

"These men thus, with candles bound on their foreheads, cut the rock, the white stone showing the direction for their labours. Placing their bodies in every conceivable position, they throw the fragments to the ground—not each one according to his strength, but under the eye of the overseer who never ceases from blows. Then boys, creeping into the galleries dug by the men, collect with great labour the stones which have been broken off and carry them out to the mouth of the mine.

"Under the eye of the overseer"

"Next, from these a crowd of old and sickly men take the stone and lay it before the pounders. These are strong men of some thirty years of age, and they strenuously pound the rock with an iron pestle in mortars cut out of stone, and reduce it until the largest piece is no bigger than a pea. Then they measure out to others the pounded stone in the same quantity as they have received it.

"The next task is performed by women, who, alone or with their husbands or relations, are placed in enclosures. Several mills are placed together in a line, and standing three together at one handle, filthy and almost naked, the women lay to at the mills until the

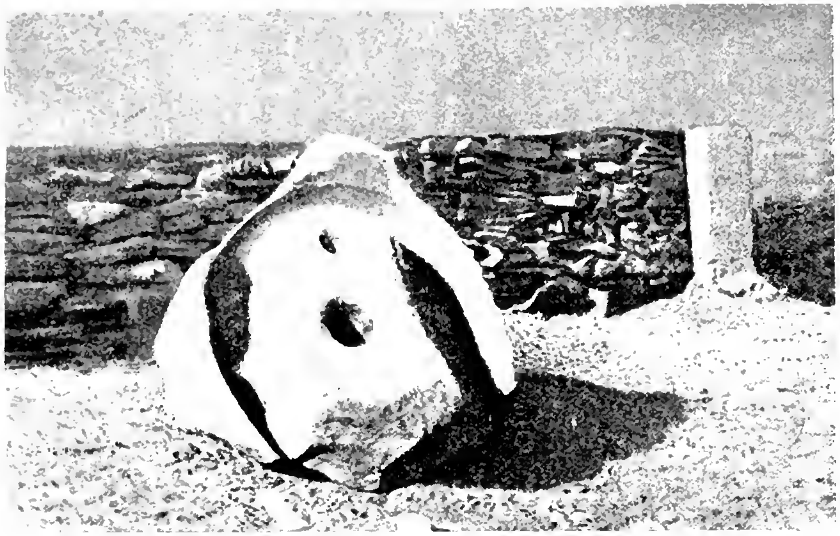


Fig. 42. Milling Stone
The small upper hole was for a handle (stick)

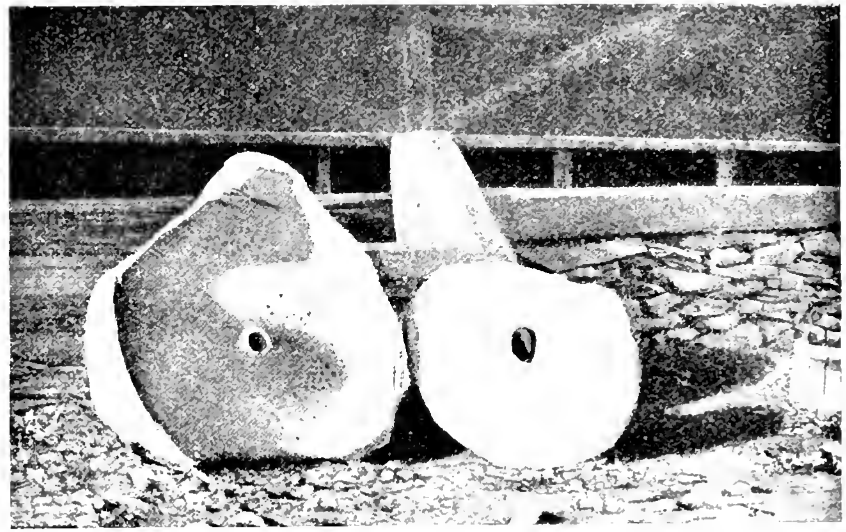
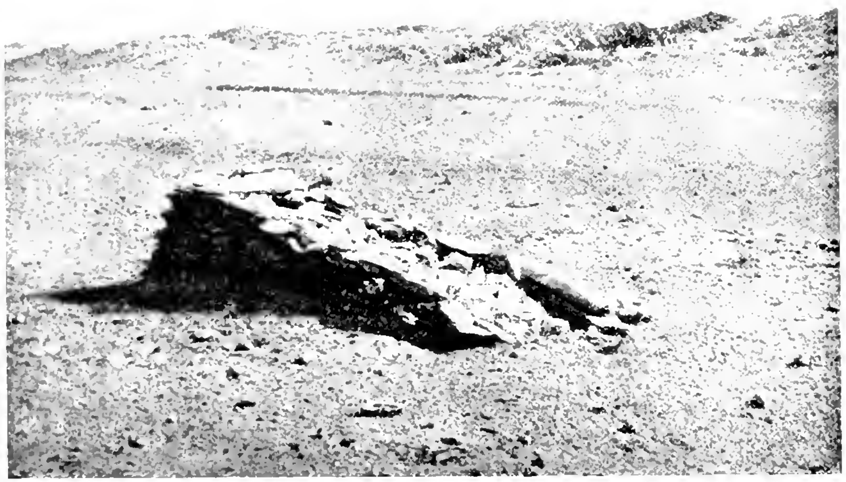


Fig. 43. Milling Stone showing inner face



F[illegible] 44. 'Wa[illegible] Tabl[illegible]'

Fig. 45.—'Wa[illegible]'

measure handed to them is completely reduced. And to every one of those who bear this lot death is preferable to life.

The Selangeus

"Others, called Selangeus (workers at the table or Serangex) take from the women the powder thus produced. These are the artificers in whom lies the power of carrying to the end this work of royal utility. They pour the stone already milled on a table rather broad and polished with a smooth surface, which, however, does not lie flat but has a slight inclination. On this table they rub with their hands the dust mixed with water, first lightly and then with greater pressure.

"By this means the earthy particles are dissolved and flow down the slope of the table, but that which is heavy and worth anything remains on the wood. And when the Selangeus has frequently rinsed the matter out with water, he handles the dust lightly with soft thick sponges, and pressing lightly from time to time he absorbs from the table and throws away that which is soft and light, entangled in the web of the sponge.

"There remains to the Selangeus separated on the table that which is heavy and shines, and which on account of its weight is not easily movable. This he transmits to the cooks, who, immediately they receive it by weight, put it into a clay pot, and, in proportion to its quantity, they add a lump of lead, some grains of salt, a little alloy of silver and lead, and barley bran.

"The pot's mouth being carefully covered and luted round, they cook it five days and five nights consecutively. On the following day, when the burnt materials are cooled, they pour them into another vase. They find none of the things which were put in together, but only a mass of molten gold, little less by weight than the original matter."

The process was somewhat rough, and it is not surprising, therefore, that a good deal of the gold obtained by means of it was anything but pure, indeed, the inscriptions distinguish between gold ore, "gold of the balance," or marketable gold, "best gold," "gold of the second quality" and "white gold." White gold was really electrum, an alloy of gold and silver, of which considerable use was made.

Dr. Beam has recently assayed some gold prepared by the ancient metallurgists and finds it be 22·3 carats fine gold; this is remarkably pure, considering the method, so far as we know it, employed.

Modern investigation

Modern investigation at the old mines of the Sudan bears out the above description substantially, but some slight alterations and further details are to be noted.

The old workings rarely reach a depth of 150 feet, and the workers seem to have preferred veins varying in thickness from a foot to three feet, a vein much thicker than this being rarely taken away in entirety, but followed along one or both sides. This custom was probably for the sake of safety, and in order to facilitate movement within the mine, for numerous footholds in the walls point to this as being the only means of egress; and in the absence of all large timber, ladders were probably unknown. Crude stairways were sometimes built of large stones, especially at the entrances to the workings. Here and there, where the sides are weak, "hitches" have been cut for timber props, and some of these remain to-day in an excellent state of preservation. The timber is a species of acacia which is very common in the desert wadies, although of stunted growth. Tool marks are found in great numbers in the sides of the workings, and appear to have been produced by a pointed iron tool impelled by some form of hammer.

Only in one instance, at the Nabi Mines, has any indication been found of the means of illumination; this consists of a portion of a broken lamp which, except for the fact that it had no handle, resembles the Roman lamp of to-day. Had these lamps been in general use in the mines, it is reasonable to suppose that a fairly large number of them would be found; in any case the smoke therefrom should be visible on the walls of the mine, especially round such niches as might be utilised for their support. But no such blackened spots are found and the marks are absent altogether. The marked absence of smoke stains on the walls raises another point. If, as related by Agatharchides and Diodorus, fire has been employed in the working faces as a means of breaking down the quartz, some indication of this should remain at the present day. In some of the Egyptian mines with which I am acquainted the working faces are smeared with soot and smoke, and powdered charcoal is observable everywhere. There is also a characteristic conchoidal appearance in a "burnt" end which is never observable in most of the working faces of the Sudan mines. Taking these things into consideration, and also the great scarcity of wood which must have prevailed then, as now, it is extremely doubtful if this firing process was ever employed in this country.

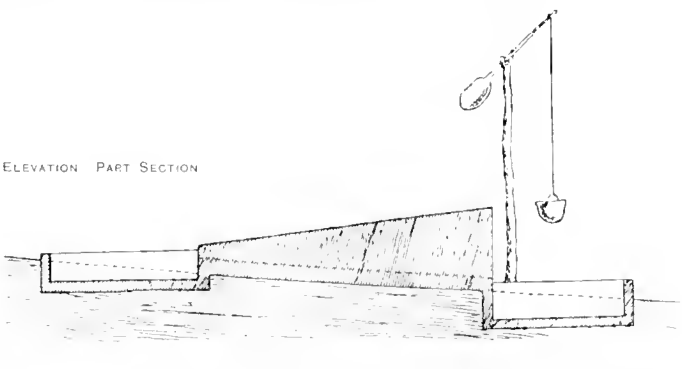
Illumination

Whatever the means of obtaining the quartz may have been, the subsequent treatment thereof cannot have differed greatly from the accounts given by Agatharchides. There seems, however, to have been some process of hand selection which escaped that writer's observation, for from the abundance of partially reduced quartz found in the neighbourhood of the works, it is evident that not one-half of that taken from the mines underwent the final crushing. The selective process was probably based on the occurrence of visible gold in the stone, or perhaps on some attendant phenomena of which we do not possess the secret. In any case, it was efficient in result, for the rejected stone is rarely worth more than a dwt. or two per ton, and has never been found to contain visible gold.

The preliminary breaking down of the quartz as it left the mine was effected by stone hammers, roughly cuboidal in shape, which have become worn on every side, with a slight indentation in the centre of each face. The anvil was a hard stone slab, or as often as not the less weathered surfaces of the rocks, which are seen to be worn into a multitude of holes. The rubbing mills, as distinguished from the grinding mills, are flat pieces of the hardest rock procurable, usually dolerite or basalt, and the mullers—from 5 to 15 lb. weight—are generally of the same material. The latter being worn on both sides, are usually lenticular, the hollow in the stone being elliptical in shape, about 20 inches by 15 inches, and often as much as 4 inches deep. Frequently the stone has been turned and a similar hollow worn on the other side until both have met.

Apparatus found in the vicinity of the mines

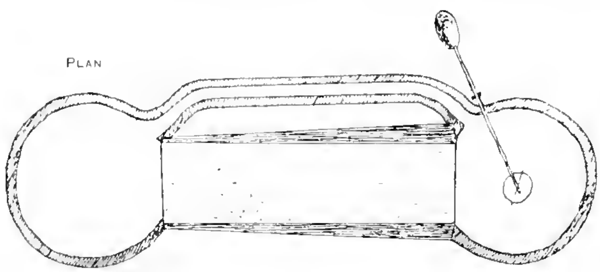
The circular grinding mills are from 18 to 22 inches in diameter, the nether stone being also of exceedingly hard rock. The mullers, which are pivoted in the centre, are usually of a softer material, a coarse-grained granite being the favourite, and the original weight would be about 50 or 60 lb. The quartz was fed through a hole in the upper stone, and rotation was effected by means of a short stick inserted in a shallow notch. Some of these mills are worn to a depth of eight or ten inches, and, like the elliptical ones, many of them have been turned and used on the reverse side. It is a curious fact that very few of these nether stones remain intact. When not worn through they have in nearly every case been broken at the side,



and this must of necessity have been intentional. The assumption is that when the former workers left the mines, these things, being too heavy to remove, were purposely destroyed to prevent their use by others. The upper stones, in many cases, they appear to have carried with them, for these, besides being lighter, entailed more work in preparation.

Washing tables

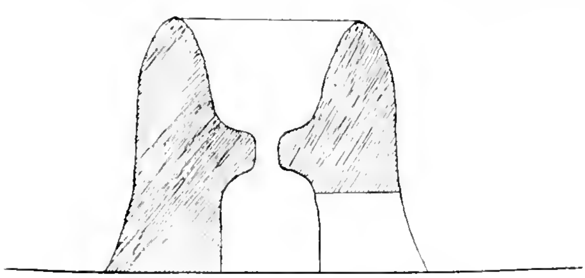
The washing tables measure about 9 feet by 2 feet 6 inches, and are built of undressed stone with rubble filling. The upper surface was plastered smooth, and sloped at an angle of $1\frac{1}{2}$ inches to the foot. As the table was usually built on ground which sloped in an opposite direction, the head of the table would stand about 2 feet 6 inches above the ground. A circular stone-lined cistern, 4 or 5 feet diameter, at the bottom of the table, served to catch the water which flowed therefrom, and this returned by a narrow stone-lined channel to a similar cistern immediately below the head of the table, whence it was raised by the operator with the aid of a small "shadoof," to be used on the table again. The sand or tailings collected in the first cistern, and was thrown out to form large heaps, many of which remain to the present day. A small rectangular stone-lined pit is usually found by the side of each table, and it is surmised that this was for the reception of the pulverised quartz as it came from the mills.



Scale: 1/6 inch = 1 foot

Melting-pots

The presence of the broken melting-pots and quantities of scoriaceous slag confirms the description of the means employed for the ultimate separation of the gold from the baser metals, and that this process was a most effectual one may be inferred from the fact that no trace of gold can now be obtained from the slags. Mercury does not seem to have been known to the workers, or, if known, was evidently not employed as a metallurgical reagent.



Scale: 1/12

Not the least interesting feature of these ancient camps are the hut remains, of which great numbers are found at every important mining centre. The walls usually consist of a single thickness of undressed stones, supported by smaller fragments wedged into the crevices; but here and there a building may be seen where the wall is formed by two facings and a rubble filling; plaster of any sort being quite unknown. The height of the walls varies from two to five feet, and the average may be taken as three feet above the ground. The plan, as a rule, is roughly circular, eight to ten feet diameter within, with no opening but the entrance, which is sometimes surmounted by a lintel, although this is very rare. No roof structure has been seen, and the former covering was probably some kind of mat or woven material. At most of the mining centres the huts are scattered indiscriminately along the edges of the wadies, or at points convenient to the works, but in others they are found arranged in compact blocks. This may possibly have been with a

Huts

view to mutual protection and defence, but if, as Diodorus informs us, the Ptolemaic mines were worked by slaves, some form of supervision would be necessary in the camp no less than in the mine, and it would be obviously impossible to exercise this in a widely scattered camp. The suggested inference is that these rectangular walls and close encampments may mark the scene of Ptolemaic and earlier work, whilst the scattered huts and isolated mills date from the period of Arabian occupation.

Ancient wells probably exist at many of the mining sites, for it is difficult to believe that the workers brought their water from such great distances as most of the present wells are removed from the mines. These wells would naturally be situated in low-lying ground, thus facilitating their obliteration by blown sand and occasional rainstorms. The burying places pertaining to the mines are usually situated in a wadi-bed, in close proximity to the scene of work. The graves are irregularly scattered but have almost invariably a general orientation north and south. They are from four to five feet deep and the body lies, with the feet towards the north, between two narrow ledges which support a bridge of stone protecting it from the superincumbent earth. At the top there is usually a ring of stones encircling the grave with an upright stone at the head and at the foot. The space within the ring is often covered with small stones, which are sometimes selected white quartz or rounded pebbles from the wadi-bed. The form of sepulture and the fact that where human remains have been found the skull is invariably of a Semitic type, and not negroid, points to these being Mohammedan. The unfortunate workers of earlier days were probably so carelessly buried that nothing now marks their graves.

Burying places

A great number of potsherds of various shapes are found in the neighbourhood of the mines; all are of common unglazed earthenware and usually of a brick-red colour. Various other articles have been found, but nearly all are remnants of the Arab occupation. They include: a short pointed iron tool, pierced for a haft, and corresponding to the modern single-pointed pick; a broad hoe with the eye attached by rivets; iron wedges; packing needles; a pair of scissors; brass scale-pans pierced with holes for cord supports; some small copper ingots which may have been weights; portions of large bronze vessels, probably cooking pots, but extremely thin and bearing evidence of skilful manufacture; fragments of coarsely woven cloth; fragments of sea-shells and ostrich eggs, probably used for the reception of gold dust; some beads and small articles of personal adornment; a small stone tablet inscribed with the emblem of the sun god Horus; and numerous fragments of broken glass commonly of a bright greenish-blue colour. Unlike the mines of the Eastern Desert of Upper Egypt, hieroglyphic inscriptions appear to be entirely absent; so far as I am aware the only inscriptions discovered in the vicinity of the Sudan mines are Cufic, dating from the ninth and tenth centuries A.D.

The Cult of Nyakang and the Divine Kings of the Shilluk

BY

C. G. Seligmann, M.D.

Preliminary Remarks

The Shilluk kings trace their origin to Nyakang, the semi-divine hero, who, with a comparatively small band of followers, took possession of the present Shilluk territory and founded the Shilluk nation. Nyakang and his followers are generally considered to have come from the west, perhaps from the banks of the Bahr-El-Ghazal or some of its tributaries, but other accounts state that their home lay far to the south of the present Shilluk domain.[1]

The object of this paper is to record the chief features of the cult of Nyakang and his successors, but in order to make this worship clear it is first necessary to say a few words concerning the organisation of the Shilluk nation.

The Shilluk country

The Shilluk country forms a narrow fringe on the west bank of the Nile from Kaka in the north to Lake No in the south. From Kodok to Taufikia the Shilluk also occupy the east bank and their villages extend some 35 miles up the Sobat River, principally on the north bank. Their territory is almost entirely a grass country, hence cattle are their wealth and principal care, and although a considerable quantity of dura is grown, not enough is harvested to provide fully for the really dense population, and famines are by no means unusual. A census of the river villages taken in 1903 gave a population in 1,010 villages of nearly 40,000 souls possessing over 12,000 head of cattle and nearly 64,000 sheep and goats.[2] It follows from these figures that the Shilluk are poor in cattle and that their villages are small, often consisting only of a few houses. This is undoubtedly the case in the majority of instances, though large villages are not unknown, indeed the village of Atwadoi, some distance to the north of Kodok, is said to contain 120 houses.[3] This presumably means 120 homesteads, since among the Shilluk each householder occupies a small group of two or three or sometimes four huts,

[1] The Choli or Acholi of the Uganda Protectorate speak a language closely allied to the Shilluk and have a branch in Unyoro called Chopi, who, as Mr. E. B. Haddon informs me, speak almost the same language as the Acholi. Mr. Haddon also points out that the Kavirondo Jaluo of Kisumu, on the east side of Victoria Nyanza extending to about 0° 30′ S., speak a language almost identical with that of the Chopi, and he refers to a Jaluo tradition that they came from the neighbourhood of a high mountain to the north. There is no doubt that the Chopi came from the Acholi country, and, as there are high mountains here, the country to the north of the Victoria Nile may well be the home of the tribes speaking Shilluk and closely allied languages. Whatever the views entertained by the Shilluk as to the direction from which their ancestors came, all agree that Nyakang left his country on account of a quarrel. According to a legend related by the chief of the Nyalwal district, Dag, the son of Nyakang, made himself a nuisance to everyone in his village by playing a stringed instrument all night, and even when his mother's brothers remonstrated with him, as was their right, he took no notice of what they said. As he was a bad nephew and disobedient they determined to kill him, but their plan, which was to spear him as he slept, was overheard and reported to Nyakang, who made a wooden image and laid it in the sleeping place usually occupied by Dag. When Dag had finished playing he quietly slipped away. Soon his uncles came and thrust spears through his sleeping place, sending word next morning to Nyakang to say that his son was dead. Nyakang sent back the answer "mourn for him, you killed him, he was your son (*i.e.*, sister's son), I shall not mourn." The uncles began the usual death ceremonies when Dag returned and twitted them with their failure to kill him, and it was as a result of the ensuing quarrel that Nyakang and his followers left the country.

[2] *Anglo-Egyptian Sudan*, *I. p.* 193. The number of cattle is probably too small, the census in 1906 gave over 22,000.

[3] *Anglo-Egyptian Sudan*, *loc. cit.*

enclosed by a fence of dura stalks. One *tukl* is the sleeping compartment for the householder and his wife, one is used as kitchen, while the remaining hut or huts are assigned to the children and servants, if there are any of the latter class.

THE SHILLUK KINGS

The Shilluk aristocracy

The aristocracy of the Shilluk nation consists of the king (*ret*), his children (*niaret*), his grandchildren (*ni'āret*) and his great grandchildren (*kwaniaret*). Royal descent is not recognised beyond four generations. Nyakang was the first of the Shilluk kings, and all subsequent kings are his descendants, their genealogy being shown in the table on *page* 218.

The Shilluk take every care of their king and pay him much honour. In the old days he was not allowed to go to battle and even now the Shilluk king keeps up considerable state and has much authority. He usually rides a donkey and never moves without a body-guard of some 12 to 20 men, for the most part more or less well armed, and all ready to do whatever he tells them, even should this mean an uninteresting and harassing journey, lasting several days, with the white man. In the old days his word was law, and his decisions are still obeyed in all matters coming before him, *e.g.* the fines of cattle that he imposes are paid with reasonable speed.

No more eloquent evidence of the power wielded by the king could be offered than the really imposing mound upon which stands the *tukl* of the present king (Fig. 49), for although the Shilluk are intensely lazy and the king is far from being generally popular, the mound was said to have been built quickly and with the minimum of grumbling.

Anyone killing a leopard, a giraffe or an antelope, called *gïk*, must hand over the skin to the king, who, while taking it as his by right, would present something valuable in return, such as a spear, sheep, or, perhaps, even a bullock. It was said that only the king could wear the skin of the *gïk*, but his sons, grandsons and great grandsons might wear leopard skins, and, in practice, I believe that some old and important men, even if not of the royal blood, were allowed to use the latter. Before the Mahdia, only the king had the right to wear certain finely woven imported cloths, though he might give any member of the royal family permission to wear material of this quality. It was said that silver, which was formerly very scarce and which even now is much admired in the form of a bracelet, properly speaking, might be worn only by the king, his sons and grandsons, though it appeared that *kwaniăret* would readily be given permission to wear a silver bracelet.[1]

All Shilluk commoners have the lower central incisors knocked out, but *ret*, *niăret* and *ni'āret* do not conform to this practice, while *kwaniăret* please themselves in the matter. This applies to both sexes.[2]

Royal marriage regulations

Polygamy is prevalent, and a large number of the *tukl* in Fashoda are the residences of the king's wives, of whom he has very many. His sons, too, take many wives, but the daughters of a king must remain unmarried, the alleged reason for this being that it is unfitting that the daughter of a king should marry a commoner, while she could not marry a *niăret* since this would be incest. The prohibition of marriage does not, however, extend to all intercourse; a king's daughter is allowed to select lovers as she chooses,

[1] A song relates how Dag, the second Shilluk king, caught a wonderful creature called Garo Wirchang, a relative of the sun, on whose wrist glittered a marvellous bracelet. Dag cut off his captive's thumb to obtain possession of the ornament, which he wore on his own wrist, and since that time all *ret*, *niăret* and *ni'āret* have the privilege of wearing a silver bracelet.

[2] There is no seclusion when the teeth are removed, but the boys whose teeth are knocked out together are looked upon as life-long companions, though I cannot say whether they form a definite age-class among the Shilluk as they do among some Dinka. It seems possible that the retention of the teeth by members of the royal family may be a device to avoid the levelling effect of the ceremony and to accentuate the difference between themselves and commoners.

and nothing is said so long as it is not publicly known that she has become pregnant; but if this were discovered she would be killed, as would also the man responsible for her condition. This rule, which until recently appeared to have been sternly carried out, led to the frequent production of abortion.

When one of the king's wives is pregnant she remains at Fashoda until the fourth or fifth month, she is then sent to a village, not necessarily her own, where she remains under the charge of the village chief (*bareng*)[1] until the child is weaned, when she probably returns to Fashoda. She usually takes a certain number of servants and cattle with her to the village in which she will be confined, and these are generally left there after her departure and become the property of the child, who is invariably brought up in the village where it is born and in which it should also be buried. This rule applies equally to all royal children of either sex in whatever part of the Shilluk territory they may happen to die.[2] Sons are, of course, more likely to leave the village in which they have been brought up than their sisters, who, as they grow up, exercise considerable influence in the village, where little of importance is done without their being consulted.

It is noteworthy that no woman is sent twice to the same village to bear children, though I believe that another royal wife may be sent, after an interval, to a village in which there is already a royal child.

Genealogy of the Shilluk kings

Nyakang (1)
Dag (2)
Oshalo (3)
Duwad (4)
Bwotch (5)
Dokor (6)
Tugo (7)

Okon (8) Nyadwai (9)

Kudit (11) Muka (10) Nur wad Nyadwai (12) Wag wad Nyadwai (13)

Nyakwatch (15) Delgud (14)

Nyababa (16) Akwot (18) Awin (17) Nyadok (20)

Akoj (19) Kwadke (21) Ajang (22) Kur wad Nyadok (26)

Yur Adodit (24) Fadiet wad Kwadke (Reigning King) Akol (25) Kwoe Kun (23)

[1] A village chief is often a *kwaniăret*. I do not recall any instance of a *ni'ăret* being a village chief, but do not doubt that such exist.

[2] Mrs. Seligmann learnt that the after-birth and umbilical cord of royal children are treated in the same way as those of commoners, *i.e.*, they are buried in the house enclosure. Considering the close relation that in some parts of Africa (*e.g.* among the Baganda) exists between a man and the stump of his umbilical cord, it is not unlikely that this practice may have something to do with the king's grave shrine being built in the village where he was born.

The foregoing genealogy shows twenty kings belonging to eleven generations between Nyakang and Kwadke, who is said to have fallen by the hands of the "Turks," as did his successor Ajang. The three kings who succeeded Ajang had short troublous reigns, all being killed by Dervishes. Their successor, Kur wad Nyadok, was deposed and exiled in 1903, and died at Halfa. The present king, Fadiet wad Kwadke, a rather incompetent ruler, was recognised by the Government at the desire of a dominant party in the Shilluk nation, but his election by no means met with universal approval.

My genealogy, compiled at Fashoda, agrees with the list given by Father Banholzer[1] in the number of kings between Nyakang and Kwadke, indeed, ignoring differences of spelling, there is a general close agreement not only between these lists but also with one compiled by the Rev. J. K. Giffen of the American Mission, for a copy of which I am indebted to Major S. Lyle Cummins, R.A.M.C. The inconsistencies are probably due to the lists being compiled in different parts of the Shilluk territory, Father Banholzer's at Lul, and Mr. Giffen's at the mouth of the Sobat River. In all that follows I shall use only my own list, since this was compiled at Kodok from information obtained in villages near Fashoda, the residence of the Shilluk kings.

The second and third of the Shilluk kings partake somewhat of the semi-divine nature of Nyakang, and it will probably be found that little is known of any king before Nyadwai, relics of whom still exist at Kodok. The following account of the origin of Nyakang is taken from the *Anglo-Egyptian Sudan*:—

"In the beginning was Jo-uk, the Great Creator, and he created a great white cow, who came up out of the Nile and was called Deung Adok. The white cow gave birth to a man-child whom she nursed and named Kola (Kollo); Kola begat Umak Ra or Omaro, who begat Makwa or Wad Maul, who begat Ukwa. These people lived in a far-off country, nobody knows where. . . . . Origin of Nyakang

"Ukwa was one day sitting near the river when he saw two lovely maidens with long hair rise out of the river and play about in the shallows. He saw them many times after that, but they would have nothing to do with him and merely laughed at him. It should be mentioned that their lower extremities were like those of a crocodile.

"One day Ukwa found them sitting on the bank, so he came up behind and seized them. Their screams brought their father, Ud Diljil, out of the river, to see what was the matter. Ud Diljil, whose right side was green in colour and in form like a crocodile, whilst his left side was that of a man, protested mildly, but allowed Ukwa to take away his daughters and wed them, merely giving vent to a series of incorrect prophecies regarding them.

"Nik-kieya, the eldest sister, gave birth to two sons and three daughters, and Ung-wad, the younger, to one son only, named Ju, or Bworo. The eldest son of Nik-kieya was named Nyakang (Nik-kang or Nyakam) and inherited the pleasing crocodilian attributes of his mother and grandfather. Meanwhile Ukwa married a third wife, whose eldest child, a son, was named Duwat.

"On Ukwa's death there was a furious quarrel between Nyakang and Duwat as to who should succeed Ukwa. It ended by Nyakang, with his sisters Ad Dui, Ari Umker and Bun Yung, his brother Umoi and his half-brother Ju, acquiring wings and flying away to the south of the Sobat. Here they found the Shilluk country inhabited by wicked Arabs, so they drove them out and founded a most successful kingdom. . . . .

"Nyakang had a creative power which he used greatly to the advantage of the kingdom. In order to people the vast territory more quickly, he proceeded to create a

[1] Father Banholzer's list will be found on page 199 of the first volume of the *Anglo-Egyptian Sudan*.

people from the animal life he found in the forests and rivers. From crocodiles and hippopotami, and from wild beasts and cattle, he created men and women. When these had brought forth many children the parent stock was removed by death, so that the children might not know of their origin."[1]

It is obvious that in this passage stress is laid on the non-human element in the ancestry of Nyakang, who himself inherited "crocodilian attributes." I feel confident that in the minds of the majority of the Shilluk people Nyakang is not associated with saurian or any non-human bodily characteristics, and, although I enquired into the matter many times (in the neighbourhood of Kodok), I never obtained anything like the consistent account quoted above, while the majority of my informants knew nothing of the white cow, Deung Adok. Nevertheless, certain of the names given by Mr. Giffen (from whose notes the account quoted was compiled) were recognised, though little was known about those occurring in the generation before Ukwa, father of Nyakang.[2]

The Shilluk round Kodok undoubtedly think of Nyakang as having been human in form and in physical qualities, though, unlike his recent successors, he did not die but disappeared. Before his disappearance he gave certain instructions to those of his companions who lived at Akurwa, where one of his most celebrated shrines now exists. His holiness is especially shown by his relation to Juok[3] the high-god of the Shilluk, who made man and is responsible for the order of things. Juok is formless and invisible, and, like the air, is everywhere at once; he is far above Nyakang and men alike; nevertheless, it is only through Nyakang that men can approach him, performing the sacrifices to Nyakang which cause him to move Juok to send rain. Juok is not worshipped directly, and although some Shilluk may vaguely associate the dead with him, this feeling does not appear to imply any knowledge of a place of the dead or of their condition. In spite of the absence of any direct worship of Juok, his name occurs in many common greetings, *e.g. yimiti Juok*, "may Juok guard you," and, like Job, a sick man may cry *er ra Juok*, "why oh Juok?"

There is a vague but quite general belief that the spirits of the dead are about everywhere, and that sometimes they come to their descendants in dreams and help them if they are ill, or give them good counsel.

This belief does not appear to have given rise to any considerable cult of dead ancestors as it has among the Dinka, although the whole working religion of the Shilluk is a cult of Nyakang, the semi-divine ancestor of their kings, in each of whom his spirit is immanent.

Royal graves become shrines

In describing this cult I shall begin by considering certain shrines which exist in the villages round Fashoda and elsewhere in the Shilluk country, but which are not shrines of Nyakang.

Fig. 50 is a reproduction of a photograph of part of a small village between Kodok and Fashoda. It will be seen that two of the *tukl* of which the village is composed are more neatly thatched than the others, and that the fence surrounding them is in specially good

[1] *Op. cit.* p. 197.

[2] Omaro was called Omaro Wakolo and said to have lived long before Nyakang, nothing else was known of him. Wad Maul was recognised as a name occurring in an old song. Ukwa and Nik-kieya (Nyakai) were regarded as the father and mother of Nyakang, but Ari Umker became the wife of Nyakang and Ad Dui their daughter. Bun Yung was unknown. Ud Diljil was said to have lived very long ago and to "belong to" the Anyuak on the Sobat River. This last observation seems to offer an explanation of the very circumstantial account I have quoted of the origin of Nyakang. Taken from notes by Mr. Giffen, whose station stands on the Sobat, it may well show Anyuak influence, and there is nothing more likely than that the local Shilluk share the beliefs of the kindred Anyuak or have been influenced by them.

[3] Juok of the Shilluk must not be confused with the *jok* of the Dinka, *i.e.* the spirits *(atiep)* of certain old and important ancestors who take a life-long interest in their descendants, whom they assist in every way, but to whom they also send sickness and death.

repair. The roofs of these *tukl* terminate in an ornament, which consists of an ostrich egg from which there projects the blade of a spear, this finish of the roof being shown on a large scale in the accompanying figure (Fig. 52). The most casual enquiry shows that the two huts, with the area surrounding them enclosed by the fence, are sacred, for, with the exception of one or two old people of either sex whose duty it is to keep them clean, no one enters the enclosure, or even approaches it, without due cause. The only exception to this rule is, that children who have not reached puberty may enter the shrine to assist the guardians. I have seen a boy of about ten carrying a gourd of water enter the shrine of Yur Adodit, near Kodok, without the least ceremony. The enclosure, in fact, constitutes a shrine, and essentially similar shrines are found in many Shilluk villages. Sometimes, but this is rare, only a single hut may stand within the enclosure, which may even be separated from a village, as is shown in Fig. 51, but more commonly three or even four huts are fenced off, one of the huts being raised over the grave of a king, while the others are used by those who attend to the upkeep of the shrine. It is not difficult to compile a list of the villages which contain the graves of the Shilluk kings, and in doing this it is found that Nyakang and his son Dag, both of whom disappeared but did not die, have many shrines called graves, Nyakang possessing no less than ten, the most celebrated of which are at Akurwa, Fashoda and Fenikang. The shrines of Nyakang do not differ in appearance from the shrines of the later Shilluk kings, and they are all spoken of as *kengo Nyakang*, "the grave of Nyakang," although it is perfectly well known that no one is buried in them.

The word *kengo* is only applied to the graves of kings and their children, the graves of commoners being spoken of as *roro*; a similar verbal distinction is made with regard to the death of kings, who are not said to "die" but, like their ancestor Nyakang, to "go away."

The graves of the kings and the *kengo Nyakang* are alike the site of the performance of certain ceremonies which show the intimate relation, amounting sometimes to confusion, which exists between Nyakang and subsequent kings. As already stated, Juok is too distant to be approached otherwise than through Nyakang, so that the actual working religion is a cult of Nyakang depending upon an absolute acceptance of the following beliefs:—

(i) The immanence in each king (*ret*) of the spirit of Nyakang, simply spoken of as Nyakang.

(ii) The conviction that the king must not be allowed to become ill or senile, lest with his diminishing vigour the cattle should sicken and fail to bear their increase, the crops should rot in the fields, and man, stricken with disease, should die in ever increasing numbers.

It follows that the *ret* of the Shilluk must be numbered among those rulers whom Dr. J. G. Frazer has called "divine kings," and like many of these in other countries, although every precaution is taken against their accidental death, they are (or were) killed in order to avoid those disasters which their senescence was thought to bring upon the State.

The Killing of the King and the Transmission of the Divine Spirit

Although there is not the least doubt that the kings of the Shilluk were killed with due ceremony when they began to show signs of old age or ill health, it was extremely difficult to ascertain exactly what was done on these occasions, and there is no doubt that a good deal of Shilluk folk-lore survives in the accounts commonly given of the killing of the *ret*. According to these any *nïäret* has the right to attempt to kill the king, and, if successful, to

The killing of the divine king

reign in his stead. The killing could only take place at night, for during the day the king would be surrounded by his friends and his body-guard and no would-be successor would have the least chance of harming him. At night the king's position was very different. Alone in his enclosure with his favourite wives and no men in the royal village to protect him, except a few herdsmen whose huts would be at a little distance, he was represented as passing the night in constant watchfulness, prowling round his huts fully armed, peering into the shadows, or himself standing silent and watchful in some dark corner. Then, when at last his rival appeared, the fight would take place in grim silence broken only by the clash of spear and shield, for it was said to be a point of honour for the *ret* not to call the herdsmen to his assistance.

Many commoners will give some such account as the above, and though nothing of the sort occurred during the recent period before the Mahdia, I believe that these tales reproduce with tolerable fidelity a state of affairs which once existed among the Shilluk, or among their ancestors before they occupied their present territory. One survival of the conditions outlined does, indeed, seem to remain. I was told on every side that the king still kept awake at night and slept only by day, and the sleepy condition of the king on the few occasions on which I saw him seemed to confirm this.

In recent times the leading part in the killing of the *ret* was assigned to the members of certain families called *Ororo*, who are said to be the descendants of the brothers of Oshalo the third king of the Shilluk (*vide* Genealogy, *page* 218).[1] It is generally believed among well-informed Shilluk that Duwad was the first king to be killed ceremonially, but, according to one account, Tugo was the first to suffer. I have not been able to obtain absolutely reliable information concerning the actual killing of the *ret* during recent times. It is said that the *Ororo* and some of his chiefs announce his fate to him, after which he is taken to a *tukl* specially built for the occasion, and strangled. The reasons determining the *Ororo* to act were said to be the ill health of the *ret* or his incapacity to satisfy his wives, which was regarded as an undoubted sign of senescence. Concerning this there are two popularly received accounts. One states that his wives would themselves strangle the *ret*, but this is incorrect; the other is to the effect that the wives notify their husband's shortcomings to some of his chiefs, who tell them to inform the *ret* of his approaching death. This is done by spreading a piece of cloth over his face and over his knees as he lies sleeping during the afternoon. I am unable to say whether there is any truth in this belief, but it is certainly very widely held, not only among the Shilluk themselves, but also among Arab traders and other foreigners such as Egyptian officers who have served among them.[2]

Ignoring these discrepancies and recent practice, there is little doubt that the old custom was to take the *ret* to a specially built *tukl* in which he lay down with his head resting on the thigh of a nubile virgin. The opening of the hut was walled up and the couple left without water, food or fire to die of starvation and suffocation.[3]

It is said that this practice was discontinued some five generations ago on account of the sufferings of one of the *ret*, who survived his companion for a number of days, during

[1] Although the *Ororo* cannot become king there are among them many highly influential men. Yang Jok, the chief (*bang*) of Nyalwal district (*podo*), is an *Ororo*, as are many of the *bareit bang Nyakang*.

[2] The Rev. Father Hofmeyer (Zur Geschichte und Gliederung der Shilluk, *Anthropos*, 1910, p. 330) gives a legend, according to which Nyakang summoned his people to a great feast, lasting four days, until a whirlwind arose which ended it abruptly. Presumably the whirlwind was caused by Nyakang, for when all had dispersed he allowed a cloth to be bound over his face so tightly that he died. An account, for which I am indebted to Father Banholzer, states that the Shilluk kings were killed by means of a cloth bound tightly across the mouth by some of the most influential chiefs, who then gave out that the king had "disappeared."

[3] I believe that the girl chosen to die with the *ret* was always one of his brother's daughters, but I am not certain as to this. According to one account the *ret* was given a pipeful of tobacco which was lit before the door of the hut was closed.

which time he was so much distressed by the stench arising from her body, that he shouted to the people whom he could hear moving about outside the *tukl* commanding them on no account to leave his successor to die slowly in this way.

Some months after the king's death, when decomposition was judged to have proceeded so far that little but the bones would be found,[1] the hut was broken open by the *Ororo*, a grave dug and the bones of the king and of his companion placed in it after being wrapped in the skin of one of the oxen killed on this occasion. A new *tukl* was built over the grave, and one or two other huts put up within the enclosure for the attendants on the new shrine which had thus arisen.

No mention is made in this account of any public announcement of the king's death, and all my informants agreed that none was ever made, but it was said that the news would spread gradually, and I have little doubt that this is what actually happened. It has already been stated that it was impossible to obtain information as to who actually killed the king, nor could I determine under what circumstances, or by whom, the king was brought to his birthplace, where his grave shrine would be erected.

During the interregnum which always occurs after the death of a *ret* the strongest chiefs (*bwong*) decide all comparatively small matters, great affairs standing over until the appointment of a new king, who is chosen by the most powerful chiefs. According to one account the matter lies in the hands of not more than eight or ten men, none of whom are *Ororo*. I am uncertain whether there is any feeling that their choice is inspired, probably not, for the object called "Nyakang" might indicate that the wrong man had been chosen, while, according to another account, the behaviour of one of the animals sacrificed before the tomb of Nyakang at Fashoda might point in the same direction.[2]

Installation of king-elect

One of the *bwong* takes the king-elect to a village called Akwach where they are joined by the other *bwong*, and all go to Kwom, a small village near Fashoda, where they stop until the return of two or three *bwong* who go as messengers to Akurwa near the northern limit of the Shilluk country. These men bid the Akurwa people to bring the sacred four-legged stool from the shrine of Nyakang in their village, and also an object called "Nyakang," which is kept wrapped in a piece of *dammur*, *i.e.* the common cotton cloth of the Sudan. "Nyakang" and the sacred stool are carried southwards towards Fashoda; each night "Nyakang" is placed upon the sacred stool, but by day these objects are borne upon men's shoulders who, as they march, sing songs that Nyakang has commanded them to sing.[3] The party bearing the sacred objects may seize anything they like on the way, but it seems that their wants are so freely provided for in the villages they pass that they scarcely exercise their prerogative. My informants from the neighbourhood of Fashoda said that "Nyakang" was more or less cylindrical in shape and 2 to 3 feet long, by, perhaps, 6 inches broad, but they admitted they knew little about it, saying that if anyone not of Akurwa looked at it steadily he would become blind. If Nyakang should not approve of the newly selected *ret*, the object "Nyakang" becomes so heavy that it cannot be removed from the shrine; it is also said that were the king-elect to die, the men who enter the shrine to bring forth "Nyakang" would not be able to see it, so that they would think it was no longer there.

[1] According to one account it was only after swarms of flies had been seen to emerge between the top of the clay wall of the hut and the thatch that the hut was opened.

[2] Father Hofmeyer (*op. cit. p.* 333) records the following:—As many small stones are thrown into the fire as there are candidates, each stone is given a name and he becomes king whose stone remains after the others have burst out of the fire.

[3] Nyakang appears in a dream to one of the guardians of his shrine at Akurwa and tells him which songs are to be sung. It will probably be found that songs played an important part in the tribal lore of the Shilluk. My notes (unchecked) indicate that there is a sort of tribal epic commemorating the great deeds of the royal family.

There is a shallow, generally dry, *khor* near Kwom, the village in which the king-elect and *bweng* await the coming of the Akurwa men. This is the scene of a sham fight with dura stalks between the Akurwa men bringing "Nyakang" and the folk waiting with the newly-elected *ret*, in which the former are victorious. No reason could be given for this "old custom," as it was called, but immediately after it the Akurwa people escort the king-elect to Fashoda. Certain of the Akurwa men now enter the shrine with the stool, and, after a short time, come out and place it on the ground outside the entrance to the shrine enclosure; they now place "Nyakang" on the stool, the king-elect holding one leg of the stool while an important *bweng* holds another. Near him stand two of his paternal aunts and two of his sisters, while he is surrounded by a crowd of *niäret*, *nïaret*, *kwaniäret* and *Ororo*. The latter kill a bullock between the stool and the fence round the shrine, and they alone may eat its flesh. The Akurwa men now carry "Nyakang" into the shrine and the *Ororo* lift up the king-elect and place him on the stool, on which he remains seated for some time, I believe till sunset, when the *Ororo* escort the new king to three new huts specially built for him, and the Akurwa men take the sacred stool into the shrine. The king stays inside his hut, or perhaps inside his enclosure, for three days; on the fourth night the *Ororo* take the king quietly, almost stealthily, to his royal residence. Another bullock is killed and eaten by the *Ororo*, after which the new king appears publicly to his subjects. The three newly-built huts which were occupied by the king are broken up (perhaps by the *Ororo*) and their fragments thrown into the river.

I believe that the installation of a new *ret* generally takes place about the middle of the dry season. It was said that the Akurwa party and "Nyakang" stay at Fashoda for some time, till about the beginning of the rains. Before leaving Fashoda a bullock is sacrificed, and a sheep is killed before crossing any *khor* on the way back. On arriving at Akurwa four or five of the cattle given them by the *ret* are sacrificed, the bones being thrown into the river.

I have little doubt that the above account of the installation of a new king is substantially correct as far as it goes; it would be unreasonable to regard it as complete though I believe it contains at least an outline of those features of the ceremonial which connect the king-elect with Nyakang. It was from this point of view that I approached my informants, and the connection between the two would thus appear to them to be the object upon which I wished them to speak. I naturally followed up any side issues which appeared, but these were few and singularly barren. I make these remarks because I do not doubt that there was a great deal more ceremonial killing of cattle on the occasion of the installation of a king than my account indicates. This is borne out by a note from the official records, given me by Captain H. O'Sullivan, Governor of the Upper Nile Province, of a sacrifice held at Fashoda after the present *ret* had been brought there. The *ret* and a "large gathering of the tribe" proceeded to the enclosure in which stands the shrine of Nyakang; no one entered the enclosure, but a sheep was brought and its right ear cut off with one of the sacred spears that are kept within the shrine. The severed ear was placed in a bowl of water held by one of the servants of Nyakang (*barit bweng Nyakang*) and the water used to wash the blade of the sacred spear, after which the water was carried within the shrine. The onlookers then advanced and knelt on the ground, forming a series of lines round the shrine and its enclosure. A "sheikh" took one of the spears of Nyakang and drove it into the flank of a bullock, which "trotted leisurely away from the place where it was appointed to die. If it returned alone to this spot all would be well I was assured. If not the Mek's [king's] election was unpropitious, and the sheikhs might wish to deliberate afresh. . . . Exhausted with loss of blood he walked leisurely, with little persuasion, to the desired spot and there sank down." After this the *ret* drank *merissa* and a sheep was slaughtered at the door of the hut he entered, *i.e.* presumably his own *tukl*.

The Cult of Nyakang at his Cenotaph Shrines

It has already been stated that there are ten tombs of Nyakang (*kengo Nyakang*). Figs. 53 and 51 are views of two of the most celebrated of these, namely, those at Akurwa and Fenikang. The former consists of two huts, the latter of five. Shrines of Nyakang

The *kengo Nyakang* are looked after by certain men and old women who are called *barit bweng Nyakang*, literally, "servant of the chief Nyakang." The original *barit* were certain of the companions of Nyakang, who came with him to the Shilluk country, and their immediate descendants, and, as far as possible, the attendants at the shrines at the present time are their real or reputed descendants. Besides keeping the shrine scrupulously clean, the old men act as priests, killing the animals brought as sacrifices, sharing their flesh and taking their skins for themselves. They are also responsible for the disposal of the bones of the sacrifice, which they throw into the river.

The contents of the *kengo Nyakang* vary, but they always include certain sacred spears, which at Akurwa, and probably elsewhere, are not spoken of as *tong*, the ordinary word for spear, but are called *alodo*. At one time these spears were those used by Nyakang and his companions. It is, however, admitted that the originals have disappeared, and they are often said to have been carried off by raiding Dervishes during the Mahdia. The spears kept in the shrines at the present day are admittedly modern, and have all been presented by one or other of the Shilluk kings. When too many spears have accumulated some of the old ones may be given to the most important men in the village—the chief of Akurwa showed me a spear which he assured me had come from the shrine of Nyakang in his village. It was beautifully made, with a long and narrow dagger-shaped head, which measured nearly 50 cm. in length by 6 cm. in breadth, the maximum breadth being attained slightly below the blade, which sprang from a socket nearly 12 cm. long. Although no difficulty was made in allowing me to handle this spear, my suggestion to buy it was put aside with perfect civility, but without the least hesitation. It was said that this spear was presented to the shrine by the *ret* Kur, who was killed by the Dervishes. These spears are used to kill the sacrifices brought to the shrine. Contents of shrines

The other contents of the shrines appear to vary; the Akurwa shrine contains the "stool of Nyakang"[1] referred to in the description of the installation of a new *ret*, and also the object spoken of as "Nyakang." The nature of this latter does not appear to be known to the majority of Shilluk, but the chief (*bweng*) of Akurwa made no difficulty about telling me that this object was a piece of wood roughly carved into the shape of a human figure, and that it had been prepared long ago at the command of Nyakang himself. I could not discover that there was any idea that the spirit of Nyakang inhabited this figure or was particularly attached to it, and when I asked him whether this was the case, my question elicited an immediate and forcible negative.

The shrine of Nyakang at Fenikang consists of five *tukl*. One of these, seen to the left of the foreground in Fig. 51 (and also in Figs. 57 and 58), is in a special sense the house of The shrine at Fenikang

[1] The chief (*bweng*) of Akurwa said that his family are called *kwarinikwom*, *i.e.* "children of the stool," on account of their being the guardians of the sacred stool.

Nyakang which his spirit is thought to inhabit. It is distinguished by a number of paintings, very roughly executed on its outer wall. Rectangular black areas relieved with white spots are not uncommon on shrines, but this is the only one I have seen whose walls were extensively decorated, or which had on it drawings that could be recognised as representing animals. For this reason two photographs of this painting are reproduced in Figs. 55 and 56. I could not learn that the designs had any special significance, and considering the exposed position of the painting and the reasonably candid manner in which my questions concerning the sacred interior of the shrine were answered, I am inclined to believe that my informants were speaking the truth when they told me that the designs referred to nothing sacred and had no significance in the cult of Nyakang. Accounts differ as to whether his spirit is always in this hut or not; the most general and authoritative opinion appears to be that the spirit is always there. Before the door of this *tukl* are a number of elephant tusks, the broad ends of which are thrust into the ground (Fig. 57); within the *tukl* there are skins on the floor as if for Nyakang to rest upon.[1] Some of the "spears of Nyakang" appear to be kept in this *tukl*, and there is an extremely sacred stool in this shrine which, I believe, is also kept there, though it may perhaps be preserved with some of the sacred spears and a number of elephant tusks in the house without the ostrich egg and spear ornament on its roof, seen in the background of the photograph, Fig. 54. The *tukl* on the right in the foreground is used by the guardians of the shrine, and one of the houses at the back of this is a store house for threshing the dura brought to the shrine when the crops are cut.

One reason given by Fenikang men for the extreme sanctity of their shrine was that Nyakang actually founded their village and lived there for some time, and the name itself is but a corruption of *fa Nyakang* "the place of Nyakang."

Ceremonies performed at the *kengo Nyakang*

Two most important annual ceremonies are performed at the shrines of Nyakang:—

(i) The rain-making ceremony held before the rains at the beginning of the month *alabor*.[2]

(ii) The harvest festival held when the dura is cut; *i.e.* about the end of the rains.

Besides these there is a ceremony which takes place shortly after the accession of a new king, and sick folk may, and often do, send animals to be sacrificed at the *kengo Nyakang*.

The following very brief outlines of these ceremonies may be useful to future enquirers:—

The Rain Ceremony. A cow and a bullock are given to Nyakang, the latter being killed, while the former is added to the herd belonging to the shrine. Both should be given by the king who takes part in the ceremony at the Fashoda shrine. The bullock is slain by one of the guardians of the shrine (*barit bwng Nyakang*) before the door of the shrine enclosure with one of the sacred spears, the king standing near the beast shouting his prayer for rain to Nyakang and holding a spear pointing upwards in front of him. As much blood as possible is collected in a gourd and thrown into the river, and the same is done with the bones after the meat has been eaten by all the *barīt bwng Nyakang*, the skin of the beast being made into a mat for the *tukl* devoted to Nyakang. Much of the dura preserved in the shrine since the beginning of the last harvest is used in making the *merissa* which is drunk at this ceremony. My Fenikang informants told me that the

[1] It is difficult to indicate the strong feeling of the real presence of Nyakang which I am convinced my informants had without being unduly anthropomorphic. In spite of the objects kept in this shrine and fit only for the use of a creature with a human body, to the priests of the shrine, Nyakang, although the founder of their nation, is now a purely spiritual being.

[2] The Shilluk calendar is lunar, hence this ceremony takes place about the time of a new moon.

king should himself come to their village for this ceremony, and the above short description is mainly from notes made at Fenikang. But whatever the theory, the usual practice at the present time is for the king to send the animals given to Nyakang to the shrines, and for the head of the *barit bwng Nyakang* to pray for rain as they are sacrificed.

I am indebted to Yang Jok, one of the most important of the Shilluk chiefs and head of the whole Nyalwal district (in which Tonga is situated), for the following account of the rain ceremony as it is held at Ashop, where stands one of the *kengo Nyakang*. A bullock or bull and a hen are killed before the shrine of Nyakang, each animal being killed by one of the *barit bwng Nyakang*. Before the ceremony the ground within the shrine enclosure and that outside the fence is swept clean by a number of old women. Drums are placed in the open space near the centre of the village and men and women dance vigorously, first holding spears and other weapons, then raising their hands, singing and praising Nyakang. If there is a tree in the open space the sacrificial bullock is tied to it. At the end of the dance the chief of the district pours water, recently brought from the river, into the hollow of his hand and spits into it and sprinkles the bullock with this. The bullock is speared high up in the flank so that the wound is not immediately fatal and allowed to go free; if he wanders to or from the river it is a good sign, and if he falls on his left side, or goes towards the shrine of Nyakang it is good, but if he falls on his right side it is bad. In theory the bullock should go to the river and come back to die where he was speared, and it seemed that in practice little difficulty was experienced by the clever Shilluk herdsmen in guiding the victim in the right direction. The beast is skinned and cut up where it falls, and the flesh is boiled and eaten by all, except by (i) puerperal women and their husbands and (ii) men or women who have had intercourse during the previous night. Care is taken not to break the bones which, with all fragments, are thrown into the river. The head, one forelimb and the bowels compose the share of the attendants of the shrine who cook and eat their portions with the rest of the community. The skin is prepared and used as a mat in the *tukl* of Nyakang, where the sacred spear is kept with which the sacrificial animals are killed.

The Harvest Festival. It is usual to bring ears of ripening dura and to thrust them into the thatch of certain of the shrine *tukl*, I believe specially of the hut in which the senior guardian lives. When the dura is cut everyone brings a portion to the *barit bwng Nyakang*. This is ground and made into porridge with water brought from the river. Some is poured out at the threshold of the hut which is specially reserved for Nyakang, and some on the ground within the hut, the outside of which is also anointed with the mixture. Until this has been done no one may eat of the new crop.

Ceremony on the accession of the king. The new king should send cattle to each *kengo Nyakang*, and also presents of spears and other valuable objects such as ostrich eggs and elephant tusks. Some of the beasts would be sacrificed outside the enclosure, others would be passed into the herd belonging to the shrine. I have no information concerning the details of this ceremony.

Ceremony to benefit a sick man. When a man is sick he may bring, or send, a sheep to the nearest shrine of Nyakang, where the attendants sprinkle it with water and spear it. They pray for the sick man, who eats a part of the flesh of the sheep or drinks some of the water in which the meat has been boiled. The rest of the sheep is eaten by the guardians of the shrine and their friends without any ceremony, but the bones and dirt are thrown into the river.

The Cult of the Shilluk Kings at their Grave Shrines

I have already pointed out that the tomb shrines of the Shilluk kings are scarcely to be distinguished from the so-called "tombs" of Nyakang, and a brief account of the guardians of the tombs of the Shilluk kings and the ceremonies that take place at their shrines will further show that the two cults are identical in form and feeling, and vary only in matters of detail, due, apparently, to the supremely sacred quality of the shrines of Nyakang. The grave shrines of the kings are tended by certain old men or women who correspond to the *barit bwoŋ Nyakang*. The guardians may be old women, widows of the dead king, old men who were his servants during his lifetime, or their descendants when they had reached the requisite age, or as a last resource when none of these could be found, old women or old men not especially connected with the dead king.[1] Just as no one except the *barit bwoŋ Nyakang* are allowed to enter the *tukl* in which Nyakang is supposed to be present, so no stranger may enter the grave *tukl* of the kings.

The guardians of the royal graves

Mrs. Seligmann was told that any sister of the king may enter his grave *tukl* and rub her hands on its floor for a blessing whenever she likes, though his brothers may not do this, but a royal daughter may enter the grave *tukl* of her father and obtain a blessing in this way. In spite of these privileges, women of the royal blood may not enter the shrines, or even the enclosed space round the shrines, of other dead kings. Should the spirit of one of these come to a royal daughter or sister in a dream and demand an offering, she takes a sheep to the guardians of the tomb and gives it to one of them to sacrifice, as if she were a commoner. There are cattle belonging to the grave shrines of the kings, and offerings are made in the same way as at the shrines of Nyakang. Thus, when the dura crop threatens to fail, or an epidemic sickness to come upon the cattle, Nyakang, or one of his successors, will appear to someone in a dream and demand a sacrifice. This is told to the king, who will immediately send a cow and a bullock to one or more of the shrines of Nyakang if he had appeared, or to the grave shrine of the appropriate king if the dreamer had seen one of the Shilluk kings. The bullock would be killed, and the cow added to the herd belonging to the shrine.

It is usual for the harvest ceremony (already alluded to on *page* 227) to be performed at the royal grave shrines as well as at the shrines of Nyakang, though it is recognised that this is not absolutely necessary. Again, each king soon after his installation sends, or should send, presents to the grave shrines of his predecessors, treating these in the same way as he treated the shrines of Nyakang, though the presents need not be so lavish. Finally, sick folk send animals to be sacrificed as offerings at the shrines of their kings just as they do to the shrines of Nyakang.

The Royal village

Although Fashoda has certainly been the royal village (*fa ret*, literally, the place of the king) from which the king has ruled the Shilluk for the last few decades and may have been the *fa ret* before that, there is evidence that it has not always been the home of the ruling sovereign. Unfortunately, I did not make special enquiries as to this, but according to tradition, Fenikang was the village of Nyakang and of his immediate successors, and Dr. T. A. Lambie of the American Mission has independently come to the conclusion that the first seven kings lived here or at Tatuga (Doleib Hill). Nyadwai, as already stated, lived at Kodok and was buried there. Dr. Lambie speaks of Wawk, the second king after Nyadwai, reigning at Apio village, near Tatuga, but on the other side of the Sobat River, and he further refers to two other kings whom he speaks of as the twelfth and thirteenth

[1] Daughters of the king never become guardians of his grave shrine.

from Nyakang as founding Warajok and Malakal villages respectively. Doubtless Wawk is identical with Wag, the son of Nyadwai, the thirteenth king in the Genealogy on *page* 218. I cannot identify the other two kings with any certainty, but one of them, Nikang or Nyakong, alleged to have founded Malakal, may have immediately preceded or succeeded Okon.

Thus the Shilluk kings had different capitals, and we have seen that they were born in different villages, that, as among the Shilluk generally, the royal after-birth was buried in the courtyard of the house in which the royal child was born, and that each king was buried in the village in which he was born and brought up. Considering all these facts it is reasonable to suppose that in the old days each king ruled the country from the village in which he was born and brought up, so that this village became the capital of the country, but remained so only during his lifetime.[1]

Reverence for Trees

Trees near royal grave shrines revered

Special regard is paid to trees that grow near the shrines of dead kings. This is not remarkable, for the Shilluk territory is in the main bare and there are few shade trees, so that any tree growing in or on the outskirts of a village is preserved and the ground beneath it becomes to some extent a meeting and squatting place. But the Shilluk attitude to trees growing near the grave shrines of their kings appears to be something more than an appreciation of the grateful shade they cast, though there is no regular cult. In a few cases in which trees have grown, or are believed to have grown, near the shrine shortly after its erection, *i.e.* within a few months or years after the burial of a "divine king," it is believed that the tree has sprung from one of the logs of wood forming the bottom or sides of the grave, and in these cases the connection between the tree and the dead king is one that would easily suggest itself. In the case of an old tree at Kodok, which grew near the grave of Nyadwai, a "big" sacrifice was made when it fell down, and its trunk and all its fragments were carefully thrown into the river. I could not discover that this was supposed to produce rain or to influence the crops in any way, but it was said if anyone burnt any of the wood of this tree, even accidentally, he would sicken. In connection with this I may refer to the fact that the bones of certain sacrifices are carefully gathered together and disposed of in the same way. There is now no *tukl* over the grave of Nyadwai, but the grave has a fence round it, and a young tree that has appeared a few yards from the stump of the old tree is regarded with considerable interest by the Shilluk. Unfortunately the grave is situated some little distance from the present native village and is surrounded by Government offices and houses. This tree did not spring from the grave of Nyadwai, since, on cross examination, it was admitted by the best informed of the Shilluk that during his lifetime it stood near his house and that he would often sit under it; nevertheless, there is a general feeling that it is associated with his grave, which is so strong that many Shilluk at one time or another spoke of Nyadwai being buried under the tree, though his grave must be nearly a hundred yards away. The photograph reproduced in Fig. 59, shows the relative position of the grave, the tree stump and the young tree.

It must be remembered that the due growth of the crops, *i.e.* of the most important part of the vegetable world, depends on the well-being of the divine king, so that there

[1] If this conclusion be adopted, it does away with any difficulty in accepting the account of the death of the king given on *page* 222, for if the special *tukl* in which the king is strangled or left to die is in the royal village, there would be no difficulty in conveying the king thither so quietly that few would know of his death until some time had elapsed. Since writing the above I have received definite information from Father Banholzer to the effect that formerly each Shilluk king reigned and was buried in his native village. Tugo is said to have been the first king who lived at Fashoda; whether this is correct or not, Fashoda certainly was not the *fa ret* of all the kings who succeeded him, though many of them, *e.g.* Nyadwai and Yur Adodit, ruled the country from villages in the neighbourhood of Fashoda.

is nothing surprising in there being a strong, almost religious, feeling for any tree growing near a shrine.

The Appearance of the Shilluk Kings in Animal Form

Assumption of animal forms by the Shilluk kings

Dead kings may assume the form of certain animals; Yur Adodit always takes that of an insect called *akwan* (in Arabic *gamal en nebi*), which appears to be the larval form of one of the *Mantidæ*. I only discovered this important belief by the fortunate accident of an *akwan* settling upon my camera while I was making enquiries near the grave shrine of Yur Adodit, which was being repaired. I was about to examine the insect when I was asked not to touch it by the *bwong* Chol whom I had been questioning. The *bwong*, with his face showing the greatest pleasure, took the insect in his hands and reverentially carried it to the shrine, only the base of which had been built up, and deposited it on a leafy branch which was thrust into the ground in the centre of the shrine, *i.e.* over the grave of Yur Adodit. Chol told me that the appearance of Yur Adodit in his animal form showed that he was favourably disposed to me, and was not displeased at my enquiries concerning the shrine, and after this incident it was distinctly easier to obtain information from Chol and his people.

Nyakang, Dag and Nyadwai all appear as a white bird called *okak* (in Sudanese Arabic *rekoiya*), or sometimes as a giraffe, though I gathered that this was very unusual. If a giraffe came straight towards the village in which the shrine stood, exhibiting no sign of fear, it would be concluded that it was a spirit-animal, and the attendants at the tomb would sacrifice a sheep or perhaps even a bullock. Father Banholzer adds "long-bodied grasshoppers" and "a kind of snake called *red*" as forms in which Nyakang appears.

I am indebted to Dr. Lambie for pointing out that unusual behaviour on the part of almost any land animal will lead the Shilluk to look upon the creature as a temporary incarnation of Nyakang. Thus, "if a little bird flies into the midst of a crowd of people and is not frightened, or attracts someone's notice in a special manner they say 'Nyakang.'" Dr. Lambie adds that unusual behaviour on the part of a water animal will be put down to the animal containing the spirit of Nikaiya (Nyakai). Occasionally Nyakang would appear as a bull. A very old Shilluk of the royal family told Dr. Lambie that when he was a youth, fifty or more years ago, Nyakang appeared as a white bull. Dr. Lambie's informant was sent to tell the king, who ordered sacrifices to be made in addition to those already offered by the local chief.

Respect shown to crocodile

I may here refer to the Shilluk attitude towards the crocodile; this animal is generally spared, as some of the worst man-eaters are believed to be men whom other crocodiles have taken, and very dark coloured crocodiles are supposed to be either men-crocodiles or their descendants. Further, there is a firm belief in the crocodilian attributes of the ancestors of Nyakang recorded upon *page* 219. Nikaiya (Nik-kieya, *page* 219) is still definitely associated with the crocodile, for she lives in the river, and though in old days she would assume human form and at times come to the village by night in all friendliness, she might seize a man or woman and bear him or her off to her home in the river guarded by *okok* fishes, and there change her victim into a crocodile to be a spouse to one of her crocodile relatives. Nyakai brings luck to those whom she visits by night to ask for fire; if a barren woman bears a child after such a visit it will be called Nyakai, and the father will take a sheep and kill it and throw it in the river. Nyakai is known by her short, stout figure and great muscular development, and by the fact that she "eats" (mouths) her words. That the river is the true home of Nyakai, even in her most spiritual form, is shown by the sacrifice made to her on another occasion. It has been mentioned that a sacrifice would be made at the shrine of Nyakang, or at the grave shrine of any king, if Nyakang or one of the Shilluk kings had appeared in a dream, or if one of the kings had possessed a man, causing him to become ill. When Nyakai takes up her abode in a man or woman the sacrifice is made by throwing a live sheep with its legs tied together into the river.

Food taboos

The Shilluk do not eat the flesh of the lion, leopard, hyaena, a species of monitor lizard (*Varanus*) and a fish called *shuro*. The latter prohibition is directly attributed to Nyakang, who told his people to bring him all the fish they caught in the river. Although they brought him many fish they kept back one and Nyakang, who saw this and knew it, as in a dream men see and know things happening at a great distance, told his people that this fish should always be unlawful food to them.

Concluding Remarks

In the foregoing account of the Shilluk cult of Nyakang and of his "divine" successors, certain assumptions have been tacitly accepted, just as they were by my informants. The most important of these could probably be deduced from what I have written, but to avoid misapprehension it seems well to state these and to give other examples of the conceptions upon which they are based.

Immanence of Nyakang in the Shilluk kings

The fundamental idea of the cult of the Shilluk divine kings is the immanence in each of the spirit of Nyakang. It is obvious that this is not congenital, for not only is there nothing at birth to show that any given member of the royal house will be king, but the ceremony described on *pages* 220 and 221 can scarcely have any other object than the transmission of the spirit of Nyakang to his successor, for there can be little doubt that the spirit of Nyakang is also thought to be immanent in the object called "Nyakang," which plays such an important part in the installation of the new king. It must be assumed, therefore, that the spirits of dead kings can be immanent in more than one person or object at one and the same time. There is no doubt that this assumption is correct, and this is borne out by a number of beliefs which have no direct connection with that aspect of the cult of divine kings with which I have so far dealt.

Ajuago

Certain men called *ajuago* have immanent in them the spirits of the early Shilluk kings, and these men have the power of healing the sick. They also do a brisk trade in charms—generally fragments of wood or bone, such as avert the evil eye (*ynop*)—and might be consulted by women who desired to miscarry. The guardians of the shrine of Nyakang might or might not be *ajuago*, they do not become *ajuago* because of their connection with the shrine, nor does their being *ajuago* alter their official position. According to my most reliable informant only the spirits of Nyakang, Dag and Bwoch (the first, second and fifth of the Shilluk kings) become immanent in men to make them *ajuago*. When a man first becomes *ajuago* he becomes ill, perhaps waking up trembling and agitated from a dream (in which he may afterwards say the spirit came to him). He consults an *ajuago* who may tell him "No, you are not ill, you have the spirit of Dag within you." A long and complicated ceremony is then performed in order that the spirit may not affect him so severely, for without this ceremony the spirit would be so strong in his body that he would not dare to approach his women. I could not discover with certainty the exact nature of the change effected by the ceremony, but it seemed to me that my informant, one Akon Achol, who had in him the spirit of Dag, considered that after the ceremony, the spirit which had previously attacked his body in the rudest fashion, became attached rather to his spirit or soul.

One ancestral spirit may be immanent in many *ajuago* at the same time, often passing at the death of an *ajuago*, or shortly afterwards, into one of his children, who thus becomes an *ajuago* like his or her father.

It was said that *ajuago* of the female sex should not marry if they were unmarried at the time that the spirit came to them; they would be allowed to take lovers, but, like the kings' daughters, they should not bear children. But I believe that women very seldom became *ajuago* in their youth, and it is certain that married women who are *ajuago* do not leave their husbands, and continue to bear children. The following information on this matter was volunteered by the *kwaniäret* Chol, one of the most reliable of informants. The husbands of women who are *ajuago* have access to their wives only during the dark half of the month for "Nyakang and Dag only come during that half of the month when the moon is bright." Unfortunately, I did not have the opportunity of following up this information or even of verifying it.

Sickness due to possession

Probably the commonest cause of sickness was the entrance into the body of the spirit of one of the divine kings, a cure being effected when the spirit could be persuaded to leave its involuntary host. I believe that only the early kings were thought to produce illness in this manner, and certainly three or four cases into which I enquired were all possessed by Dag. One of these cases, a woman, who recovered after two sheep had been sacrificed to Dag, wore bead anklets, and amidst the beads there were threaded small pieces of the concha of the ears of the goats. These anklets were considered protective against future possession by Dag.

A few days later we met a *bang* who had been badly treated and imprisoned by the king. On his release his friends brought him beads, sheep were killed, and he now wears the beads and pieces of the ears of the sheep in exactly the same manner as the woman who had recovered from sickness, the result of possession by the spirit of Dag, the second Shilluk king.

All these facts indicate the close similarity between the cults of Nyakang and that of his successors the Shilluk kings, and the likeness that exists between the shrines raised over the graves of the kings and the "tombs of Nyakang," as well as the similarity in the ceremonies performed, merely serve to emphasise the identity of the "divine" kings and their semi-divine ancestor. It is even certain that, in the minds of many of the Shilluk, the spirits of Nyakang and his successors are considered as identical, that is to say, the spirits of his successors, although worshipped each at his own shrine, are recognised as being manifestations of the spirit of Nyakang. In proof of this I may adduce the following information, given by Chol at the end of a discussion on the shrines of the Shilluk kings, that whatever king appeared in a dream it was really Nyakang who was communicating with the dreamer.

Importance of Shilluk beliefs from the comparative standpoint

Finally, I may be permitted to draw attention to the importance, from the comparative standpoint, of the ceremony by which the spirit of Nyakang is transmitted in turn to each of the Shilluk kings. Among all the instances of the killing of "divine" kings collected by Dr. Frazer, there is none—as Dr. Frazer himself observes—in which there is proof that "the soul of the slain divinity is transmitted to his successor" (*Golden Bough*, 1900, II. 56), and upon this defect in the chain of evidence Professor Westermarck has based his criticism that it is not really the soul of the divine king that is transmitted, but only his holiness (*Man*, 1908. 9). The Shilluk custom seems to supply the missing link, and to justify us in holding to the explanation advanced by Dr. Frazer in those African instances in which it cannot be proved or shown with a high degree of probability that it is only the king's holiness (*baraka*, in Professor Westermarck's convincing example from Morocco) that is transmitted to the new sovereign.

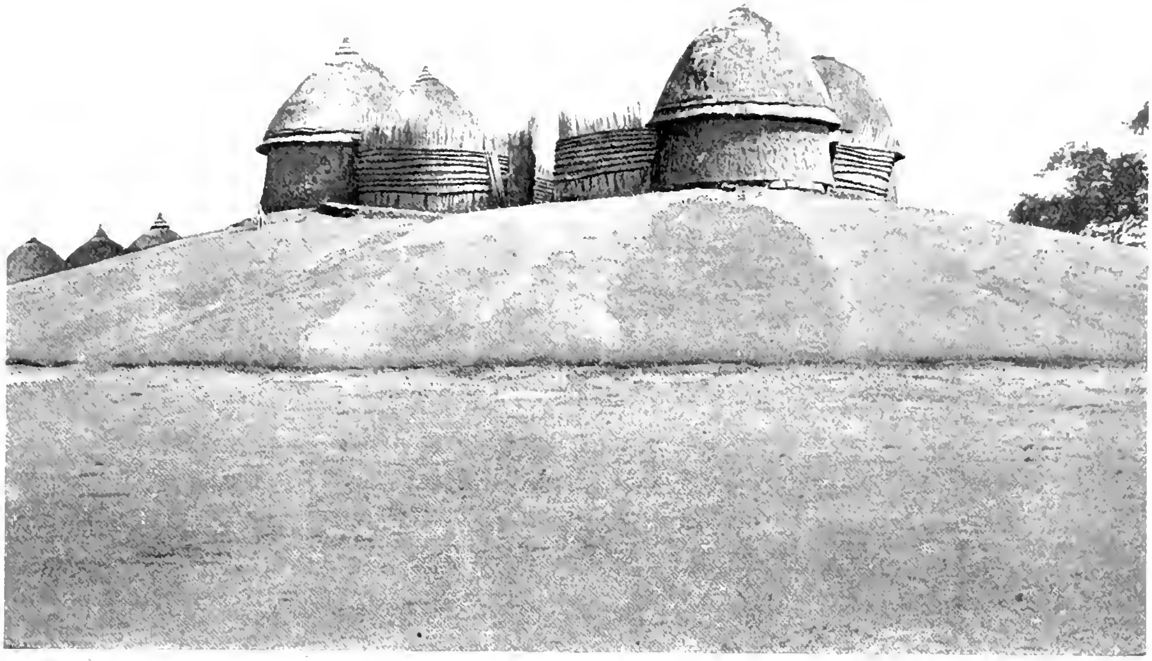


FIG. 49.—DWELLING OF SHILLUK KING, FASHODA

FIG. 50.—SHILLUK VILLAGE NEAR FASHODA

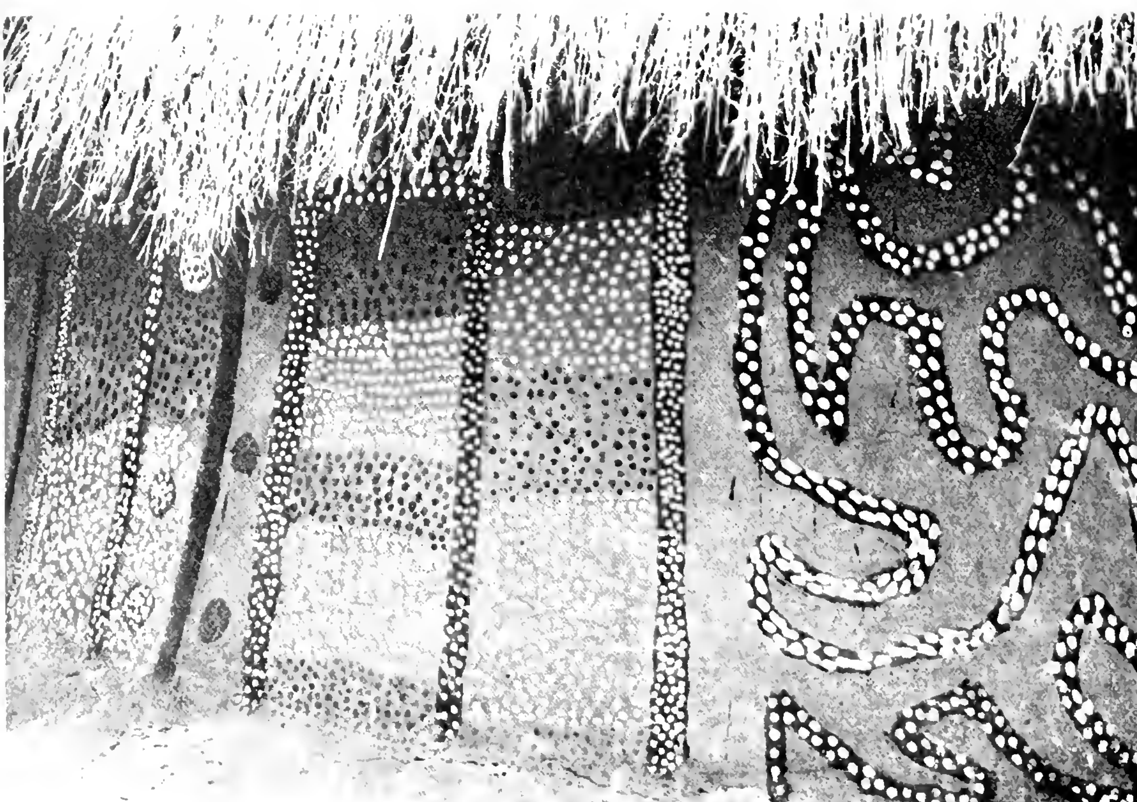
FIG. 31. TOMB SHRINE OF SHILLUK KING NEAR FASHODA

[illegible]—TOMB SHRINE OF SHILLUK KING IN VILLAGE NEAR FASHODA

FIG. 53. SHRINE OF NYAKANG AT AKURWA

FIG. 54. SHRINE OF NYAKANG AT FENIKANG

FI[illegible] 75. PAIN[illegible] NY[illegible]IN[illegible] A[illegible] F[illegible]



[illegible]—PAINTING [illegible] N[illegible] NYABANG[illegible] A[illegible] BEN[illegible]

FIG. 57.—[illegible] OF NYAKANG AT FENIKANG, SHOWING ELEPHANT TUSKS BEFORE TH[illegible]

FIG. 58.—PART OF [illegible] NYAKANG AT FENIKANG

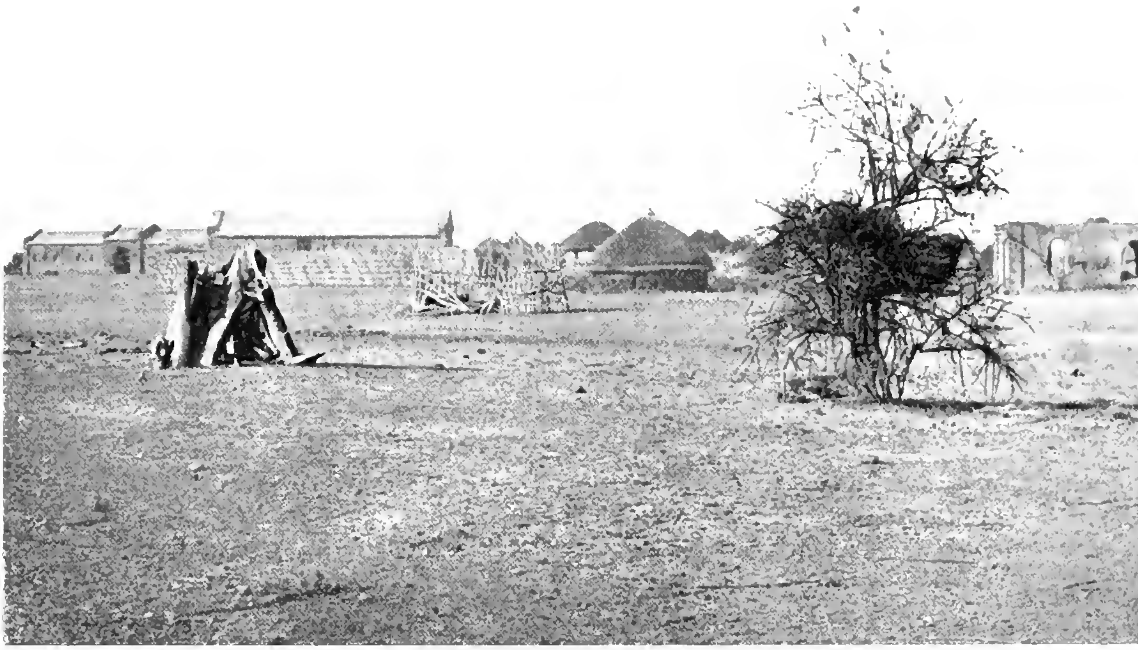


FIG. 59. TEM[illegible] NYA[illegible] [illegible] GRAVE [illegible] K[illegible]

[illegible] 60.—GRAVE [illegible] YUR ADO[illegible] [illegible]EW [illegible] BUI[illegible]

Some Tribal Customs in their Relation to Medicine and Morals of the Nyam-nyam and Gour People inhabiting the Eastern Bahr-El-Ghazal

BY

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Attached Egyptian Army

Introduction

In compiling this article I have been at some pains to limit its scope so far as possible to the medical customs, superstitions and other matters relative to medicine, in its broader sense, of the savage people dealt with. I have found it, however, impossible to dissociate these customs entirely from others of a general nature, and this more especially since medical and surgical practices in these latitudes form as yet no exact science, and merge imperceptibly with the religious, social and moral usages of the community. The difficulty, too, of interpretation (very often through two or more languages) in a country where local dialects abound has rendered my information far from accurate, thorough, or comprehensive.

It had been at first my intention to include the medical practices of the Dinkas amongst these notes; this idea, however, I have abandoned, since it would, I feel, only complicate and lengthen my subject unduly by the addition of material which has already been dealt with, far more ably than I could hope to do, by Major S. Lyle Cummins, R.A.M.C. (late E.A.), in a paper on the "Sub-tribes of the Bahr-El-Ghazal Dinkas" (*Journal of the Royal Anthropological Institute*, January, 1904).

Tribal Distribution

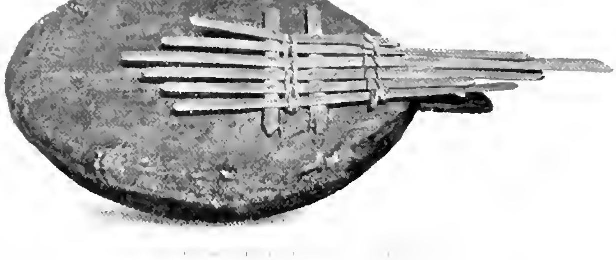
Before entering on the subject matter of the paper it will be as well, in the first place, to outline briefly the various more important divisions and sub-divisions of the two main tribes dealt with, the Nyam-nyam and the Gours (commonly mis-spelt and pronounced Jurs), amongst each of whom prevail customs, sometimes peculiar to the tribe or to a sub-tribe, sometimes slightly diverse, though often nearly universal and differing in no essential between the two peoples. This close similarity of customs and superstitions not only amongst adjacent tribes, but often arising independently between savage races widely separate in type and locality, is of great interest.

Similarity in customs between widely separated tribes

The Nyam-nyam People

The origin and present constitution of the Nyam-nyam race is very instructive: it may be outlined as follows:—

The Avungara, a tribe raiding from the south-west, conquered and coalesced with their kindred, the Zandeh (the Azandeh of Belgian territory), over whom they took precedence, constituting themselves the royal house of the tribe. These two then combined against the closely-connected Amiemba and Abangbinda, conquering and coalescing with them under the cognomen Zandeh. Still advancing north commanded by the warlike Sultan Yambio and his eldest son, the present Sultan Mange this



quartette of bronze-skinned, high-caste peoples, forced in succession the pronouncedly negroid Bagaro, Bakka, Mundu, Morro, Makrakka and Avokia, who are designated under the common heading Gebelawi (tribes from the neighbourhood of the Bahr-el-Gebel), to submit, enslaving and not admitting them to a general equality in the coalition.

Origin of the name "Nyam-nyam"

The "Turks" (Galaba, Arab traders) who entered the country during the early days of its first conquest by Egypt (and therefore long anterior to these Zandeh raiders), paying little heed to distinctions of tribe, had named all the savages of the district "Nyam-nyam," an onomatopæic word suggesting the smacking of lips, and reminiscent of their cannibal habits and rapacity for food of any description (*vide* Diet). This name has persisted as that of the polygenous race under discussion, amongst whom the "royal" Avungara are still isolated and uncontaminated. The Zandeh, too, whose language is now almost universal

throughout the Nyam-nyam, and who seem to have absorbed both the Amieumba and Abangbinda, are also comparatively pure. The negroid Gebelawi merge with both the Zandeh and Gour and are very intermingled, though differences in custom are still traceable between them.

For many of these details I am indebted to notes by Captain H. W. Channer, late Inspector, Eastern Bahr-El-Ghazal.

The accompanying table will show the tribal formation of the Nyam-nyam more plainly:

Avungara conquered the Zandeh and, combining with them, overcame the Amieumba and Abangbinda	Four kindred tribes which coalesced under the cognomen Zandeh, the Avungara persisting as the royal house	Zandeh	Nyam-nyam a name loosely applied by the "Turks," which has persisted
Bagaro Bakka Mundu Morro Makrakka Avokia	Conquered in succession and classed, under the common name of Gebelawi, as serfs of the Zandeh	Gebelawi	

NOTE.—I have not even touched on the further sub-divisions, such as Bakka into Bobyma, Bokum, Bobundili, etc., which are endless and irrelevant.

THE GOUR PEOPLE

As regards the Gours I need only enumerate their chief sub-divisions which, though closely allied by race, almost invariably possess (like the neighbouring Nuba tribes of Kordofan) distinct dialects, usually unintelligible to their adjacent kindred. The close connection between the Gours and Gebelawi (Nyam-nyam) will be seen from the partition of the Mundu and Morro between them. These two tribes are also intimately associated with the Kederu people, and the Kederu with the Dinkas to whom they bear a strong resemblance.

Such commingling of tribes and races at the limits of their extent is indeed only natural and will account, to a large degree, for the similarity of customs and superstitions existing between them.

The most important Gour sub-tribes are the Morro and Mundu or Mundari (common to both Gour and Nyam-nyam). The:—

Ungori	Kermo	Bulomaza
Gabouro	Rigno	Girra
Bitou	Burnio	Aingara
Bouti	Umbia	Lali
Barri	Billi	Numori
Kiddu	Moukia	

NOTE.—For many of the details of the above list I am indebted to El Mul Awal Zaki Effendi, late Mamur of M'volo.

CHARACTER AND TYPE

The next point which requires some consideration in order to appreciate the origin and purpose of medical and other customs amongst these people is a character in which profound superstition (as a basis of their religion), animalism and non-morality blend in a mind of very low type, and are often further complicated by the inroad of civilisation and Islamism.

Matters that do not affect him personally and which he cannot grasp, the savage lightly passes without a thought, as natural phenomena beyond explanation, among which are numbered gramophones, cameras, guns, field-glasses and the like. He is inquisitive, incredulous and distrusting to a degree, however, where his own person is concerned.

The magical basis believed to underlie medical procedure

In medical treatment, therefore (beyond the usual "dopeing" to which he is accustomed), he suspects always an ulterior motive, drugs (pills and tabloids in particular) are minutely mysterious applications suggestive of magic. Blood examinations and the like are for the purpose of casting a spell or working a "Sahar" on his person through the essential medium obtained. The stethoscope conveys the conversations of conflicting devils within his interior. The hypodermic syringe, with its potent dose, must needs transmit a spirit (probably evil) to his body. A surgical operation with its lethal sleep, cruel instruments and strange "Dawa" (medicaments) means death, mutilation and resurrection in one. On recovering consciousness he strongly suspects not only a damnable inquisitiveness on the surgeon's part, but probably the removal of some vital organ, the loss of which he will detect and regret anon.

As regards the autopsy there is a panic of suspicion and superstition in the black man's mind, so much so that in dealing with the Zandeh at Meridi I found it highly inadvisable to attempt one. They suspect interference with the deceased in his after-life, a probing into the "beyond," cannibalism and I know not what. Such is, indeed, not to be wondered at, and only shows how difficult modern medical treatment must remain amongst these people. The fear of trifling with the dead is very universal. In trying

Fear of trifling with the dead associated with ancestor-worship

to obtain skulls as anthropological specimens I found great difficulty in the Bahr-El-Ghazal, and have since experienced the same with the Nubas of Southern Kordofan, purely on superstitious grounds, among people whose beliefs are so intimately connected with spirit and ancestor "worship."

From them I gather that recent ancestors are too well known to be respected. The more remote are quite forgotten, whilst the intermediate are most to be feared and fall within the sphere of "worship." Unfortunately, also, it is *their* heads that the anthropologist wants. Beyond the spirits of the dead are shadowy "gods," one or more supreme "Allahs" (Umbolic among the Nyam-nyam, Torro and Bolinbula among the Gours), mythical and receiving little attention. There is no such thing as real worship; sacrifices, rites and propitiations are addressed, as a rule, to the active factor in disease, death, famine and mishap, the Evil Spirit.

Civilisation and Mohammedanism

The infusion of crude civilisation and Mohammedanism by Arab traders and soldiers, along the main roads of commerce, has had a marked influence, not only from a religious but from a medical standpoint.

"Imitative" civilisation is better than none at all

The aping of the higher by the lower civilisation has resulted in the metamorphosis of the aboriginal into something perhaps a trifle ridiculous but certainly less savage. Such influence is, I think, on the whole, good—it is at any rate an advance.

An amusing case of the converse was that of an Egyptian soldier, entering the Bahr-El-Ghazal at the same time as myself, who, deeming it best to do as Rome did, expended much money on the local pagan charms, which he considered would have far more influence, beyond the limits of the Mohammedan world, than his old Koranic "hegabat."

Civilisation makes these people aware of their nakedness, and gives them rags to hide it, sometimes also such things as tarbushes and unwieldy boots (on one occasion a sun umbrella, purchased for a large tusk of ivory, value about £E 30, from a Greek trader). It gives them worthless money, alcohol, tobacco and hashish, both of which latter they cultivate. Contact with a *higher race*, for the first time, disturbs the conceit and self-satisfaction common to all savages. Finding themselves black they smear their faces with caustic juices in order to lighten their colour, and scratch, scar, or cauterise "shiluk" (tribal marks) on their cheeks in the most approved Arab style.

The new *religion*, whether actively professed or not, produces what one may term an *unconscious conversion* (often merely the profession of faith), brought about by contact with Mohammedan Sudanese troops and Arab traders. There are no missionaries of any denomination in these parts.

Influence of Islam

They submit to being numbered among the circumcised, adopt many of the medical superstitions, charms and cures of the Mohammedan, and alter their names to those of Islam (no small matter when one considers the importance attached to names amongst savages).[1] This religion gives them, too, a single God and the simplest creed, at the same time interfering in no way with their routine occupations, or with the number of their wives. The last is, I consider, the most important determining factor in the rapid spread of Islam, rather than of Christianity, throughout Central Africa (*vide Proceedings of the Missionary Conference*, London, June, 1910), and naturally so, since the surplus of female over male is very large, under which circumstances I consider polygamy must, as it should, obtain amongst an unsophisticated people.

[1] *Vide The Truth about Totism*, by Andrew Lang

Morality

As "moral," it is usual to consider whatever existing conventions account "correct." The standard of morality varies widely, therefore, according to place and period, and has been wittily described as "merely a matter of latitude." Towards the Equator it is, as might be expected, virtually at nought.

These people are, as I have said, "non-moral" rather than immoral, ignorant not innocent. Those that look upon them as simply unsophisticated and only corrupted by civilisation, are vastly mistaken. (A glance at any Sudanese regiment recruited from these regions will prove this.)

Vice has no place in their vocabulary, and crime does not exist for them until it is found out. Their "Moral Code"[1] is merely one to regulate possession and check violence towards the possessor and possessed. The savage's laziness being extreme and his affection limited apparently almost entirely to his children, his ambition is to exist in a state of married indolence, raise a family (the female children being valuable assets), and amass what little comes his way. Winwood Reade[2] paints him thus in a few words:—"He basks all day in the sunshine. . . . When the meat-hunger comes upon him he takes up bow and arrow for a few days and goes into the bush. His life is one long torpor with spasms of activity. Century follows century, but he does not change." Nor will he change as long as he has enough to eat. Stress of civilisation alone can raise him from such a rut.

Primitive moral sanctions

Punishment

As regards morality, however, it is the punishment rather than the crime, that interests us more directly from a medical standpoint and this chiefly among the Nyam-nyam, whose methods of mutilation and execution are very drastic. With the Gours, mutilation is said not to exist and crime to be lightly punished; they are a happy and effeminate people.

Mutilation.[3] Ungna-dro-baso (*Zandeh*)

A practice confined almost entirely to the cannibal Nyam-nyam with whom it must have been very prevalent before the present Government's days. I imagine, too, that many of the so-called Belgian-Congo atrocities were due more to carelessness and inadequate supervision, on the part of the authorities, over a brutal and licentious savagery than to any gross inhumanity on their own part.

The Zandeh, Bagaro, Avokia, Mundu and Bakka were apparently the chief offenders, while neither the Gours, Dinkas or Shilluks resorted to it as far as I can gather.

It was meted out for the following crimes:

Crimes punished by mutilation

- (*a*) Adultery and Rape. (As amongst most savage people, Dinkas, Nubas, etc., the woman being held irresponsible.)
- (*b*) Intrigue against the life or property of a chief.
- (*c*) Refusal to obey a tribal call to arms.
- (*d*) Cowardice in front of an enemy.
- (*e*) Neglecting to pay tribute of meat or corn to a chief.

A sultan is the only person who can authorise mutilation, but he leaves all details to the mutilator.

The usual routine was therefore for the wronged man, having gained his Sultan's

[1] For details of such a savage "Moral Code" as instanced by the unwritten laws of the people, I would refer to Captain H. O'Sullivan's "Dinka Customs and Laws," Appendix "D," *Sudan Annual Report*, 1907.

[2] *The Martyrdom of Man.*

[3] All mutilation has of course been entirely suppressed by the present Government.

consent in the first place, to consult the oracle or Benga (*vide page* 252). As soon as the answer was propitious, he gathered three or four others and proceeded with them to track down the offender, who, when caught, was placed with his back against a large tree trunk, his arms and legs being strained backwards, passed round its circumference and secured from behind, in this way the body lay well forward (*vide* Fig. 63). With one sweep of a knife the mutilator then removed the entire genitalia, next the upper lip, and then both ears in part or entirely (sometimes, they say, the poor wretch was blinded at the same time), finally both hands were severed through the wrist joints and with this the bonds slipped off and the victim fell forward on his face unconscious.

Method of mutilation

The pain, shock and loss of blood resulting from such fiendish torture, must have been so great, that it is hard to conceive how any could survive it, yet many have. I met several, and gathered these details from two who, however, cited ten instances of death resulting amongst cases they could recall by name.

These two men, Babinia, a Bagaro, and Tikma, a Zandeh (*vide* Figs. 64 and 65), were saved by friends who followed in the track of the mutilators, and dressing their wounds with wood-ash and green leaves, staunched the bleeding and carried them to the nearest village.[1]

Various modifications of this mutilation exist the ears, the lip or both being frequently spared. The hands and genitalia are, however, always removed in any such case, since it is rightly deemed that a man so treated would, were his hands spared, be a most desperate enemy.

Mutilation not necessarily discreditable

Mutilated men are looked upon with no disrespect by their fellows. They usually marry, as is the custom amongst well-to-do Mohammedan eunuchs, and, like them, are often given posts of responsibility for which they are particularly suited in the *ménage* of Sultans and important chiefs. One such, Bopora by name, I found holding such a position in Sultan Yango's household (*vide* Fig. 66).

These men have a peculiarly helpless, and, when the upper lip is removed, cringing and effeminate look which is far from pleasant. They become by practice very capable with their dismembered arms.

[1] Tikma appealed at the time to the late Major Boulnois (then Governor of the Bahr-El-Ghazal) and received compensation in the form of a wife who has since raised a family to him.

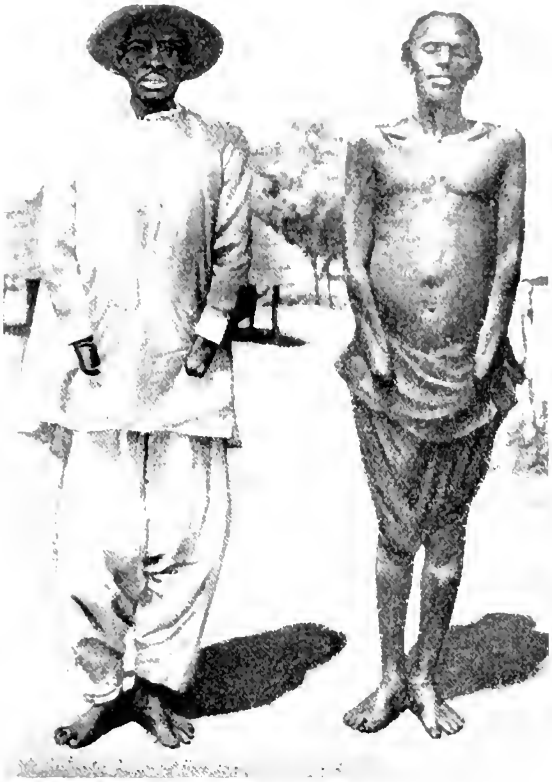


FIG. 64.—MUTILATION.
Tikma and Fabinia, two men mutilated by the Nyam nyam.

FIG. 65.—MUTILATION.
Tikma, a mutilated Zandeh. Note the loss of the upper [illegible] and the upper portion of the ear.

FIG. 66.—MUTILATION.
Sultan Yanei and some of his [illegible] [illegible] position of chief [illegible] the Sultan's [illegible] [illegible] Fabinia [illegible] mutilated [illegible]

Blinding. (*Zandeh*, Modi-Boglico)

This mutilation is carried out as follows: The victim having been firmly secured round the body and head against the trunk of a convenient tree—a sharp iron hook is attached by a length of thong to an adjacent sapling, which is strained back until the hook can be placed within the victim's orbit, when it is suddenly released each eye in succession being destroyed thus. Simple "poking out" of the eye, as in King Lear's case, may take the place of this more elaborate procedure. Blinding is inflicted for the punishment of crime, or to remove an evil eye. Several cases of the latter (two old women) are reported from amongst the people of a local chief near Meridi, who, like the late Khalifa, had a profound dread of this member. The hands are commonly removed as well as the eyes for the reasons given above, and as stated, sometimes emasculation is performed at the same time.

Blinding

Execution

Is usually the reward of simple offences against Sultans and high Chiefs, or for murder and manslaughter among their people. The methods employed are as follows:

Throttling. (*Zandeh*, Muvo-Gowko)

The victim is tied hand and foot, his neck being placed against a tree trunk and a length of rope thrown loosely round both. The executioner holding the free ends behind the tree throws his weight suddenly back and presses against the trunk until death from suffocation results.

By the knife. (*Zandeh*, Muvira Gowko)

Here the neck of the pinioned victim is cut with a sawing movement of the knife "Sappi" "As one would cut the neck of an animal."

By the spear

Various methods of execution

This, described by Livingstone as the commonest form of execution in Central Africa, is also employed, especially towards enemies of war. One such I met at Amadi, a Gour who during a Nyam-nyam raid was taken prisoner and had his right hand removed; being then speared in several places, he was left for dead—but recovered—his only grievance now being that his hand was cut off to be eaten (?) at a time when meat was plentiful in the district.

By poison

In this method small beans from pods on a certain tree called Tappa are used by the Nyam-nyam. The victim is forced to eat four such, split, baked and crushed up with water. Extreme thirst ensues which is satisfied with quantities to drink; the body is then said to swell enormously, especially the head, neck and arms, death resulting in about half-an-hour.

By fire

This method is apparently not resorted to, though for the wholesale killing of game, elephant in particular, the Nyam-nyam employ it.

Ordeals

Ordeals in lieu of execution will be dealt with later (*vide page* 252).

Flogging

Is a punishment usually reserved for women at the hands of their husbands. Women being "possessions" and legally considered irresponsible and unaccountable for crime, are not as a rule more severely dealt with.

Theory of Disease

It is interesting how nearly akin is the theory of disease in the case of these pagan people, and the rude Mohammedan tribes of Kordofan[1] where "The Evil-Eye" and "Evil spirits and influences" were found to be the two important factors in its causation.

Amongst both peoples (Mohammedan and Pagan) too, the influence of the supreme Allah on the one hand and the semi-mythical Umbolie (Nyam-nyam) and Bolinbula (Gour) on the other seems almost entirely lost sight of in a maze of more potent, if more worldly, supernatural influences.

This makes an interesting comparison with ourselves, since such a supreme power, "The will of God," would of course form the basis, were it worked out, of the Christian theory of disease upon which such a well organised structure of Science has arisen. It is the *Evil Spirit* then, that is the all-important factor in the causation of disease amongst both the Nyam-nyam and Gours.

Belief in continued existence of the spirits of the departed

With them, assuredly, "The evil that men do lives after them;" and so it befalls that the ghosts of their malign forefathers, who still lurk in an after-life, on the same world as themselves, amongst the thickets and along the forest paths, animating animals, hiding as snakes in the long grass, or writhing in storms and whirlwinds and ever seeking to regain a more human and concrete existence, or to disease and destroy those that still possess it, are most to be dreaded.

On this subject Livingstone remarks: "The prevalence of certain superstitious ideas through the whole country north of the Zambesi seems to indicate a community of race among the tribes. All believe that the souls of the departed still mingle among the living and partake, in some way, of the food they consume. In sickness, sacrifices are made to appease the spirits who wish, as they imagine, to take the living away from the earth and all its enjoyments." It is by giving an opening to such evil spirits, through the "Sahar," spells, and incantations, that one man can damage another and inflict disease upon him.

The influence of the *Evil Eye*, though, I think, an independent aboriginal idea, is a less important factor. It has been brought into prominence, however, by contact with Mohammedans, whose Koranic charms one sees not infrequently worn by these people, against it and other evils.

It is not to be wondered at under these circumstances that the theory, diagnosis and treatment of disease is very indefinite, and that—from neglect, infant mortality, malpraxis, ignorance of the infectivity of certain maladies and accidents—the death-rate, especially amongst males, is a very high one, the fittest only, in a large part women, surviving.

"Theory of disease" amongst the Shilluks

The Shilluks (according to a member of the Austrian Mission, who kindly gave me this note) have such a well-defined and interesting theory of disease that I think it worth recording, in comparison with the above.

Amongst them disease is classed under three headings:—

1. Jok, arising from the ill-will of ancestors and other evil spirits, and combated by animal sacrifices to the offended one. The sick person is sometimes placed within the eviscerated abdomen, or wrapped in the warm entrails of the sacrifice.

2. Yuop, arising from witch-craft, invoked by an enemy, in which case a counter-spell is prescribed by a recognised witch-doctor.

[1] *Vide* "Medical Practices and Superstitions of Kordofan."—*Third Report, Wellcome Tropical Research Laboratories*, Khartoum.

3. Angongo, produced by obvious and natural causes, wounds, burns, accidents, etc., for which various drugs and courses are resorted to.

Doctors

Amongst all the tribes (but especially throughout the Gebelawi Nyam-nyam) there are recognised doctors, some purely spiritual (exorcists, diviners, witch-doctors, and devil-dancers), who correspond to the Mohammedan Fikis; others dealers in physic alone, and others again that combine the two offices, a classification very similar to that in Kordofan (*vide* Ibid, Third Report).

Varieties of "medical practitioners."

The doctor, in the Zandeh tongue, is termed Binza, sometimes Kugour (a bastard word) by the Gours, Dakaoa, and amongst the semi-civilised of both races Hakim, the Arab name. He usually traffics from place to place armed with a paraphernalia of drugs, dressings, and implements (Plate XVII., figs. 2, 3, 5, 6, 9), often, too, with the native wooden pillow (Fig. 62). One such with whom I came in contact at Meridi (and to whom I am indebted for much information), Bonda[1] by name (*vide* Fig. 67), applied himself solely to physic and the supernatural. He would have no truck with obstetrics or surgery (perhaps fortunately so), the former remaining in the hands of married women, aided sometimes by small boys (a custom also common to some parts of Uganda, Mr. E. W. Haddon, Collector, Gondokoro, informs me). There are besides these professional doctors a community which might be termed "hereditary specialists," their secret knowledge of remedies and incantations, for special cases, being jealously guarded and passed on from father to son. Such family remedies form quite a feature of savage medicine as they must have done in ancient Egyptian days when the "profession" was entirely composed of "specialists." For his fee the doctor may be rewarded in "kind" (grain, chickens, eggs, etc.) or in the very primitive "coin of the realm" shown in Plate XIX., figs. 1–4.

Cures and Rites

Though not as elaborate or numerous as are those of the Arabs (which have, however, influenced many of them considerably), the cures and rites of the Nyam-nyam and Gour are so confused together that it will be as well to consider them under one heading. Unless otherwise noted these customs are common to both people.

The Salt Cure. (*Nyam-nyam*, Goa).

"Goa."

A grey, salty paste manufactured from the ash and charcoal of Kata-Dendera, Dama, and Kata-Bumblie (specimens of these roots could not be identified), to which is added Tikba, or native wood-ash salt, derived from the wood of the Paio tree. This complicated mixture is essentially contained in a bush-buck horn (*vide* Plate XVII., fig. 1), suspended by a brass ring, from which it can be extracted on a long skewer of wood or bone.

Goa is a far-reaching and universal remedy; it is taken internally in small quantities for fevers and illnesses of every description, whilst externally it is added to fat or oil and applied over any site of pain or swelling, alone, or in conjunction with scarring or tying. Another of its uses is in the "sucking cure."

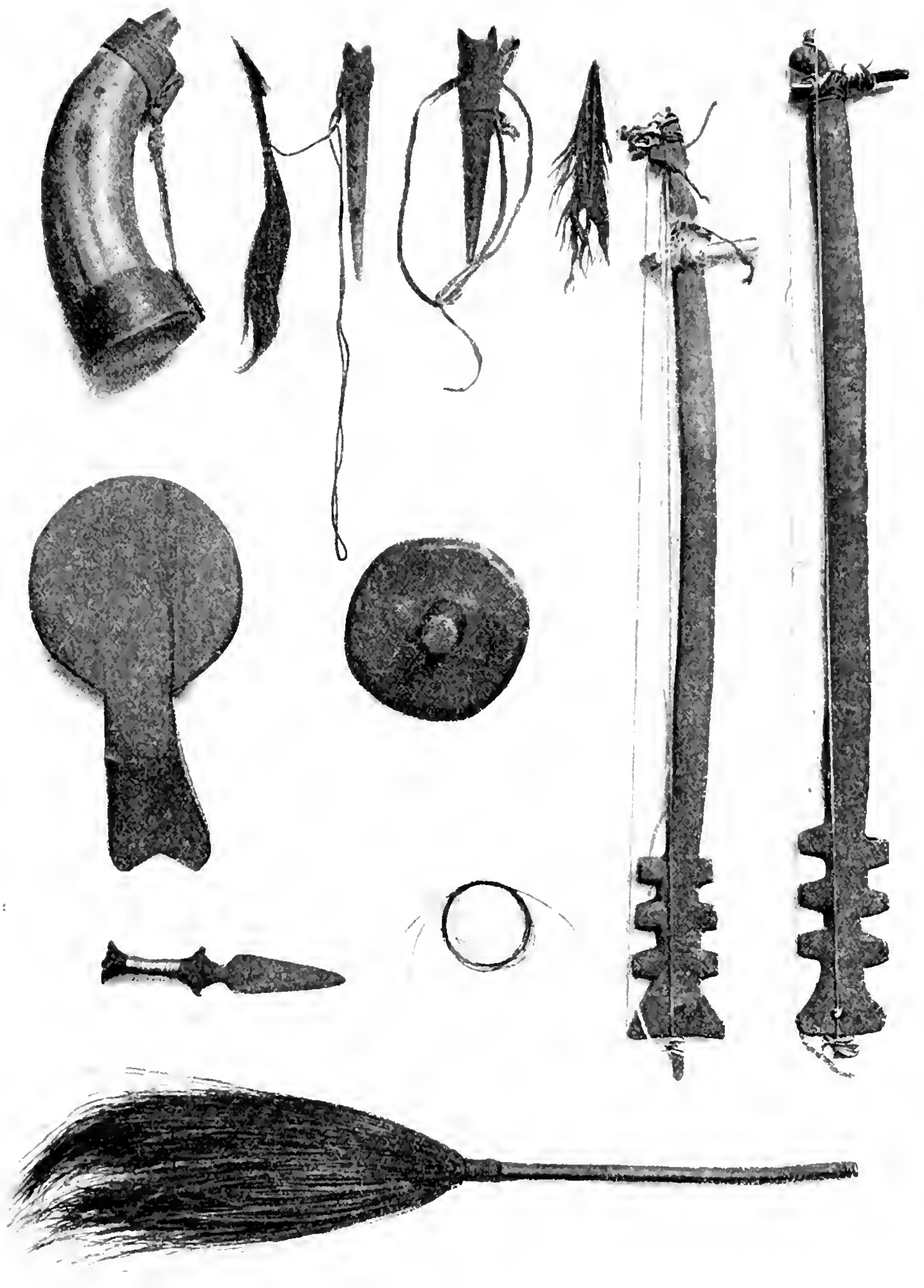
"Guano."

Sucking Cure. (*Nyam-nyam*, Guano)

This procedure has its counterpart amongst ourselves in the recently revived vacuum methods of surgical treatment. I saw it carried out on several occasions, once by the medicine man Bonda as follows:—The malady being pain and stiffness of the neck, the patient a youth of about 19 years, Bonda first palpated the part carefully, in a

[1] This man's full name was Bonda-Ding-Ringba *alias* Mohamed Allah-Gabob, an example of the change from Pagan to Mohammedan nomenclature.

PLATE XVII



1. Salt and drug horn.
2, 3. Gour whistles used to attract game and drive off evil spirits. In the whistle is kept a greasy feather for cosmetic use.
4. Oracle or divining board of the Nyam-nyam tribe. (*Vide also* Fig. 79.) Employed by their witch doctors. Tribal questions, questions of life and death, guilt and innocence, diagnosis of health and disease, etc., are settled by this oracle. The surfaces of the plates having been copiously wetted with saliva and the juice of a certain berry, divination is accomplished by the doctor striking the handle on the smaller plate sharply with each question put, the lower part being held firm. If it moves readily over the body plate, "yes" is signified; when it sticks, "no." Propitious dates, numbers, etc., are told in like manner, the date or number at which the plates cohere being the one selected.
5. Nyam-nyam witch-doctor's knife used for blood letting, etc.
6. Giraffe hairs used as sutures.
7, 8. Nyam-nyam stringed musical instruments used as a pastime and also in devil-dancing and divination, minus the gourd sounding board.
9. Nyam-nyam witch doctor's switch, which seems to be a badge of office.

most professional manner. Thrice then he passed the Goa skewer between his lips; next, seizing the patient by his shoulders, he made a violent and sudden snap at the seat of the lesion. Catching a large fold of skin tightly between his teeth, he pulled it out and sucked vigorously and noisily for about two minutes, at the end of which time, releasing his hold, he triumphantly produced a small spicule of bone from his mouth, the which, he informed us, as the cause of ill, he had extracted painlessly and with no apparent scar. The deception was obvious, and yet no one seemed to consider it as such, whilst the sufferer admitted himself vastly relieved.

"Extraction" *Extraction of foreign bodies*

The extraction of foreign bodies on a much larger scale, however, is common amongst these people. I saw several pieces of iron, bits of stone and fragments of a burma (clay water vessel) which had been removed by a Gour doctor from a Sudanese Mohammedan soldier, the method being to place the sufferer on an angareeb (native bed), under which were set many gourds filled with hot water. As the steam uprose through the open meshes of the bed the doctor recited incantations, to such effect that the missiles fell one by one from the man's body into the receptacles beneath.

Tying cure *The tying cure*

The use of "ties" of native cord and leather (very often coupled with the addition of small charms or with scarring of the part) placed round affected limbs in lesions thereof, such as about the brow in headache, and encircling the chest for cough (*vide* Figs. 68, 69), is a favourite form of treatment. These "ties" will be referred to again later.

"Scarring" *Scarring*

Besides its employment for cosmetic effect (*vide* Fig. 78), scarring is, as in nearly all primitive medical practice, a universal remedy for the relief of pain and swelling, and for the cure of internal lesions having no outward manifestation. A knife or spear-head is the instrument used, the scars being made in a regular pattern, often in groups of three.

Cupping *Cupping.* (Makanowa bunga tirio, Gour tongue) (*vide* Fig. 70).

The cup consists of a perforated bush-buck horn, often possessing no leather valve, as in the Arab instrument (the operator substituting his tongue in the intervals of sucking). Dry and wet cupping are employed. This method is, I suspect, an Arab innovation, the word Makanowa being a corruption of the bastard French-Arabic, Mekana (an instrument).

Heat *Heat cure*

Cauterisation, so common amongst the Arabs, is seldom, if ever, employed by these people.

Hot water and hot mud are, however, used as applications for the relief of pain and swelling, the former also as a beverage in cases of fever.

Saliva *Spitting*

Is employed in many cures, the saliva being used particularly as a ready first-aid application to wounds and abrasions. It is also dispensed with certain prescriptions. The employment of saliva in the oracle Euwa will be described anon. (*Vide page* 252.)

Spitting has no religious significance as in the Mohammedan Azima[1], though a superstitious dread attaches to saliva (as to any part or secretion of the body) in its relation to the working of Sahar, and spells, which have been aptly named "contagious magic."

To spit as a greeting, an almost universal primitive custom, is common amongst these people.

[1] *Vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum

Fig. 67. The Doctor.

Bonda-Ding-Ringba *alias* Mohamed Allah Gaboh. A Nyam-nyam doctor armed with his stock-in-trade. Note the bundle of charms (Bagara) and the Gca horn slung on his basket.

Fig. 68. The Tying Cure.

A tight cord tied round the chest of a man suffering from pleurisy. The "tie" is also accompanied by some cylindrical wooden charms (Bagara). The patient is having his temperature taken.

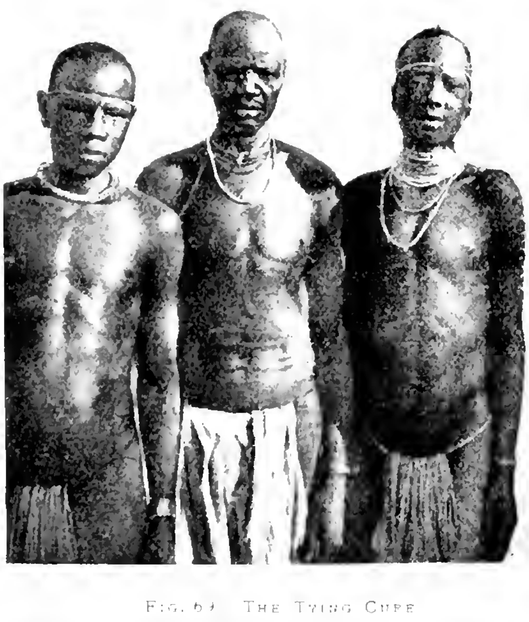
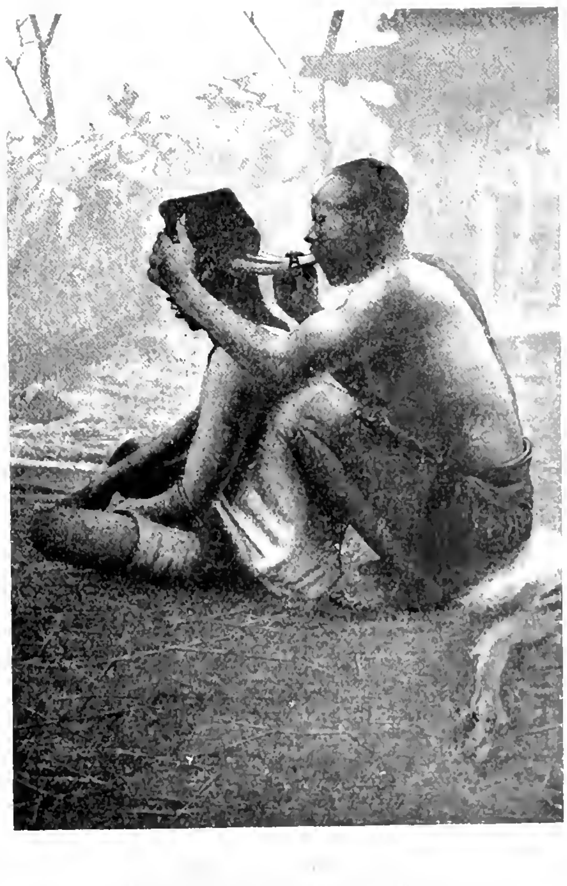


Fig. 69. The Tying Cure.

Four men, two wearing "ties" for the cure of headache. The effeminacy of their ornaments should be observed.



Whistling cure

Whistling cure

Carried out by blowing on primitive whistles, different varieties of which exist for the relief of headache and mental conditions, or to protect the whistler from danger, as also to attract harmless and repel carnivorous animals. Scrapings from many such whistles are supposed to possess medicinal properties. Further reference will be made to them under the heading "Charms."

Oracular Rites

The Benga Rite

I can do no more than outline this interesting oracular rite, which depends on the feeding of a fowl with a Benga poison (a powdered red root obtained from the Congo). The poison is administered on the end of a straw or quill, whilst the question requiring solution is repeated in a low monotonous chant by the operator. Having been given an indefinite amount, the fowl is released and observed, its decease or survival signifying the answer. In this way any question concerning life or death, health or disease, guilt or innocence, can be settled.

Benga poison is also administered to fowls in simple sacrifices of propitiation or thanksgiving.

The Ordeal

Should one condemned by the Benga Rite wish to challenge its decision he may be permitted to swallow the drug himself; death resulting proves his guilt, whilst if he live his innocence may still be left in question.

Captain A. L. Hadow (Inspector, Eastern District, Bahr-El-Ghazal) quoted me the case of a man who underwent this ordeal three times in succession without evil effect.

Devil-dancing divination

Divination

Space will not permit of my entering into a full description of this remarkable rite.

In the first place the devil-dancer (*vide* Fig. 71) fortifies himself and his assistants with a salt called Biero (perhaps a stimulating narcotic? hashish) contained like the Goa in a bush-buck horn or Koura. This is to give him and them the necessary "power," as also to frighten away evil spirits. Having so done he stands naked in the centre of a circle of onlookers, a large wooden rattle (Unzoro) grasped in each hand and palm leaf rattles bound round each leg. Sprinkling some powdered root on the ground to hallow it, he pauses while the matter to be divined is put to him, his assistants chant dismally, accompanying themselves on native musical instruments (Plate XVII., figs. 7 and 8; Fig. 61) while beating the time on tom-toms. Suddenly with a bound he flings himself into a frantic confusion of dance—leaping, strutting, shrinking and shuddering as though a host of devils were about him. Attacking the unseen, retreating, whirling and contorting, the drums throbbing madly and the chant[1] becoming more animated, he foams at the mouth, perspiration pouring from his body, his eyes are half closed. On a sudden he stops, bows his head and delivers his divination in a low dreamy voice. It is a very strange and moving sight.

The Divining Board. Enwa Rite (*Zandeh* tongue) (Plate XVII., fig. 4 and Fig. 79)

The board consists of two small discs of hard wood (about 6 inches in diameter). One the Um (or mother), having three legs on its under surface, is placed on the ground and held in position by the operator's foot. Against its smooth upper surface is applied the

[1] One of these chants was translated to me as follows:—"A curse on the Hakoma (Government) that has killed the aged Yambio hiding in the grass, and has caused Mange, like a jackal, to seek refuge from place to place, hiding in the grass." This seemed very irrelevant and rather revolutionary—on such an occasion.

second disc, the Walad (or son), which is quite plain and rounded off above into a small handle (*vide* Plate XVII., fig. 4; also Fig. 79).

Before working the oracle there are much the same preliminaries as described under "Devil-Dancing." Then both discs are wetted first with water, next with the operator's saliva and finally with the slimy juice of the Katoura (*Zandeh*) Bukutro (a variety of wild tomato) and closely applied. With a series of jerks and asking the question for solution with each movement in the "This year, next year, sometime, never" style of our youth, the diviner causes the upper disc to slip over the lower. At first it slides freely, then, the suction becoming intense, there is a sudden check which means a question answered.

By this method, any matter can be decided, without resource to the Benga Rite.

I think Euwa is confined to the Nyam-nyam, Benga being common to both races. Euwa confined to the Nyam-nyam

Other means of divination

(*a*) The diviner rubbing the palms of his hands together (sometimes moistened with his saliva) and obtaining "sensational" replies therefrom.

(*b*) Rubbing the soles of his feet in a like manner.

(*c*) Eructating noisily and so obtaining council and information from the "voices within him."

(*d*) Sand-gazing and other forms of hypnotic oracle, so common among the Arabs, do not seem to be employed by these people. The bearing of divination on their medical customs is important since it is undertaken in the case of all maladies of a serious nature, when not only the cause, diagnosis and treatment, but also the eventual issue, can be determined.

EVIL SPIRITS

The Spell of Sahar or Zarr

Sahar or Zarr[1] is the infliction of illness, misfortune or death, by evil ancestral spirits, brought about through the machinations of an enemy, the medium being some object, a part of, or intimately connected with, the intended victim.

Most illnesses and diseases are attributed by both Nyam-nyam and Gour to Sahar (*vide* "Theory of Disease") as also the death of all persons not of advanced years. It is not everybody that can inflict a Sahar, and those that can are not easy to detect.[2] The Benga or Euwa will reveal them, however, and the possession of a vermiform appendix is said to be diagnostic (a rough autopsy is therefore conclusive).

For this latter interesting fact, which I have since verified myself, I am indebted to Captain A. L. Hadow.

Blood-brotherhood

By Blood-brotherhood is meant a mutual coalition, and a protection effected between two men, each against the Sahar of the other, through the possession by each of a portion of the other's person. "Sahar" and Blood-brotherhood

The rite, enacted in turn by each, consists in incising the other's forehead with a knife, drinking the outflow of blood, smearing an adjacent lock of hair in its residue, and cutting this off to keep in a small cylinder of wood or in a neatly woven hair bag as a charm, (Bagara). Many carry six or more such guarantees.

[1] This word, meaning "Evil-one," again an adoption from the Arabic, refers among the people of Kordofan to one possessed of an evil eye (*Vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum, p. 282), not, as here, to "one possessed of devils."

[2] The same difficulty of detecting one possessed of an evil eye exists amongst the Arabs of Kordofan (*Vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum).

Blood brotherhood is a very intimate relationship, not lightly entered into, since the initiated are not only bound mutually to support and aid each other, but are presumed to have an affinity in health, disease and vitality which gives this most excellent custom an interest and importance medically which it might not otherwise possess.

Casting out of devils

The mystic ritual for the expulsion of "devils," prevalent among the Arabs, has no equivalent with these people, who are content to effect the same ends by the simpler means of drugs, charms and spells.

Sacrifices less elaborate in this district

Sacrifices

Nor do the Nyam-nyam and Gour offer up the elaborate sacrifices of cattle and sheep to propitiate offended spirits as do the Dinkas, Shilluks, and others. This is of course accounted for by the entire absence of domestic animals (save dogs and fowls) in a country rendered impossible for them by the death-dealing tsetse fly.

Fowls, usually in association with the Benga Rite, form the only sacrifices of these people.

Charms

Charms called Bagara (*Nyam-nyam*), Tok (*Gour*) (*vide* Plate XVIII.), amongst these, as amongst all savage and semi-civilised people (*vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum, *page* 281), play a most important part in their customs and very existence. Not only from a medical standpoint, but possessing as they do a potent influence and restraint over their general conduct and dealings with one another, they become indirectly a very decided factor for good throughout the community. Livingstone draws attention to this when he says, "The belief in the power of charms for good or evil produces not only honesty, but a great amount of gentle dealing—the powerful are often restrained in their despotism from a fear that the weak and helpless may injure them by their medical knowledge."

Charms for prophylaxis

In their "medicine," charms are undoubtedly the most important factors for the prophylaxis, if not also in the cure, of disease.

"Prevention is better than cure" is an unwritten, even unrealised, instinctive motto of the savage, and so, in order to avoid the thousand and one ills that "flesh is heir to," he decorates himself with charms, prescribed by recognised authorities, collected by himself or borrowed from his Mohammedan brethren.

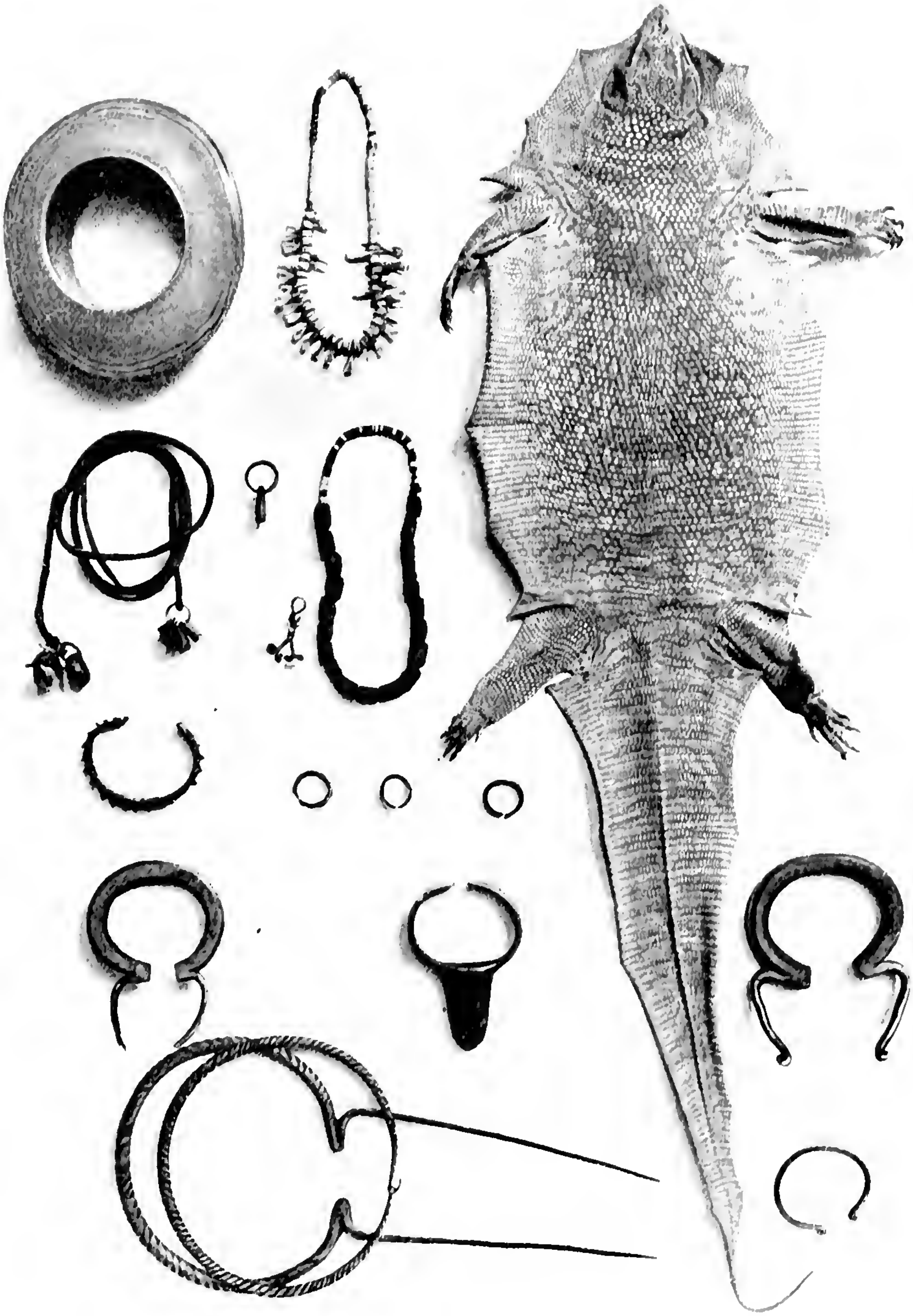
Again, to quote Livingstone on Central Africa, "Their religion . . . is one of dread, numbers of charms are employed to avert the evils with which they feel themselves to be encompassed. Occasionally you meet a man more cautious than the rest with twenty or thirty charms hung round his neck, on the principle that among so many he surely must have the right one."

Most ornaments too, besides holding a position in the "decency of dress" seem gradually to have attained a superstitious significance in the savage mind, as gems, trinkets, mascots, and the like do over the savage remnant in ourselves. Thus the Gours, an effeminate and more highly decorated people than the Nyam-nyam, wear every variety of ornament, rings, earrings, anklets, and bracelets (*vide* Plate XVIII.), which are presumed, by adding charm to the body, to give it health, strength and increased vitality. (Indirectly they are right.) The Dinkas and Shilluks hold the same idea as regards their heavy ivory armlets and woven giraffe-hair neckbands, which are very hard to obtain on that account (Plate XVIII., fig. 1).

Magic attribute of ornament

PLATE XVIII

[illegible]



1. Ivory armlets worn by the Arabs as a sign of superiority, to attract and engender love, and to maintain the strength of the body. They are never under any circumstances removed, and often bite into the muscle of the limb to a terrible degree.

Tooth necklace to protect and prolong life and to render the wearer brave.

3. Leather waist girdle decorated with a nut and iron bells to prevent skin disease. Necklets of hippopotamus hide are worn for the same purpose.

4. Tortoise-shell in a brass ring. A charm to procure good luck in fishing and in love.

Man's brass ear-ring as a love charm.

6. Scented wood necklace as a charm for love.

7, 10, 13. Three Genti bracelets worn by men and women, defensive and cosmetic in character. They all bear the same relation to bodily strength and virtue which most such savage ornamentations seem to do.

8. Three Nyam-nyam brass finger-rings of native make.

9, 12. Kederu woman's "defensive" anklet and bracelet. These, often, and pearls sometimes, are carried by many women of the Bahr-el-Ghazal tribe.

11. Large iron necklet worn by Kederu women. These, with many other metal ornaments of savage Central Africa, are used not only for cosmetic effect but as a sign of wealth and for self-defence. One has seen severe septic wounds inflicted by such ornaments.

14. Waran lizard skin used for the prevention and cure of [illegible]

As I have already remarked in discussing the "Theory of Disease," it is primarily against *Evil Spirits* that these charms are directed, and secondly against the *Evil Eye*. Thirdly, one must include also protection against the *active violence* of men and beasts. As regards men no doubt this belief is justified, such charms being, as I have quoted, no mean safeguard to the weak and helpless or to the stranger, whose "unknown gods" and unknown amulets form invaluable allies.

Charms worn chiefly by males

The wearing of charms is chiefly confined to the male, which is here, as among wild animals and birds, the ornamental sex. The females are very unadorned and unadorning.

Each amulet is pierced with a brass or copper ring and hung on a band round the neck, wrist or waist in company with other beads and trinkets.

Classification of charms

The neatly bound Koranic and mystic writings which form the chief talismans of the Arab (*vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum, *page* 281) are replaced among these illiterate people by common objects, which may be classified under three heads:—

(*a*) Substances possessing a supposed medico-magical value.

(*b*) Objects, pleasing, bizarre, or mysterious, which are of attractive value.

(*c*) Conventional or specific charms having a recognised reputation and value.

To discuss these more in detail:—

(a) Substances of medico-magical value

As distinct from the recognised drugs (to be described later) are, like them, usually the roots, branches, bark and fruit of trees, plants, etc., or animal substances, such as scraps of flesh, certain organs, bone, etc. Among them may be mentioned:—

1. Tokai (*Gour*). Two nearly equal sections (about 4 inches long) of the branch and root of a certain tree carried on the person of either sex, scrapings being eaten with the food to ensure the birth of a male child.

A pharmacology of magic

Here the root and branch probably are held to possess a sexual relationship one to another (a fact noticed by me amongst certain charms in Kordofan) as also do the adjacent iron and copper or brass bindings in many of their love charms.

2. Aloko (*Nyam-nyam*). A section of root carried to prevent, and scrapings taken with water to cure, general "stomach" disorders.

3. Lejo (*Nyam-nyam*). The leaves of a tree carried in a small leather bag, infused, and the infusion drunk and applied externally as an aphrodisiac.

4. Cane Root (*Gour*). Small segment of cane root carried by the Gours to prevent, and scrapings eaten to cure, snake-bite. Among the Nyam-nyam the same charm acts as an aphrodisiac.

5. Discs of Skin (*Gour* and *Nyam-nyam*). Small discs of dried pig, cow, crocodile or lizard skin (Plate XVIII., fig. 14) worn round the neck to prevent and cure skin diseases, a custom common also to the Dinkas, Shilluk, and Kedern people.

6. The pudendae of the male crocodile carried on the person and administered in small quantities as an aphrodisiac. (This is a very universal custom in the Sudan).

7. Kunga (*Nyam-nyam*). A polished disc of tortoise-shell.

8. Koka (*Nyam-nyam*). A disc of buffalo horn.

9. Zumbo (*Nyam-nyam*). A disc of antelope horn.

10. Gugaga (*Nyam-nyam*). A small segment of cane root.

Nos. 7 to 10 are carried and scrapings taken internally for their supposed aphrodisiac effect. They are very closely allied to the "Pretty" Love Charms, yet to be described, among the *Gours*.

11. Kudo (*Gour*). A section of root carried by travellers to protect them against their hosts in strange villages. Chewed it is said to act as a hypnotic.

(*b*) *Objects of attractive value*

These might be termed "Pretty" charms, they include the trinkets, etc., above referred to. Many such charms have no recognised object or effect but are collected by the wearer and carried, as the Arabs say, "Sakit" or, as we should express it, "For luck." The majority, however, are, as *protective mascots*, supposed to possess the quality of attracting and fixing the regard of the Evil Spirit or Evil Eye and so diverting it from the wearer. As *Love Charms*, on the other hand, one must presume that they attract the lady's eye but rapidly divert it to the more pleasing personal qualities of the possessor. Among these attractive objects are such things as claws, teeth, bright feathers, coloured stones all bizarre or pleasing, whilst a sardine tin-opener and a "sparklet" bulb, which I saw worn at M'volo, must be numbered amongst the mysterious. "Pretty" charms.

Some of those having a recognised purpose are:—

1. Bi Bili (*Nyam-nyam*). Numerous small segments of a root worn to protect the owner from accident and disease, also to "turn away wrath."

2. Magoforo (*Gour*). A Gour charm of the same nature as No. 1.

3. Human Teeth (*Gour*). A necklace (*vide* Plate XVIII., fig. 2) made of human teeth (mostly milk teeth and incisors, the wearer's were among them). This secures a long life to the possessor and increases his fertility.

4. Scented Wood (*Gour*). Segments of scented wood alternating with bright blue beads, worn on a necklace as a love charm. (The belief in scents as aphrodisiacs is, I imagine, quite universal.)

5. A Love Zone (*Gour*) (*vide* Plate XVIII., fig. 3). Consisting of a number of primitive little bells and hard nuts strung on a leather girdle round the wearers' waist. (This has its equivalent in the Hagub worn by Arab women).

6. A Love Charm (*Gour*). Small rudely decorated segments of cane worn pendant as Love Charms.

7. Tortoise-shell (*Gour*) (*vide* Plate XVIII., fig. 4). A disc of tortoise-shell worn to attract fish to the bait—among the Nyam-nyam this has been described as a Love Charm.

(*c*) *Conventional or specific charms*

A system of charms, having an established and recognised potentiality. Amongst them are:— Conventional charms

1. *Whistle charms (Nyam-nyam)*

These (*vide* Plate XVII., figs. 2 and 3) have already been dealt with under the heading of "The Whistling Cure"; little further need be added, save to name a few varieties.

The charms consist of small cylinders of wood (4 by 6 inches long), burnt or stained on the surface, which is finely polished. At one end they are slightly hollowed to form the whistle, at the other perforated for a brass or leather carrying loop.

(*a*) The Oulourn is to attract the love and attention of women.

(*b*) Baghaoy, a whistle tied to the native Lyre or Kude (as these charms frequently are), is to drive away fear; scrapings are also taken medicinally for headache.

(*c*) Ingbara Amgunza, to protect from accident and bring success while hunting.

(*d*) Angalabay, to ward off the attacks of carnivora.

(*e*) Korra, to attract game.

(*f*) Kadra and Ungandria, two whistles used in conjunction to attract elephant for spearing from among the branches of large trees. (The usual methods of Nyam-nyam elephant hunting, pit-trapping and "burning out" are also in vogue.)

2. *Gun medicine charm*

"Gun medicine"

To give the user a good "eye" for straight shooting and to safeguard him against shot. It is a very universal idea, met with all over the Sudan amongst both the primitive Mohammedan and pagan population. Livingstone refers to it in Central Africa as "Gun medicine, without which they believed that no one could shoot straight. . . . . . Sulphur was a favourite gun medicine, and I remember Sechele giving a large price for a very small bit . . . . . also . . . . . for another medicine which was to make him invulnerable to musket balls."

The Nyam-nyam gun medicine is called Mobienia; it consists of a section of the root and another of the branch of a certain tree, each charred at one end. For use the charcoal is rubbed into the outer angle of the "sight" eye and between the thumb and forefinger of the right hand.

To strengthen the eyes (not specially for hunting purposes), both lids are blackened with the charred ends. (For a similar purpose the Arabs employ *Kohl*.)

Bullets that have killed an elephant are also greatly prized as gun medicine and charms to bring success with safety in the chase.

Hunting amulets are indeed very numerous, especially among the Nyam-nyam and have already been referred to under "Whistling Charms."

3. *Mourning charms. (Nyam-nyam)*

Gorowa, a bracelet made up of beads with several small squares of polished ivory interspersed, each of which latter is in memory of a departed wife. It is worn so that a wife's death may not lessen the vitality of the husband. Sultan Yango carried such a bracelet, set with, I think, five ivory squares.

Mourning charms

The customs of wearing rudely worked mourning-rings of brass and copper (Plate XVIII., fig. 8), which are first placed on the finger of the deceased and then transferred to that of the mourner, as also of wearing a "pretty" charm, or simply a tie of native cord round the neck for the space of one year after the demise of a wife, are of interest. They are common to both Nyam-nyam and Gour.

4. *Lightning charm. (Nyam-nyam)*

Patr, a charm consisting of two small sections from the branch of a tree that has been struck by lightning. This is worn on the person or placed within the dwelling-hut to protect against lightning; in the latter case it is termed Logo, and is then said to possess the additional quality of quieting a nagging wife, perhaps for ever, if scrapings are surreptitiously introduced into her food.

Maladies

The following are some of the savage's recognised complaints and their native remedies (*see also* Drugs).

Fever

Treated with draughts of hot water and infusions of certain drugs (amongst them ardaib fruit, probably introduced by the Arabs) (*vide* Drugs 6, *page* 261).

Smoking the body as described by Livingstone, who, "after being stewed in their vapour bath and smoked like a red herring over green leaves," felt little the better, is also resorted to. Fumigation, however, does not hold the important place it has in Arab treatment.

Chest complaints

For these, being internal lesions with no external manifestations, scarring and cupping (probably an Arab introduction) are employed, also the "Tying Cure," as already described (*vide* Fig. 68) (*vide* Drugs 2 and 12, *page* 261).

The Nyam-nyam are particularly liable to chest diseases, acute pneumonia, bronchitis and pleurisy, from which the mortality is very high. More especially is this the case among prisoners confined to cells and men enlisted into regiments serving away from the Bahr-El-Ghazal; so much so that I feel sure the entire question of savage recruiting in the Sudan will require careful consideration. It will, I imagine, resolve itself eventually into one not only of territorial enlistment but of territorial service.

Liability of the Nyam-nyam to chest complaints

Eye diseases

Are very uncommon, though minor accidents are frequent, for which spitting in the eye of the sufferer and the external application of wood-ash or red-clay are the usual treatments. Strengthening of the eyes with "Gun Medicine" has been referred to.

The inability to open or close one eye without the other is very frequently met with amongst these people, and interferes greatly with recruiting and the training of recruits.

Chigger. Tuk Tuk (*Zandeh* tongue)

This was apparently non-existent in the Bahr-El-Ghazal before the arrival of the Belgian outposts at Meridi, and elsewhere. Their Congolese troops, termed Tuk Tuk, from which the name of the disease is derived, suffered severely from it.

Chigger is now to be found in many of the Government stations of the S.E. Bahr-El-Ghazal and is spreading, I believe, along the main roads of the Province. It is to be hoped that Relapsing Fever has not been, or will not be, similarly introduced.

The native treatment is to rupture or extract the parasite and then apply wood-ash.

Guinea Worm

This disease was, I believe, widespread among the natives of the Bahr-El-Ghazal when first occupied by the present Government (Major S. Lyle Cummins, R.A.M.C.); so far, however, the Nyam-nyam and Gour seem to have escaped, as also, I believe, have the Shilluks (American Mission). I saw three cases in the Dinka country, but none further south.

Snake-bites and scorpion stings

Considering the prevalence of poisonous snakes in the Bahr-El-Ghazal it is remarkable how few cases of bite one encounters. Though preventive snake charms are carried, little actual treatment with the exception of scarring and sucking is adopted in such cases.

Stomach complaints

The savage, having what the Americans aptly term a "cast-iron digestion," and enjoying an extraordinary immunity towards foul water and filthy food, is seldom troubled in this matter. The effects of over-eating are, however, not uncommon when meat is plentiful.

With the exception of certain roots employed for pain and dysentery (*vide* Drugs, 1, 3, 5, *page* 261) little further treatment exists, nor are established purges or emetics found among the people.

Venereal disease

Introduced by the "Turk" whose name in Arabic it bears, Ayat el Turkowi or Ayat Tashwish. Though prevalent among the riverain people and at Government posts, there is little elsewhere. The Dinkas are said to isolate cases of such disease as the Abyssinians do leprosy.

Headache

Seems very prevalent especially amongst "carriers," from the constant pressure of the loads on their heads. It is universally treated by the "Tying Cure" (*vide* Fig. 69), the tie being passed round the brow or caught up strongly under the eye-brows until local œdema results.

The Nyam-nyam also employ the "Whistling Cure" whilst the Gours "let blood" from the site of pain.

Sunstroke

Though uncommon amongst these people in their own country, the effects of the sun are very much felt by them in the hot, arid, deserts farther north, for military service in which they are by no means suited. Violent headache, fever, nose-bleeding and sometimes coma are the usual symptoms.

Mental disease

Mental disease is uncommon. Those afflicted, whilst being treated with some consideration as "empty ones" within whom ancestral spirits have entered, are not looked upon with as much indulgence and respect as are the demented in Mohammedan countries.

Skin disease

The Nyam-nyam and Gour being essentially cleanly-bodied people are little affected by skin diseases. For its prevention and cure they carry the "disc of skin" charms referred to and apply "red earth." The former people also wear the leg-bone of a tortoise stained blue as a safe-guard (*vide* Drugs, 8, 9, 13, *page* 261).

Leprosy

Isolated cases I found among the Gours, though none farther South. The uncleanly, foul-fish eating riverain people of the extreme Eastern Bahr-El-Ghazal are, however, very prone to it as to various other skin lesions.

Deformities

A supplementary fifth finger or first toe are surprisingly common amongst these savages who are usually proud of the addition. The late Dr. Pirrie also draws attention to this deformity (*vide Third Report*). As acquired deformities, umbilical hernia in children, prepatellar bursæ among the women from the constant kneeling attendant on corn grinding, and keloid scar deformities are most frequently met with.

Elephantiasis. Kouk (*Gour*)

Is prevalent in a mild form throughout the Gour country, no treatment very naturally being attempted.

DRUGS

The distinction between simple drugs and the medico-magical charms referred to above is by no means well defined. The following are a few of those which are used solely for medical effect. In most instances specimens of these drugs have unfortunately proved impossible of classification.

List of drugs used solely for their medical effects

1. Bazamangwa (*Gour*)

The root of a tree, scrapings of which are suffused with water and given for colic. It is said to rapidly relieve pain.

2. Bedungana (*Gour*)

The root of a tree burnt, crushed and mixed with fat or oil being locally applied and taken internally for chest complaints.

3. Kujaloko

A small aromatic fruit with a hard shell used in stomach troubles and many other ills.

4. Duleib Palm (*Borassus flabellifer*)

The fruit and young root shoots are used as a food possessing medicinal qualities.

5. Yeo or Teo (*Nyam-nyam*), or Dingiti (*Gour*)

A circular, yellow fruit, about the size of a damson, having a pleasant acid taste. It is employed as a stomachic and thirst quencher.

6. Ardaib (*Tamarindus indicus*)

The fruit is brewed into an acrid acid concoction with water and thus used as a universal remedy, especially applicable to fevers.

7. Gaganga

Cane root infused with water to act as an aphrodisiac.

8. Glimbia

The bark of a tree scraped and reduced to a pulp with water. This is plastered over skin lesions, so also are chewed tobacco and certain crushed leaves.

9. Unkoa

A wood reduced to a charred condition. Crushed and added to oil, it forms a caustic ointment used in skin lesions.

10. Alouan (*Gour*)

The root of a small creeping plant used in solution to secure the lactation of parturent women.

11. Madida (*Gour*)

The root of a tree employed to check *post-partum* hæmorrhage.

12. Fat and Oil

Animal (particularly hippopotamus) fat, fat derived from a certain caterpillar Koluba (*Gour*) (*See* Diet) and Sim-Sim oil are used as applications and administered internally for many ills, particularly chest troubles.

13. "Red Earth"

Wati (*Zandeh*) or Homra (*Arabic*) is a red clay obtained in certain localities and used as a powder, or mixed with oil to a paste, for cosmetic purposes, as a protection against "fly" and mosquitoes, in skin diseases and for a surgical dressing, also simply to "strengthen the body." It is a widely used remedy. I found it employed in Uganda and also among the Nubas of Kordofan.

14. Wood-Ash

Is used as a tooth powder, a drug, a dressing, and as a substitute for salt when no better can be obtained. It is also applied to the bodies of men and animals to ward off the bites of mosquito and tsetse.

Note.—For this purpose "red earth," a "wash" made from tobacco, and the smoke of burning leaves and green wood are also employed. Elsewhere in the Bahr-El-Ghazal (according to a note kindly supplied me by Dr. Andrew Balfour) the root of a tree (*Vitis producta*), called Yiao in the *Gour* tongue, is crushed up with water, and applied as a "wash," or given internally as a draught for animals in the tsetse country. A similar, if not the same root, is mentioned by Livingstone.

15. Salt

As an article of diet and for medicinal purposes is very highly valued. It forms, therefore, one of the most important media of exchange among traders who import the native Arab article (Natrun) in "heads" and occasionally the purer rock salt of commerce.

The potash salts manufactured by the people themselves are many in number:—

Dokodo (*Gour*) derived from the ash of Yada or Begno woods by solution, filtration and evaporation of the filtrates.

Tikba (*Nyam-nyam*) from the same process with the ash of Paio wood.

Yobo (*Morro. Nyam-nyam*) salt derived in like manner from the seed heads of a large thistly plant termed Bringa or Yabu.

Livingstone mentions the "Burning of coarse rush stalks of Tsitla in order to extract the salt from the ash," and the late Boyd-Alexander referred to its being obtained by the natives round Lake Chad from the rotting vegetation in stagnant pools.

Salt is frequently carried in hollow horns as shown in Plate XVII., fig. 1.

16. Tobacco *(Nicotiana tabacum)*

Tobacco and Hashish

Is widely grown and used (smoked and chewed) in the Bahr-El-Ghazal as indeed throughout Central Africa. (*Vide* Livingstone, Schweinfurth, Boyd-Alexander, and others). It is called by the universal name of Tumbak, by the Nyam-nyam also Goundo, and by the Gour, Tabba.

The tobacco leaves are crushed when fresh and roughly moulded into discs varying from a few inches to a foot in diameter according to local custom. It is chewed, or smoked in crude pipe bowls attached to a length of hollow stick (*vide* Plate XIX., fig. 5), or else in a primitive hubble-bubble made from a long thin-necked gourd perforated to allow the clay bowl to protrude into the water (*vide* Fig. 73).

Tobacco is a staple remedy for nearly all ills, being used as a drug, a dressing, and also in the preparation of a wash to safeguard animals against the bites of "fly."

17. Hashish

(*Cannabis indica*)—termed Bange in the *Zandeh* tongue (the Bang of Persia)—like tobacco an importation of the "Turks" is grown in small quantities, chiefly at centres of civilisation along main roads. It is usual for the hashish smoker to keep a few living plants close to his hut, plucking and smoking the leaves (mixed with tobacco) as he requires them. Livingstone describes hashish as being "extensively used by all the tribes of the interior" in Central Africa, and Dudley Kidd[1] mentions its use amongst the Kaffirs, even by their children, who employ it to add dash and excitement to their games.

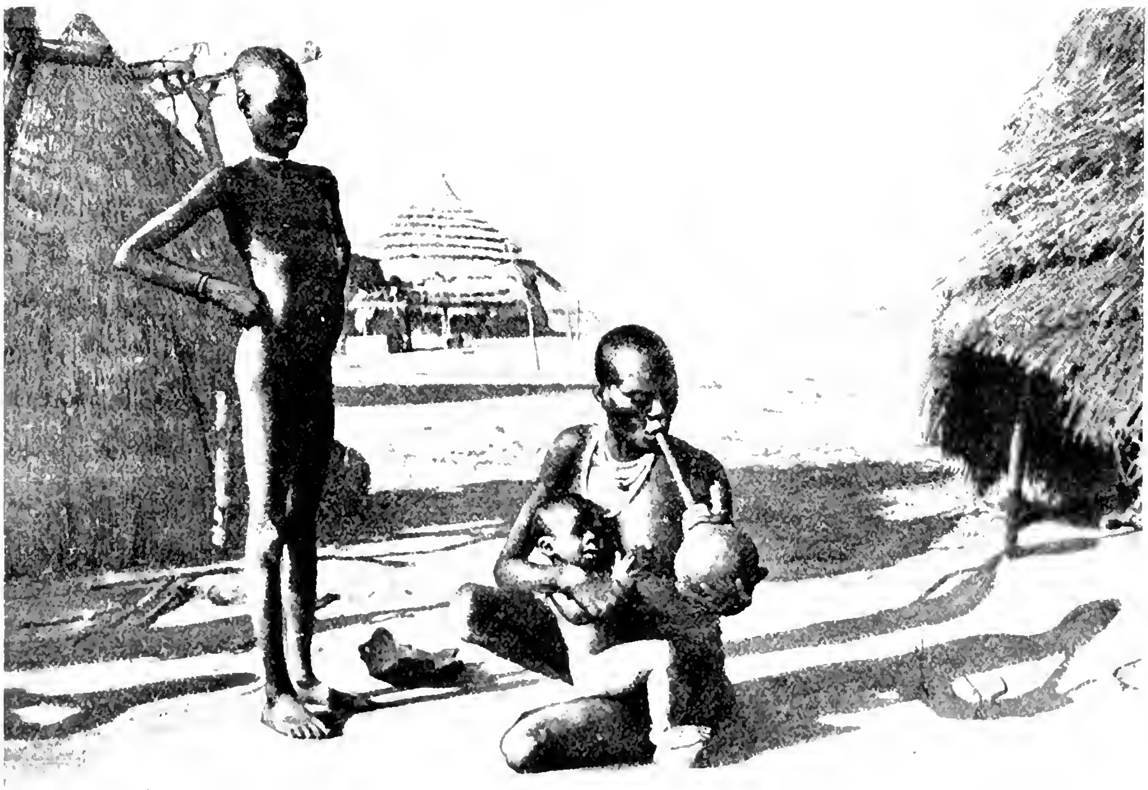
[1] *Savage Childhood*

Fig. 71. Divination.

A Nyam-nyam [illegible] devil-dancer and his assistants

Fig. 72. Food.

Two Nyam-nyam dogs indigenous to the [illegible]untry. They are penned up and fattened for eating purposes, there being no cattle [illegible] sheep in these districts owing to the prevalence of [illegible] fly [illegible]tsetse.



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Arrow Poisons (Quanzi Benga) (*Gour* and *Nyam-nyam* tongue)

Besides the lethal Benga, which we have already mentioned in discussing "Divination," "The Ordeal," and "Execution," there are many other substances, chiefly vegetable products, employed as arrow poisons, amongst the Nyam-nyam and Gour.

Substance used to poison arrows

1. Giru (*Nyam-nyam*). The seeds of a small bush, crushed, charred and mixed with a fat for application to arrow heads.
2. Gumarie (*Gour*). The juice derived from the root of a shrub similarly used.
3. Ellie (*Nyam-nyam*), Turuf or Bulo (*Gour*), Shagar el Leban (*Arabic*). The milky sap of the candalabra tree (*Euphorbia Candalabrum*) inspissated to a thick paste and then moulded over the neck of the arrow head (*vide* arrow on extreme right in Plate XIX., fig. 9). This poison is said to rapidly deteriorate and lose its effect. In this it resembles Benga.
4. Maerube (*Gour*), the poisonous juice derived from a bulb, about the size of an onion.
5. Dadala (*Gour*). The same from a bulb slightly smaller than "No. 4."
6. Tappa (*Nyam-nyam*). Already referred to under "Execution," *page* 246, is also used by the Nyam-nyam as an arrow poison.

Specimens of these poisons have so far defied classification, two bulbs of "Nos. 4 and 5" were planted out by me and have been growing now for over a year without producing the flowers which are essential to their identification.

Putrid flesh, though used by the adjacent people of Mongalla (Captain P. S. Dove, Senior Inspector) and by the tribes near Wali in the Lado (Boyd-Alexander), snake venom employed by the Dinkas and Shilluks (Austrian Mission), the entrails of certain caterpillars "A Bushman spear and arrow poison" (Livingstone), and tetanus-infected soil adopted elsewhere on the west coast, I believe,—are apparently none of them common to the Nyam-nyam or Gour.

Surgery

The term "surgery," as applied to the procedure of these people, is in reality a misnomer, since with the exception of occasional *circumcision* (introduced by Mohammedans), certain tribal *cosmetic operations*, and the every day minor *surgical dressings*, *scarrings*, etc., it does not exist.

Circumcision

Called by the mutilated Arabic word Tahuri, or Ganzai in the *Zandeh* tongue, is of Arab introduction and forms one of the outward signs of that "unconscious conversion" to Islam, already referred to in dealing with the influence of civilisation on these people.

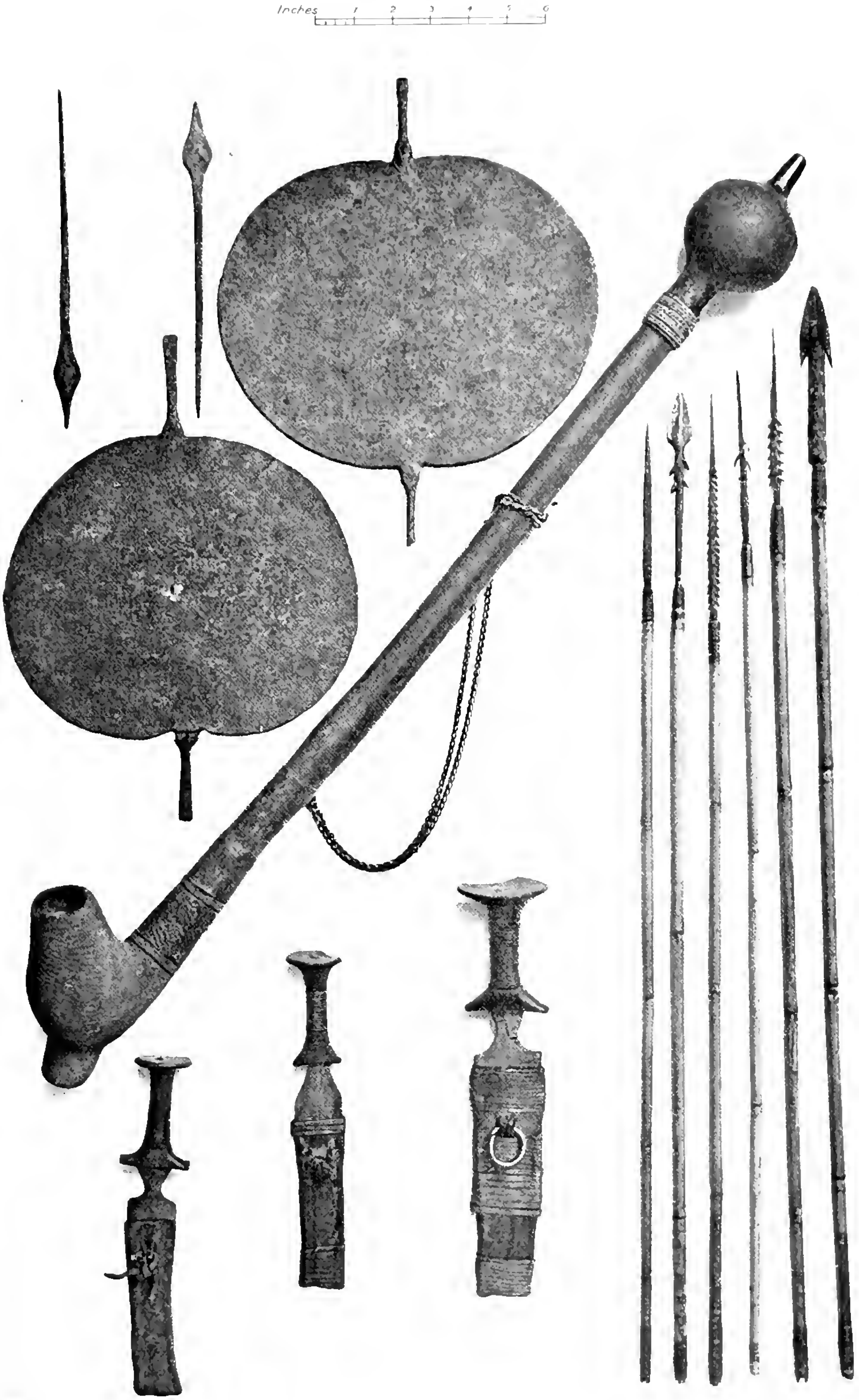
Circumcision

Circumcision is so far entirely limited to adult males, members of the community at stations where that crude Mohammedan element, the Sudanese soldier, is present. The female Tahur of the Arabs has as yet found no footing. The operation is nearly always associated with the adoption of the simple creed of Islam (though the reverse is by no means the case) and with other manifestations of civilisation. A circumcised man immediately gains in social standing and prestige so that its influence is decidedly for good.

Tahuri is carried out by the simplest Arab method, a knife (Sappi) being employed and the bleeding controlled by a split cane clamp. Dressings of Kita-Dondura leaves and hot water or powdered Gangula root are applied.

A month after the operation a Deluka (Dancing Feast) is held at which the circumcised appears clad in a short "kilt" of flowing grass or hair. (Termed Mududa and very similar

PLATE XIX



1-4. The doctor's fee (Nyam-nyam) Disc and arrow shaped iron money. The most primitive "coinage" perhaps existent. Iron is the only metal of the country and in it lies the value of exchange. A little brass and copper are imported but knowledge of the rare metals is absolutely nil, silver and gold having no value over copper, brass and iron; ordinary coins possess no value except as ornaments.

Tobacco pipe in which the coarse home-grown tobacco, originally introduced by Arab traders, is smoked. Hashish, an Indian hemp, probably introduced in the same way, is grown and smoked by the Nyam-nyam cannibal tribes of the Southern Bahr-El-Ghazal.

6-8. Three Nyam-nyam knives, two small worn by women and larger one by men. Used for all purposes, including the rough attempts at surgery, circumcision (which is occasionally practised), and mutilation—removal of hands, ears, eyes and genitalia.

9. Poisoned arrows. *Tip* on extreme right arrow shows adhering poison.

to the Arab Rahat). A like custom is mentioned by Boyd-Alexander among the Aboboa tribe; he says: "The young boys are circumcised and for a period wear a peculiar loin cloth consisting of a fringe of grass. This is the only time I have seen this custom (circumcision) practised among the Congo tribes." I imagine here again it is also a Mohammedan introduction.

Tribal Cosmetic Operations

These operations hold as a rule the same religo-sexual significance as circumcision and face-scarring do among the Mohammedan Arabs.

Extraction and mutilation of teeth (Plate XX.)

By far the most important of their tribal cosmetic operations is the extraction and mutilation of teeth. A custom which seems to be absolutely universal amongst pagan people throughout the length and breadth of Central Africa. "So universal that a person who has his teeth is considered ugly." (Livingstone.)

The teeth implicated are the incisors, upper, lower, or both, sometimes also the canines. The operation is performed at puberty (14–16), the males always, and the females usually (according to custom) being submitted to it.

It is an "extraction" and not a "breaking-off" as has been erroneously described by Schweinfurth,[1] Livingstone and others.

A gouge (specially constructed) or simply a spear head or knife blade being inserted between the middle incisors and levered from side to side until these two teeth are loose enough to be prised out, after which the adjacent ones (if required) are readily freed in like manner and removed between the finger and thumb.

The *pointing and paring* of teeth, among those who do not extract them, is carried out by the local "expert" (the nearest approach to a savage dentist), who roughly chips the teeth into the required shape with a small chisel (a stone acting as mallet); they are then fined down and smoothed by rubbing the surface with a hard stone (*vide* Figs. 74 and 76.)

Separating teeth (an uncommon practice) is accomplished by inserting pegs of wood of gradually increasing size between them until the required parting has been reached. On asking the reason why the Gours extracted teeth which God had given them to bite and eat with, one made answer with this counter question, "Why do you remove the beard and hair that God has given you and denied to us." Livingstone, on asking the same question of the Ba-to-ka people, received the answer that they "wished to look like oxen and not like zebras." More relevant reasons are advanced, however, as:—

Tooth extraction and the reasons for its practise

1. To distinguish tribe from tribe.
2. As a sign of the state of manhood and womanhood.
3. Simply as an ornamentation.
4. To make a distinction between men and animals, especially monkeys.

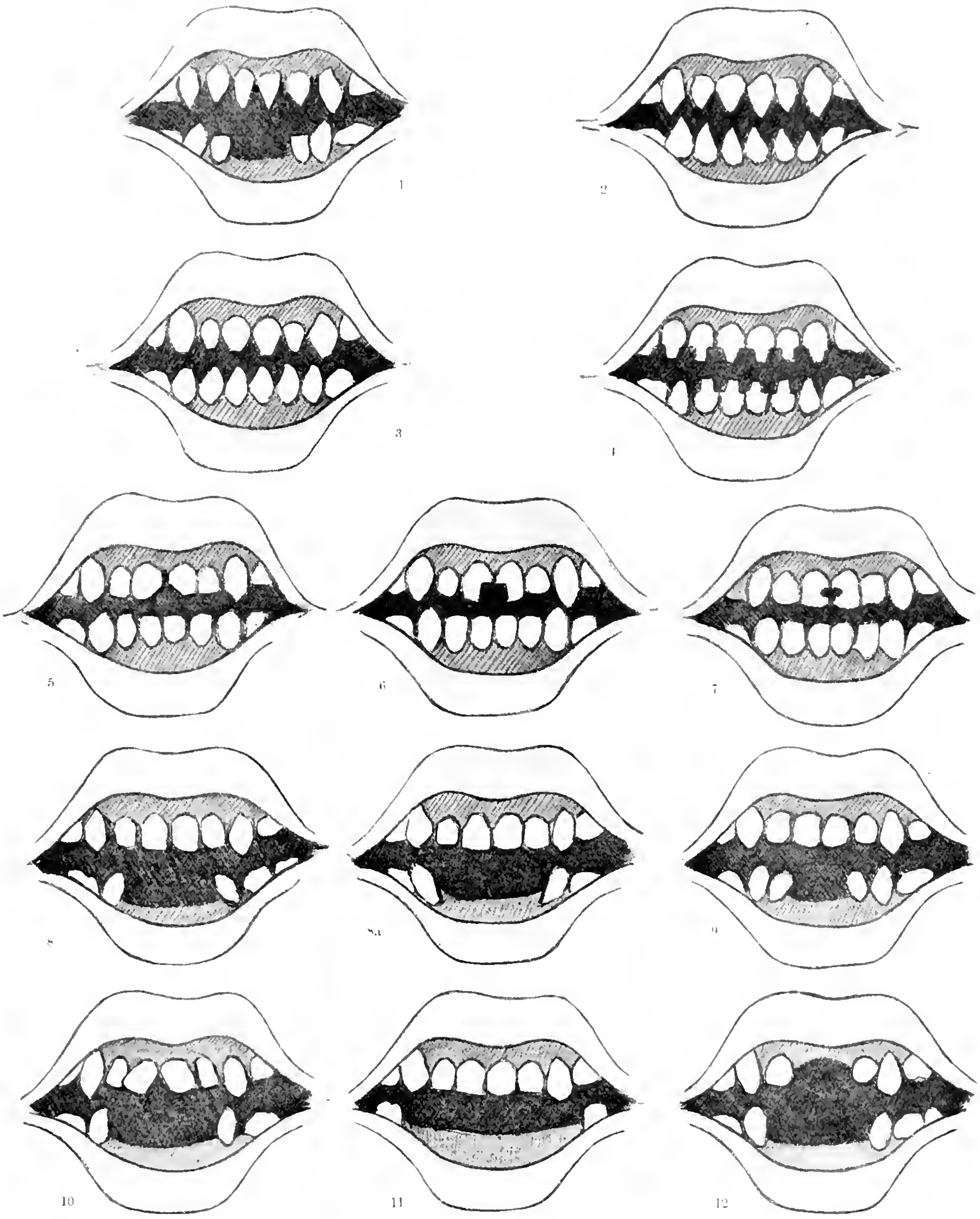
Note.—The Dinkas and Shilluks say teeth extraction is necessary to the pronunciation of their language, whilst the Nubas add a further reason in that those very sick or suffering from lock-jaw (a common disease among them) may be more easily fed.

The Zandeh give strange reasons for the sharpening of their teeth:—

1. That they may look animal and ferocious.
2. As ornament and for customs sake alone.
3. To bite and tear meat more effectually.
4. To show their cannibal proclivities.

[1] "One will hardly fail to notice among all the negro people who dwell in the plains of the Upper Nile a singular want of the lower incisor teeth which in early life are always *broken off*." Schweinfurth.

PLATE XX



EXTRACTION AND MUTILATION OF TEETH

1. Extraction of lower and pointing of upper incisors. (Nyam-nyam).

2, 3 and 4. Sharpening and pointing of incisors and two lower canines. Various designs in use by the Zandeh Nyam-nyam.

5, 6 and 7. Sharpening and notching of central upper incisors by the Avungara (or Royal House).

8, 8a and 9. Removal of all or only the central lower incisors, with alterations in direction of the unopposed teeth. (Gebelawi Nyam-nyam, Makrakka, Bagaro and Gour).

10. Extraction of four lower, with separation of upper central incisors. (Bakka).

11. Extraction of four lower incisors and two lower canines. (Gour).

12. Extraction of four lower and two upper incisors. (Gour).

These advanced reasons point the great difference in character between the Zandeh and Gour.

Methods employed by the Nyam-nyam

Nyam-nyam tooth extraction and mutilation

From the following notes it will be seen how confused are distinctions of tribe as marked by their dental operations. To describe each in some detail:—

The Zandeh Nyam-nyam custom is to mutilate and not to extract teeth. Contact, however, with the Gebelawi Nyam-nyam has given rise to frequent extractions of the lower 2 or 4 incisors, sometimes combined with pointing of the corresponding upper teeth (Plate XX., fig. 1). The usual Zandeh custom is then to sharpen or point the four upper incisors and the two central or all four lower incisors, according to various designs (*vide* Plate XX., figs. 2, 3, 4).

The Avungara (or Royal House) often leave their teeth entirely uninterfered with, or may sharpen or notch the two central upper incisors (*vide* Plate XX., figs. 5, 6, 7).

The Amienmba and Abangbinda sharpen the four upper or upper and lower incisors. Both sexes of these tribes are similarly treated though the custom among the females is not universal.

The Gebelawi Nyam-nyam as a general rule remove the four (sometimes only two central) lower incisors (*vide* Plate XX., figs. 8 and 9). In this they resemble the kindred Gours. From contact with the Zandeh, however, they have acquired the custom of sharpening and notching their teeth solely or in conjunction with extraction.

Thus amongst the Bakka, for example (*vide* Plate XX., figs. 8, 1, 10, 5), I found:—

1. Simple extraction of the four lower incisors.
2. Extraction of the four lower combined with sharpening of the four upper incisors.
3. Extraction of the four lower combined with separation of the two upper central incisors.
4. Notching of the two upper central incisors alone.
5. Teeth quite undisturbed.

This of course all points to a great confusion of custom. The Makrakka and Bagaro again sometimes leave their teeth unaltered, sometimes they extract the lower incisors or merely notch the upper central incisors (*vide* Plate XX., figs. 8, 6). The Mundu, Morro and Avokia adhere nearly always simply to the removal of the four lower incisors.

Gour teeth extraction

Methods in use among the Gours

The Gour tribes almost universally extract the four lower incisors. Sometimes they remove the two lower canines at the same time or combine extractions of the four lower and two upper central incisors. (*Vide* Plate XX., figs. 8, 8a, 11, 12). The teeth removed are perforated and hung on the Tok necklace already referred to (*vide* Plate XVIII., fig. 2).

It is not uncommon to find certain Gours and Nyam-nyam with complete sets of teeth, scarred with "Shiluk" (Tribal Marks) and circumcised in evidence of their having been formerly enslaved by Arabs. Among both these people, too, are men scarred with the tribal markings of the Shilluks and Dinkas as the result of their capture during raids and inter-tribal warfare. Little or no facial deformity results, as a rule, from the extraction of teeth, though the unopposed incisors usually spread outwards, inwards, or forwards (*vide* Plate XX., figs. 8, 8a).

Scar tattooing

The facial scars, for ornament solely, or to distinguish tribes, sub-tribes and families so universal amongst the Arab races of the Sudan and negroid Sudanese who have come in

FIG. 74.—TEETH

A Zandeh girl with sharpened teeth

FIG. 75. LIP PERFORATION

A Gour woman showing the deforming and "castanet" effect of lip discs. Notice also the fresh leaves which constitute the sole dress of both Gour and Nyam-nyam women.

76

A [illegible] of Nyam-nyam [illegible] with [illegible] contact with them, as amongst many uncontaminated tribes of Central Africa such as their neighbouring Shilluks and Dinkas—

"The curved incisions that for three months past
Proclaimed his manhood on his forehead set."

("*A Dinka Story*")

Scarring

are not found among the Nyam-nyam or Gour. On the other hand, their place is taken, especially among the Nyam-nyam, by very extensive scarring of the body (chiefly about the abdomen, back and breasts) in both sexes.

These scars are arranged, as a rule, in symmetrical and regular designs (*vide* Fig. 78), usually radiating round the umbilicus and nipples. There is no unity of pattern according to tribe or family.

The operation is generally commenced before puberty and completed bit by bit (sometimes left incomplete), though it may be undertaken in adult life, when it appears often to bear a relationship to "Blood-Brotherhood," each "brother" aiming at a similarity of design.

The scheme is first marked out in "red clay," or left to the artist's eye. Small folds of skin are then pinched up and rapidly incised, a stipple effect being gained by the number of small keloids resulting. The pain must be intense, but, since the operation is solely for cosmetic effect, and of no sounder *raison d'être*, it is cheerfully submitted to. Into the fresh wounds wood-ash and oil are rubbed to increase the scar tissue and act as a dressing.

Spurious face markings

The false "Shiluk" (tribal face scars) already referred to (*vide* Civilisation, *page* 242) as being affected by those who wish to ape a superior caste (that of the Arab or Sudanese soldier), are produced by the application of the caustic juice of a plant termed Leshe (*Zandeh*), which is painted on in the design required (commonly three diagonal lines across each cheek). It burns into the skin, removing much of the pigment and leaving light-coloured markings very difficult to distinguish on casual inspection from real scars.

A general lightening in the colour of the face is also produced by the wider application of a weak solution of this same plant.

Lip perforation (*vide* Figs. 75 and 77)

Is seldom employed by the Nyam-nyam. Among the Gour women (as is the Nuba custom), it is almost universal, more exceptionally it is adopted by their men. One such

Lip perforation

instance was that of a chief near M'volo, who wore so highly-polished a cartridge case in his upper lip that in the sunlight it was impossible to look him in the face without dropping one's eyes, an effect obviously aimed at.

The operation is performed in early childhood, one or both lips being perforated with the point of a spear and pegs inserted, of gradually increasing size, until cylinders of wood, stone or metal (usually the butt ends of 12-bore shot cartridges) can be introduced. These cylinders (unlike the Nuba variety) lie flush with the outer surface of the lip, the upper and lower incisors being removed for their better reception within. The general effect produced is beak-like and loathsome in the extreme. When both lips are so deformed they resemble castanets constantly clacking together with the jabber of their possessor.

FIG. 77. LIP PERFORATION.

[illegible] women of [illegible] show the hideous deformity produced by "lip-discs." The ear-rings, heavy bracelets, leaf-skirts and "charms" will also be noted.

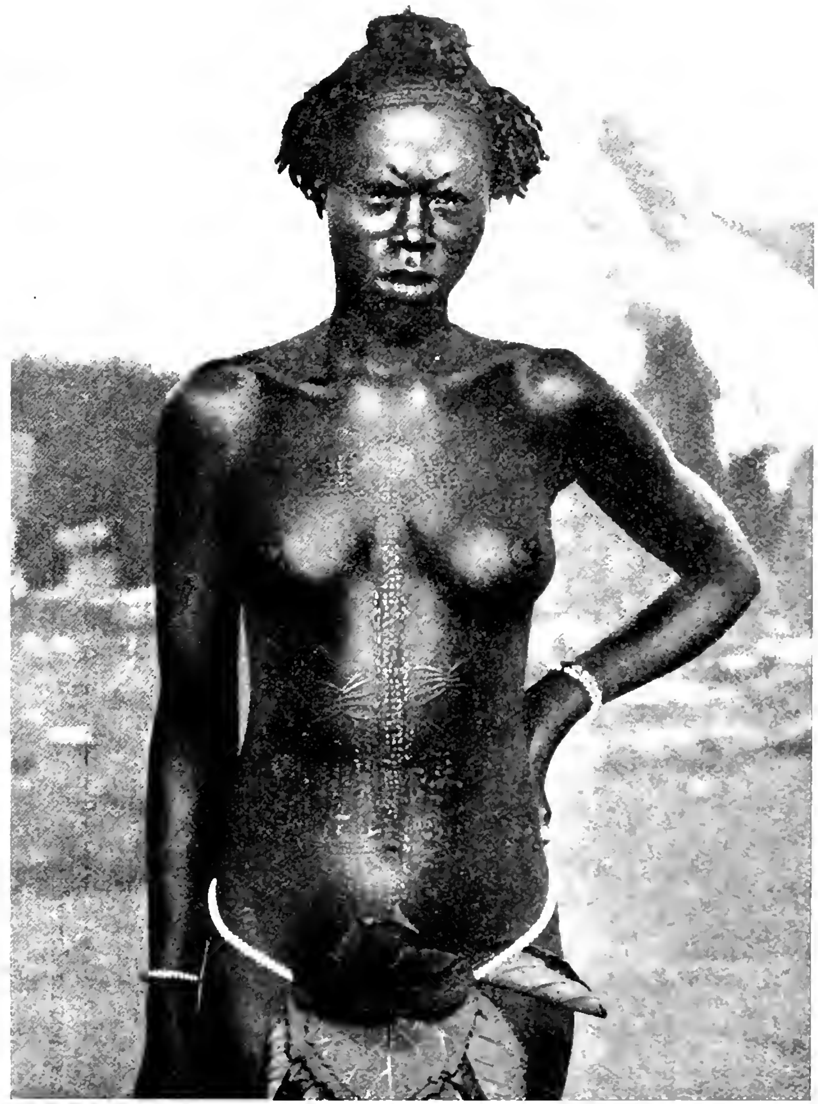


FIG. 78. COSMETIC SCARRING.

A Nyam-nyam woman extensively scarred in symmetrical design over the body and wea the primitive leaf-skirt.

Nose and Ear perforations

Nose and Ear perforations

The Gour woman, indeed, seems to aim at making herself as repulsive as possible for the delectation of the male. She not only mutilates her squat, ungainly body with scars, hideously deforms her naturally ugly face by the addition of lip discs and the extraction of teeth, but also perforates her nasal septum for the reception of a long moustache-like straw or thin stick, and the margins of her ears for the carrying of innumerable brass rings and occasionally their lobes for the reception of discs.

After perforation the ears are protected by means of half sections of small gourds placed over them and secured in position by cords fastened around the head.

Minor Surgery

A few words on the minor surgical methods of these people will bring this section to a close.

Wounds and Ulcers

Wounds and ulcers are usually treated (after cleansing with water) by the application of wood-ash, the antiseptic properties of which are well-known, charcoal, green leaves, oil, chewed-up or macerated herbs or tobacco, saliva, mud, earth and dung being also employed.

The use of Kita-Dondura leaves and powdered Gangula root, by the Nyam-nyam, has been referred to in dealing with their circumcision. Scrapings from the bark of the Barin Bala tree, or the Dagba tree-bark pulled off in large strips, are applied by them as dressings, these being held in position by ties of cord or bark, or by means of a coarse meshed net.

Fractures

Are splinted with lengths (1 to 2 feet) of twig, bamboo, or dura (millet) stalk, from four to eight in number, arranged at intervals around the limb and bound in position with several "ties," little padding being used. The splints are removed every three or four days, an advance on the continuous splinting methods of the people of Kordofan, where they are left *in situ* for as many weeks.

Surgical methods and appliances

This primitive form of splint apparently is, and has been, common to all primeval people—Sudanese, Congolese, Arabs and Abyssinians alike. Professor Elliot-Smith found it also among mummies of the Fifth Dynasty (*vide Third Report, Wellcome Tropical Research Laboratories*, Khartoum, *page* 316). Indeed it is so obvious a resource that it must suggest itself to any one in an emergency.

The Gours use broad strips of bark as slings for broken arms.

Foreign bodies

Thorns, chiggers, etc., are extracted by means of another thorn or the point of a knife, the patient, if in pain, being given a stick to bite on and so prevent his crying out.

Surgical instruments and appliances

These are so primitive that mere mention of their names will suffice. *Spears and knives*, "sappi" (*vide* Plate XIX., figs. 6-8), come first in importance, rude *forceps*, made of brass or iron, are also used, and *probes*, Mema (*Zandeh*), of wood or split chicken bone. For such purposes the Nyam-nyam woman's *hair pin* is employed as well. Their splints, slings, ties and nets for bandaging, wound guards, tooth chisels, cupping horns and circumcision clamp have already been referred to.

Personal Hygiene

Cleanliness

Under such primitive conditions as exist among savages, only very elementary ideas of personal hygiene maintain, or are necessary. Cleanliness of person and dwelling are the two main points which suggest themselves, and in these the Nyam-nyam and Gour (unlike many of the riverain people) are very particular.

Dress

Their dress being of the simplest (a small loin cloth for the males and a bunch of leaves for those "unconscious Eves," the women, *vide* Fig. 75), there is little possibility of the collection of vermin (except in the hair). Their bodies they frequently wash in water and the Gours in particular are fond of anointing themselves from head to foot with oil which they carry in a small gourd cruse, or, by suspending a loop of hippopotamus blubber around their necks, they let the exuded grease gradually trickle down over their persons. Dress and Undress

I have already mentioned the importance of ornaments as essentials of dress amongst these people, in particular the Gours. Scarring of the body too, among their females, seems to hold a similar significance, and without it a woman is considered certainly unconventional, perhaps hardly decent.

A comparison between the men and women of this race is interesting in respect to clothing; the men are finely built, sleek, well covered, easy going and decidedly effeminate, wearing beads and ornaments of a light and flimsy variety (Fig. 69). The women, *passées* after the age of 18 or 20, like the men, carry knives and not infrequently spears. They are short and squat, deformed by lip, nose and ear mutilations, their bodies covered with "ornamental" scars and laden with the most ponderous trinkets of iron (necklets, anklets and bracelets, Plate XVIII., figs. 7 and 9-13). Their appearance is Amazonian, therefore, and hideous in the extreme.

When among such people, one realises the enormous blessing of ample clothing to hide not nakedness but ugliness. Very little suffices to mark the difference between mere decency and indecency so-called—a distinction which varies so widely according to place and circumstance. The Dinka virgin, for instance, considers it indelicate to wear any covering whatever.

Diet

The ordinary diet of the Nyam-nyam and Gour is of the plainest and coarsest variety, a factor which contributes largely towards the excellence of their teeth. Millet (Dura) is the staple food, a couple of handfuls eaten raw or crushed and boiled with a piece of raw hide, to give it flavour, or ground and mixed with sim-sim oil to form *Mullah*, will suffice them for the day.

Meat. Meat, however, is for them one of those "luxuries of life which are its only necessities," eaten raw, or cooked, fresh or decomposed, flesh, fat and viscera, nothing comes amiss. The onomatopaeic significance of the name Nyam-nyam has already been referred to. It is not ill-merited. Their orgies over the decaying carcases of animals where the jackal and vulture have to be driven away to make place for the superior animal, man, are indescribable. The like have been recorded by the ancient Egyptians during their exile in the Sudan enforced by the Hyksos Kings. What cannot be eaten at the time is cut into strips, dried or smoked as Sharmata (Pemmican) and stored in their huts. Having no domesticated flocks or herds for killing purposes (owing to the prevalence of tsetse), and, finding the trapping and hunting of game only possible during the three Voracity of the Nyam-nyam as meat eaters or four dry months of the year, meat is as a rule scarce, which fact, coupled with their inordinate craving for it, must tend strongly towards cannibalism.

Indeed, almost any form of flesh is devoured; amongst other unconventional varieties are:—

Dogs as food

1. Dogs (*vide* Fig. 72) indigenous to the country are preserved for fattening and eating by the Nyam-nyam. (The Gours do not touch human, dog, or the flesh of carnivora.)

2. Reed-rats (Far-El-Boosa, Arabic—*Thryonomys swinderenianus*), a large rodent, almost the size of an otter, which frequents the Riverain roads of the Southern Bahr-El-Ghazal, is particularly appreciated. I have tried the flesh, which is indeed excellent.

3. Lizards and snakes, skinned, cut into segments and cooked or dried.

4. Snails. Like the ancient Romans and modern Continental nations, both Gour and Nyam-nyam consume snails (N'Ginza, *Zandeh*, a large species of marsh snail 1 to 3 inches in diameter), several varieties of which exist. Extracted from their shells and boiled with water to a homogeneous mass they are considered a great delicacy.

5. Ants. The large red ant, taken at the season when enormous numbers of the winged variety swarm from their nests, is like the Kungo fly farther south, cooked and eaten, being, I believe, very palatable.

6. Locusts are also consumed, a custom common to Kordofan and many other parts of Africa and Asia from time immemorial.

7. Caterpillars. A variety called in the *Zandeh* tongue Arami, very plentiful at certain seasons are boiled down to form a thick yellow butter.

8. Butterflies. By name N'Gongo and Aga (*Zandeh* tongue), are similarly made use of.

Other unusual articles of flesh diet are any form of carnivora, apes and monkeys. Fish is largely caught and eaten along the numerous rivers of this country, though the fresh water oyster is considered poisonous, and left therefore untouched.

As regards vegetable diet, plantain, melons, tomatoes, dulaib palm, roots and fruit and sundry berries and nuts are the chief varieties.

Drink

The quite unsophisticated savage, I presume, drinks nothing but water, and little of that. After eating, the mouth is usually rinsed out, and sometimes the teeth cleaned with a fore-finger dipped in wood-ash, before the one draught sufficient for his needs is swallowed.

Merissa (Native Beer) is now largely brewed and consumed, as is Umbilbil, a similar product.

Cannibalism

I have reserved this subject of especial though morbid interest as a "bonne bouche" to the last.

Cannibalism not yet abandoned

That the cannibal habit was very rife with the Nyam-nyam of the Bahr-El-Ghazal before the present Government's days is an undoubted fact. It still exists among their Azandeh brethren of the adjacent Belgian Congo, and, as the sad death of Captain Roenning (then Commandant of Kiro and Lado), who on his way to Boma in 1908 was captured, "torn to pieces and devoured raw"* proves, the custom is by no means extinct in Central Africa.

For the most convincing and gruesome details as to its practise there, I would refer to Grogan's *From the Cape to Cairo* (*pages* 184 and 185), from which there can be

* *Official Report*

no doubt as to its prevalence and the revolting nature of its details. On enquiry in the Eastern Bahr-El-Ghazal the Nyam-nyam naturally belittle as much as possible their cannibal tendencies, whilst the Gours, who for long enough formed these people's staple human diet, exaggerate them in every way possible. It is hard, therefore, to come at any exact information on the subject. It would appear, however, that the Zandeh were the original cannibals and that they introduced the habit amongst the conquered and enslaved negroid Gebelawi races, a peculiar transference from a higher to a lower type.

The Zandeh probably the original Cannibals

Those used for food were commonly the killed, wounded and prisoners taken during raids. Persons about to die amongst their own tribe are declared also to have been violently put to death and eaten by their neighbours. Indeed, one Sultan Bambia, near Tembura, was said to have a contract with an adjacent chief for the mutual exchange of such victims, whilst amongst the Azandeh Monbutto, members of the same family are reported to have helped in devouring one another. Schweinfurth, indeed, mentions this latter tribe as far surpassing the Nyam-nyam in its cannibalism. Judging by Grogan's adventures and from an account given me by Zubeir Pasha of his experiences in this same region, these details seem little exaggerated. Human carcases were apparently treated exactly as are those of animals, the skin being drawn off complete, the body eviscerated, disjointed, cut into sections, and laid on a bed of fresh leaves prior to distribution. Babies were seemingly treated whole. Human meat, termed Kowar (*Zandeh*), besides being eaten raw, was, true to the old song, either "roast or boiled or dried in the sun," the flayed hide sometimes being converted into a water-skin.

The eating of the flesh of enemies was considered to make the consumer fierce, warlike and wise. This has its parallel among the people of Kordofan, who consume small quantities of the flesh of various carnivora for a like purpose. The undoubted relation of cannibalism to other "moral perversions" is strongly exemplified among the Nyam-nyam. It is a subject which has been dealt with by Richard Burton in the Appendix to his *Arabian Nights*.

Birth

Child-birth with all savages, among whom education has not hypertrophied the infant's head to pathological proportions, is a physiological and simple act. Great cleanliness is preserved, the expectant mother being laid on a bed of freshly-cut leaves. Every woman who has had a child is considered qualified as a midwife, and as this is an event of their teens, the calling must be considerably overstocked. The assistance rendered by small boys in cases of difficult labour has already been referred to, though difficult labour among these people, apparently does not present the insurmountable obstacles met with in civilised life. The newly arrived child is left unclothed, its bed being the mother's arms, or a nest of fresh green leaves.

Child-birth

Gour mothers often carry their infants slung in a neat basket over their backs, which can be tied to one of the beams in the wattle-hut and so serve as a cradle.

Death

Death among the crude and superstitious is always looked upon with great awe. These people, especially the Nyam-nyam, are no exception to the rule. As it is considered a visitation of the evil powers, the dying are often shunned and neglected therefore, and in instances where some great one "shuffles off this mortal coil," or a series of unaccountable deaths occur (from infectious disease), the entire village may migrate to avoid further inflictions of an unseen vengeance.

These deserted homesteads are no uncommon sight therefore. On arriving at Dego's village in the north of the Lado District to investigate the question of Sleeping Sickness reported as existent there by the late Boyd-Alexander, I found the chief's grave conspicuous in the centre of a fast decaying and completely depopulated village, the inhabitants of which had, I discovered, migrated to a situation one day farther South after Dego's death.

Death and burial

Space will not permit of my entering into the many burial rites of these tribes which are strangely interesting and complex; how the Nyam-nyam, cruel even in death, requires (be he a sultan or chief) living sacrifices of from 2 to 10 women (according to his rank), who are immured, still living, beside his dead body, or how the favourites and councillors of a sultan consider themselves lucky if they are left alive and not called upon to flatter and advise their departed master in a shadowy after-world.

Conclusion

Before ending I must apologise for having diverged somewhat widely from the thread of "medical custom" which has formed the nucleus of this essay. In considering the racial peculiarities of any people, from whatever standpoint, one is inevitably drawn towards comparison with others and other customs. I have, I feel, unconsciously done so too much in the preceding pages.

Such a divergence has, however, emphasised for me, at least, the extraordinary similarity of thought, custom and belief which obtains apparently throughout the entire extent of savage and semi-civilised Africa. Like the chemical transfusion of liquids the change is imperceptible and gradual until harmony is reached. Thousands of centuries have levelled widely diverse peoples to a similarity of idea and custom which must strike the most unobservant on travelling a hundred miles in any direction through wild Africa, or if he cannot travel, on reading any two able books on the customs of any two races throughout this Continent. In this homogeneous mass of humanity, which has lain fallow through "half an eternity,"

"When holy were the haunted forest boughs,
Holy the air, the water, and the fire,"

Need for force in the civilisation of the African

there exists an incalculable latent force, only awaiting the vitalising spark of civilisation to give it an entity. And yet, so far, civilisation has done but little, to my mind, in that it has striven sporadically to do too much. It seems to me that it is the force and not the finesse of civilisation that is required, the rousing of the savage (necessarily against his will) from his infernal lethargy and sloth, to the necessity, if not "to the dignity" of labour (a point strongly emphasised by the late Cecil Rhodes), his impressment, sweating, forcing, what you will, justly done (as by a parent towards a vicious child) and without bias or interference with his sounder essential traditions. In the light of which considerations there may, I think, be found an apology for the main lines of that drastic Belgian-Congolese industrial policy which has lately raised so much controversy.

The object and value of coin before culture, of spades before spears, of rakes and hoes before books and pens, of a monotheistic belief in the simple creed "La illaha ill Allah" (There is no God but God), without distinction of religious sect or faction, in fact, that "pure worship, not of one faith, not of one land, which all men lofty of soul will practice till the end of time," as Renan puts it in his *Life of Jesus*, seems to me what is wanted. These are, I am convinced, the forces necessary to arouse the black man from his torpor and destroy that greatest of all obstacles to progress and reform, savage superstition. They surely are essential before any details of religion, *morale*, or education, and it would seem largely through their influence that what I have described as the "unconscious conversion" to Islam, has made such advances amongst:—

"Your new-caught, sullen peoples,
Half-devil and half-child."

As regards the healing art (our original subject), after due consideration, one must conclude that it is more magical than medicinal, and in its superstition an unqualified danger. Were the crudest outline of medicine and hygiene more widely distributed among these people (on such a system as the present training and posting of "sanitary barbers" in the rest of the Sudan) the benefit would be great, especially in its influence on the increase of population, due to diminished infant and adolescent mortality.

And yet, when all has been said and done, it remains an open question whether, politically at any rate, it were not as well to leave the savage utterly to his primordial darkness.

I would like here to express my thanks to the numerous officials and authorities whom I have quoted in reference, more especially to Major S. Lyle Cummins, R.A.M.C., for many valuable suggestions; as also to Mr. Stanley C. Dunn, Sudan Government Geologist, for his kind permission to produce illustrations (Figs. 69, 70); to Mr. George N. Morhig, proprietor of the English Pharmacy, Khartoum (Figs. 73, 77); and to Messrs. Saoulli & Chrissanthou, proprietors of the Victoria Book Stores, Khartoum (Fig. 78).

FIG. 79.—EUWA DIVINING BOARD (SIDE VIEW)
(Vide page 252)

FIG. 80 PUBLIC GARDEN AND GORDON STATUE KHARTOUM

FIG. 81. TRAMWAY, KHARTOUM

FIG. 82 VIEW [illegible] KHARTOUM

FIG. 83. EMBANKMENT ROADWAY, SHOWING [illegible]

Some Municipal Engineering Problems in the Tropics

(With special reference to Khartoum City)

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Introduction

In tropical countries, as in Europe, the development of a city is generally attended by a series of engineering problems peculiar to each stage of its growth. The following notes refer specially to some of the problems which have presented themselves in the development of Khartoum and to the provisions made by the Municipality for the future development of the city. The history of the new Khartoum began with the reconquest of the Sudan in 1898, when the ruins of Gordon's old town were removed, to a large extent, and a new and modern city was laid out.

The meteorological conditions obtaining and the geographical position of a town affect, to a large extent, the particular lines of its development. The following description of the conditions at Khartoum will give a better appreciation of the special problems under consideration.

Meteorological and other conditions at Khartoum

Khartoum, the capital of the Anglo-Egyptian Sudan, is situated at the junction of the Blue and White Niles in north latitude 15° 30′ and about 1,260 feet above the level of the Mediterranean. The climate is a semi-arid desert one, there being a rainy season from July to September, but the annual amount of rainfall varies considerably, and in some years there may be only a few heavy showers. The maximum temperature in winter is generally over 90° F., but the cool and dry north wind which prevails makes it very pleasant. The maximum summer temperature is seldom over 110° F., but this, with a prevailing south wind, is often very trying, more especially during the occasional dust storms. During the rains, although the temperature may fall considerably, the increased humidity makes it equally unpleasant. Comparatively cool nights are experienced however, practically throughout the whole year. The temperature in winter seldom falls below 50° F.

A description of these meteorological conditions, which, it will be observed, are somewhat peculiar, is given by Dr. Balfour in the Third[1] and also in this Report[2] of the Wellcome Tropical Research Laboratories.

Khartoum is built on a bed of alluvium, the surface of the ground being practically level throughout, while part of the town is below the level of extreme high Nile. The

[1] *Loc. cit., pages 62–64* [2] *Volume A, page 263.*

difference between high and low Nile here is about 23 feet and the flood commences annually about the month of June.

The population of Khartoum is at present 22,680, and of Khartoum North 38,700, making a total of 61,380, by far the greater proportion of whom are Sudanese.

Problems to be considered

The problems to be considered may be divided into the following sections:—

(I) Town planning

(II) Streets and open spaces

(III) Buildings and

(IV) Water-Supply and Sanitation.

In each section the historical aspect will be treated in so far as it affects the present arrangements or the further developments proposed by the Municipality.

1. Town Planning

It has been stated generally, that the requirements to be observed in the planning of a town are proper sanitary conditions combined with convenience and the preservation of amenity, all of which, it may be said, tend to promote the highest well-being of the community. It is evident that the ideal town will vary with the character and needs of the inhabitants, as well as with its geographical position and the climatic conditions obtaining.

In Khartoum, the climate, more especially in summer, renders it desirable that Europeans should live in houses so arranged as to be exposed to the prevailing north or south wind. Whenever possible, therefore, they are placed fronting to the north or south and surrounded by gardens or open spaces. The natives, however, can live comfortably in much more crowded circumstances, so that, owing to this and to the cost of land in the city, the houses in the native quarter are often built abutting and with courtyards (*hooshes*) in the centre of them. Partly for these reasons the streets, especially in the European quarter, have been made of considerable width.

The result of compliance with the foregoing conditions is that, for the number of its inhabitants, the city is spread out over a comparatively large area, thus involving a greater expense in street making, conservancy, etc., than would be the case where the conditions allowed of a more compact town.

Old Khartoum

The old Khartoum of Gordon's time was very far from ideal so far as the requirements of Europeans were concerned, and, but for the peculiar circumstances which permitted a fresh start to be made, we might now be in the position of trying to remedy past errors and to improve and develop the city at great trouble and expense.

The following descriptions of old Khartoum and of the development of the new city are extracted from a paper, by one of the authors, on "The Planning of Khartoum and Omdurman."[1]

"From the accounts of the travellers, Petherick and Melly, who visited the Sudan in 1846 and 1850 respectively, it appears that Khartoum had then become a place of considerable importance. They recorded the irregular construction of the town and the presence of narrow and winding streets which were quite impassable after rain. Here and there were spaces resembling squares, and the architecture of the houses was primitive. There were only a few European residents."

[1] "The Planning of Khartoum and Omdurman," by W. H. McLean, at the R.I.B.A. Town Planning Conference, London, October, 1910.

"Sir Samuel Baker visited Khartoum in 1862, and he described it as a miserable, filthy and unhealthy spot. The houses were built chiefly of mud brick, and the town had a densely crowded population of 30,000. He again visited it in 1870 and found the population had fallen to about 15,000, and the town in the same insanitary condition."

"In 1880, Felkin, a medical man, records improvement in the sanitary arrangements, the existence of good houses and better class shops, and the erection of grand Government buildings, and a large hospital."

Such, then, was the old Khartoum which was destroyed by the Dervishes when Gordon fell, in 1885, and remained in ruins until the reconquest of the country by Lord Kitchener in 1898.

New Khartoum

The early development of the new Khartoum (Fig. 84) is thus described:—

"With the occupation of Khartoum and Omdurman the formation of a civil administration for the government of the country was immediately begun.

"The Municipality of Khartoum was established by order of the Governor-General in Sudan Gazette No. 29 of November 1, 1901.

"Major E. A. Stanton, late Governor of Khartoum, in a lecture[1] at the Royal Colonial Institute, described the early development of the new Khartoum. The ruins of old Khartoum, he said, were levelled with the assistance of the troops, streets were driven through the debris, and other necessary works undertaken as funds became available. The various public services were gradually inaugurated. The land settlement appears to have given considerable trouble owing to the 'land grabbing' propensity of the native, but eventually disputes were settled and house building begun. Then the land boom came up from Egypt and prices rose from 1*d*. or 2*d*. per square yard to £2 or £3 per square yard. The crash came early in 1907 with the breaking of the Egyptian bubble and Khartoum has hardly yet recovered.

"The Sudanese native villages immediately to the south, outside the old fortifications, were built to accommodate the natives who had been living previously amid the ruins of old Khartoum. In this way an attempt was made to segregate the native population, a very desirable arrangement, more especially from a sanitary standpoint, as the epidemics to which all tropical cities are liable can be so much more easily dealt with.

The general scheme

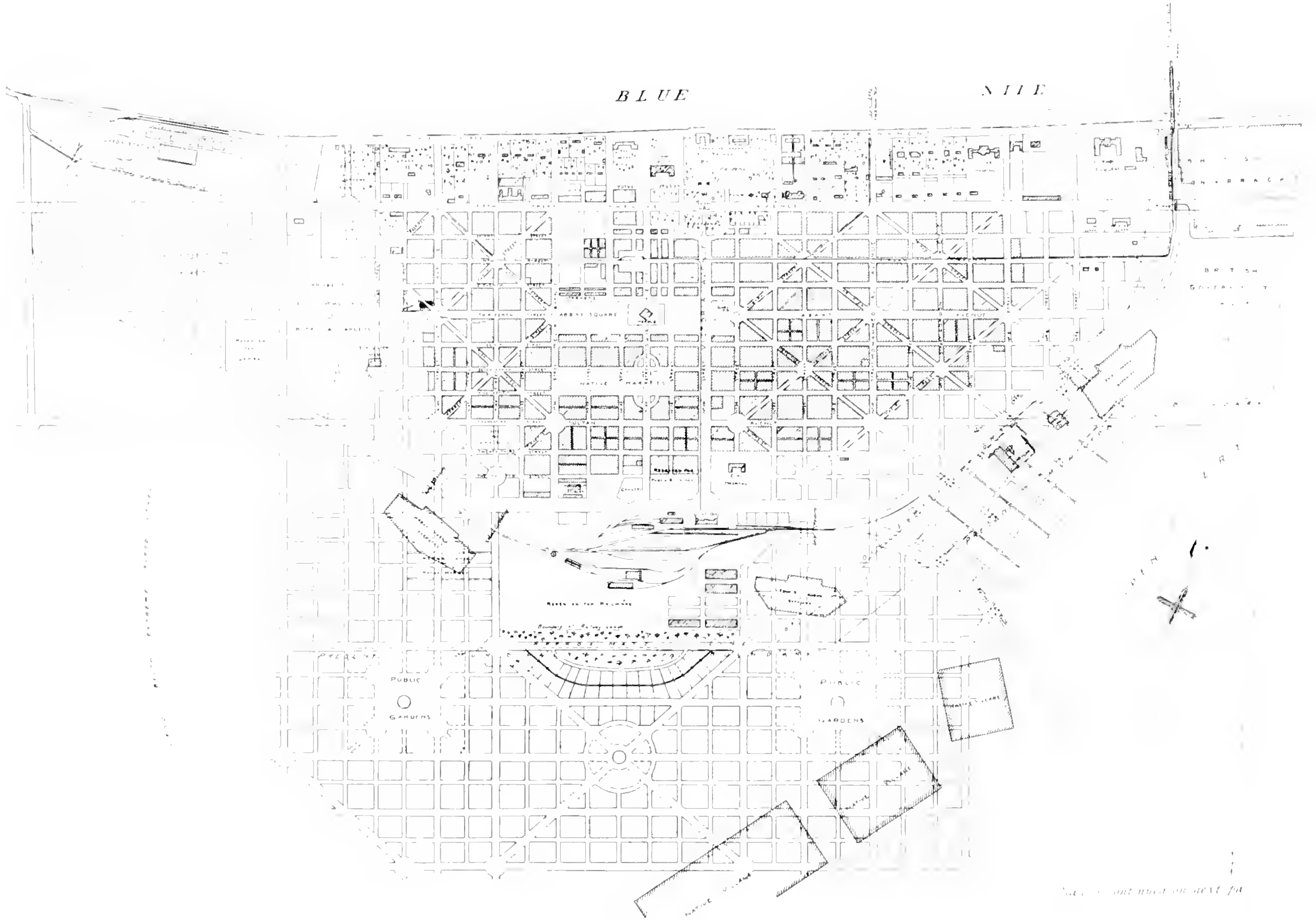
"The general scheme on which the town has developed was initiated by Lord Kitchener before he left the Sudan, and the most striking feature of the plan is the diagonal streets which appear to have been introduced primarily for military purposes. Each crossing of these diagonals commands a considerable portion of the city. The diagonal streets are undoubtedly a useful direct communication between various points, but at the crossings they form awkward building plots, which are somewhat inconvenient in the business quarter of the town.

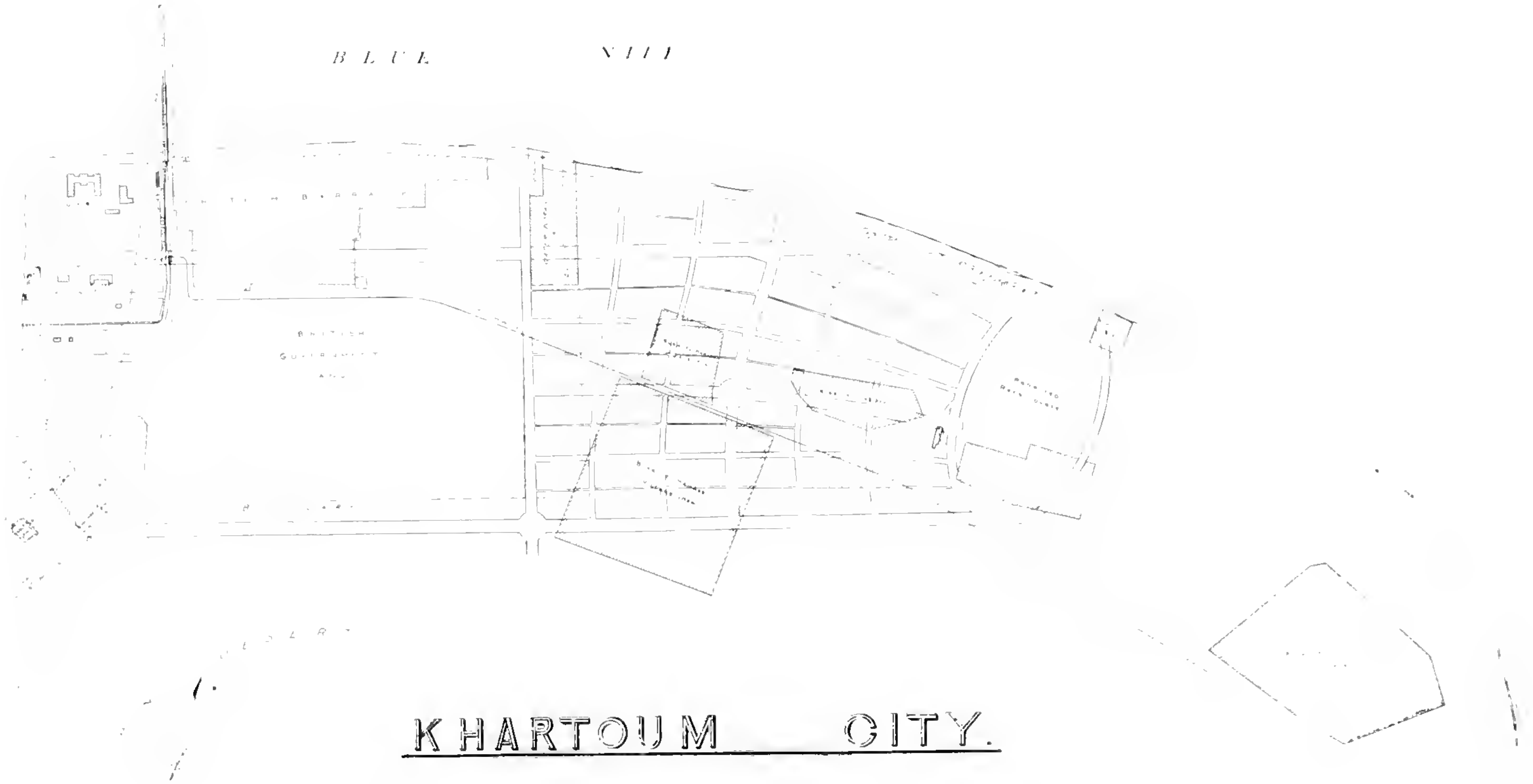
"The general scheme of the planning is that the main avenues running parallel to the river intersect those running at right angles, forming rectangles approximately 500 yards square. These rectangles are subdivided by three streets running each way parallel to the main avenues and by the diagonal streets connecting the intersections of the main avenues.

"All the land between the Embankment and Khedive Avenue is Government land, while that to the south, where hatched on the plan, is principally private property.

"With the laying out of the Government land to the North of Khedive Avenue there was not quite such a free hand owing to the desirability of utilising and preserving what

[1] "Khartoum and the Sudan," by Major E. A. Stanton, late Governor of Khartoum. Read at a Meeting of the Royal Colonial Institute on February 15, 1910.


BLUE NILE
BRITISH GOVERNMENT
ABBAS SQUARE
NATIVE MARKETS
PUBLIC GARDENS
PUBLIC GARDENS
NATIVE VILLAGE



KHARTOUM CITY.

PROVISIONAL PLAN SHOWING PROPOSED LINES OF DEVELOPMENT

NOTE THE PLOTS OR AREAS ALREADY BUILT ON ARE SHOWN HATCHED

SCALE 1:23760

Fig. 84

remained of the principal buildings and gardens of old Khartoum, and this accounts, to some extent, for the want of symmetry in the plan. The palm groves in the gardens form one of the most attractive features of the city."

The land to the south of Khedive Avenue was divided into three classes, and the steps which were taken in connection with its allotment for building purposes, to ensure some uniformity in the class of buildings and the preservation of amenity, are described with reference to "Regulations" in Section III (Buildings).

The plan (Fig. 84) of the present city shows that the municipal boundaries enclose a strip about $1\frac{1}{4}$ miles wide between the Blue Nile and the old fortifications, which run from the Water Works on the east to the White Nile on the west, a distance of about $4\frac{1}{2}$ miles.

The bridge across the Blue Nile has been recently completed and the railway carried round to the New Central Station and thence to the Moghren Quays, thus completely encircling the city. Under-bridges are provided on the Embankment and on Khedive Avenue, but beyond the latter point the railway is practically at ground level. At present, access across the railway is obtained by means of level crossings, but some of these will be ultimately replaced by bridges. Incidentally, the railway embankment forms a protection against flooding of the low-lying lands during extreme high Nile, and also mitigates the sand drift from the surrounding desert.

Future Khartoum

The new Khartoum has now almost extended to the limits of the original scheme of planning, and, with the construction of the railway, it became necessary to consider the lines of future development. The determination of these has been greatly facilitated by the fact that the greater part of the land surrounding the present town is Government property.

The lines of future extension shown on the plan (Fig. 84) were laid down in consultation with Lord Kitchener at the time of his recent visit to Khartoum, and he has therefore been able to complete the scheme initiated by him in 1898.

It will be observed that the railway gives an opportunity for a girdle avenue round the city, and that the continuation of the diagonal streets provides convenient radial communication with the central area. A special feature is the prolongation eastwards of Sultan Avenue till it meets the Embankment in a large ellipse enclosing a race course, etc. The area between these avenues will be ultimately a superior residential quarter.

The extension to the south includes provision for three public gardens and a market, and two diagonal avenues giving convenient communication to the railway crossings.

The Zoological Garden is at the west end of the town, and the Governor, Major C. E. Wilson, proposes to have it removed behind the site for the Museum, and to combine it with a large Botanical Garden, as shown on the plan. The space between these gardens and the railway and behind the Moghren Quays and goods station is intended to be the Merchants' quarter.

Flooding during high Nile

All the land to the south-west of the city outside the railway is liable to flooding during extreme high Nile, but when reclamation works have been executed it is proposed to lay out this area as a residential quarter.

It will be noted that it is not proposed to continue the system of diagonal streets, as their *raison d'être* in a small garrison town is not applicable to a large city. The inconvenience of the awkward plots formed at the crossings of these diagonals is referred to under "Streets" (Section II). Where possible, the original "gridiron" system is continued, as, owing to the direction of the prevailing wind already referred to, it is desirable for the houses to have an approximately north and south exposure.

II. Streets and Open Spaces

The proper width of the streets is one of the first problems that presents itself. Under certain conditions in the Tropics it may be permissible and even desirable to adopt somewhat narrow streets, but in Khartoum a liberal width has been allowed, especially in the main avenues. Thus the wind has free access to the houses, which, as has been shown, is so necessary in the hot weather when "air movement" must be obtained either naturally or artificially.

The disadvantages of the wide streets are the increased cost of construction and maintenance, the greater area of land required, and the consequent spreading out of the city. Wide streets

The following particulars of the streets in Khartoum, details of which are given in Fig. 85, are taken from the Paper already referred to.

"Victoria Avenue, the most important, is 180 feet in width and is centred on the Palace, from which there is a most striking vista away to the south with the luxuriant gardens in the foreground. Khedive Avenue, running at right angles, is next in importance, being 150 feet wide. The Gordon Statue is at the crossing of these two principal avenues.

"The main streets are 120 feet and the secondary streets 80 feet wide over all, and many of the plots in the third class or native quarter of the city have lanes 12 feet wide running through them, made principally for conservancy purposes.

"Fifteen feet of the width of all footpaths is contributed by the owners of the abutting properties, who are permitted, however, to build arcades over this portion.

"The streets and avenues are named on the following system, which has proved a satisfactory one. All streets running parallel to the river are known by odd numbers, the Embankment being 'First Street,' and all streets at right angles to the river are known by even numbers, beginning at the east end of the city with 'No. 2 Street.' The principal streets and avenues have special names in addition. The diagonal streets are named after the more important battles fought in the country, *e.g.* 'Atbara Street.' System of naming streets and avenues

"The sections (Fig. 85) show the types of avenues and streets. Khedive Avenue is the largest type, in which the footpaths each occupy about one-third of the total width, and along each footpath two rows of trees are planted.

"The Embankment is of a similar type, but the footpath widths vary considerably owing to the irregularity of building line and the river embankment where there is no retaining wall or other protective work.

"Thirteenth Street (Abbas Avenue) is the main street type with 30 feet footpaths, half of which may be covered with an arcade. Seventh Street is the type in the business part of the city.

"Owing to the expense which would be involved in constructing and maintaining such an enormous area of street surface, only the middle third of main avenues and streets are macadamised at present. The side portions form soft 'going' for horses, while the vehicular traffic takes the centre. In the business part of the town the whole width is, of course, macadamised. Curb stones are laid in some of the principal avenues and streets, but the footpaths are merely made up with earth, except where proprietors have constructed tiled or other pavement in front of their premises. Meantime, only a few of the main avenues and streets are macadamised, but the work is being pushed forward as funds become available.

"Fig. 85 shows a block in the third class or native quarter with the 12 feet wide conservancy lanes traversing it. An enlarged plan of the Double Street Crossing is also shown."

Diagonal crossings

From the detail of the double diagonal crossing referred to it will be seen that the shape of some of the plots makes them very inconvenient, especially in the third class residential or business quarter of the town, where the buildings are usually erected on the frontage. In many cases the owners of such plots have kept the buildings back somewhat and planted the corners as gardens, the effect being excellent.

Owing to the very arid climatic conditions during the greater part of the year, combined with the high winds, it is extremely difficult to maintain the surface of the macadamised streets. Experiments have been made with various mixtures of tar and pitch as binders, but it was found that the limited funds available precluded their use meantime. In spite of the destroying action of sun and wind, fair results have been obtained with a mixture of Nile mud and sand, especially in places where the subsoil is damp, due to the presence of salt. Further experiments with crude petroleum and other materials are in progress, however.

The Embankment and the streets running north and south, which are exposed to the prevailing winds, are troublesome to maintain as are also those constructed without a proper bottoming. The foundation is Nile mud, a clayey soil which is exceedingly hard when dry but becomes soft when damp so that in the absence of efficient bottoming the upper crust breaks up under heavy traffic. This is what happens in the case of those streets bottomed only with small stones which sink into the foundation.

The metalling used has been principally weathered fragments of iron-stone broken to 2" cubes, but recently fine grained grey granite has been laid in some of the main avenues.

The distressing effect of the glare from roads in the Tropics metalled with light-coloured materials is well known. The glare from streets metalled with the iron-stone or grey granite is not uncomfortable when blinded in the ordinary way with sand and mud, and it is even lessened by the application of some of the special "binders" referred to. The selection of colours and materials to modify the effects of the light and heat rays of the sun is dealt with in reference to "Buildings" (Section III).

Rain-water drainage

The drainage of the rain water is often a problem in the Tropics, as the rains occur generally during only a part of the year and are then exceptionally heavy. It is usually necessary, therefore, to provide a special rain water drainage system. At Khartoum the rainy season is from July to September, the remainder of the year being practically dry. The amount of rainfall recorded varies from a maximum of 188 mm. (7·4") in one season to a minimum of 15 mm. (·59") in another season, the maximum recorded for any one day being 45 mm. (1·8").

The system adopted meantime is that of open trenches, as recommended by Mr. C. E. Dupuis,[1] M. Inst. C. E. At the street crossings steel pipes are used and the main trenches are carried along the less important streets, and across open spaces where possible. The inconvenience of the trenches is thus reduced to a minimum.

As very few of the streets are metalled to the full width between kerb stones the trenches are excavated entirely through soft material which is replaced after the rains. Fig. 86 shows the details of the system. To reduce the depths of the main trenches the outfalls to the river are comparatively frequent, and, as they are all somewhat below high flood level, the trenches can only be emptied by pumping if heavy rains occur during extreme flood.

[1] Late Inspector General, Sudan Irrigation Service, now Adviser to the Egyptian Ministry of Public Works.

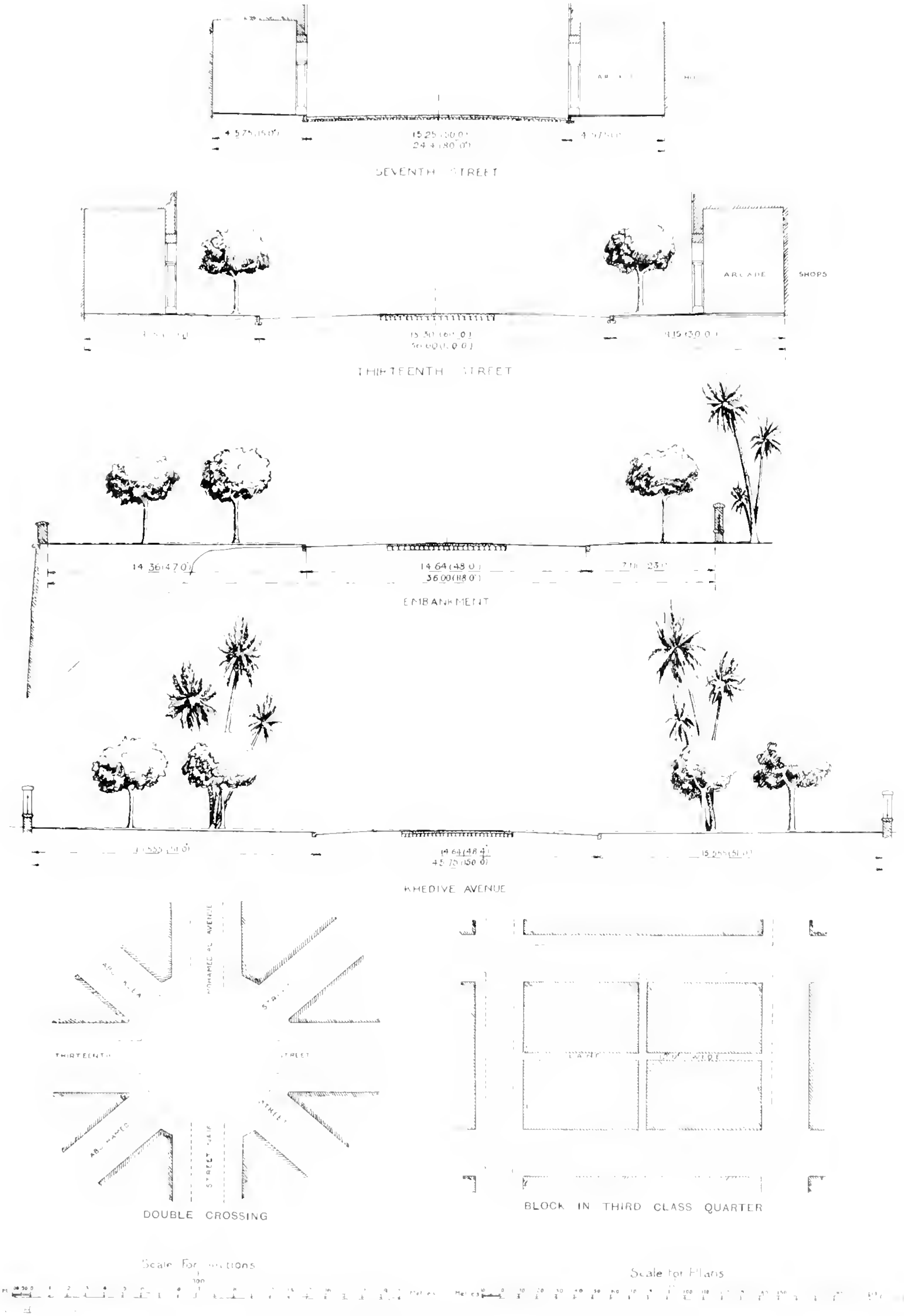


Fig. 5. Typical Sections of Avenues and Streets.

Tramways

The permanent way of tramways is now such an integral part of street-making that some reference might be made to the system in vogue at Khartoum. The tramway here is in reality a light railway of ·60 metre gauge, consisting of flat-bottomed rails weighing 12 kilos per lineal metre, laid on steel sleepers. It does not run in the metalled parts of the streets, but where this is unavoidable, as at crossings, guard rails are provided to preserve the flangeway. Tramway section rails are also in use at crossings and on curves, but these are not satisfactory unless some causewaying is done both outside and inside the rail. The photograph (Fig. 81) shows the Khartoum Central Station and the type of rolling stock in use.

Open spaces

The provision of a certain amount of open space, while improving the amenity is also very desirable on hygienic grounds, especially in the more densely populated native and business portions of a town.

Reference to the plan (Fig. 84) will show that in the first class quarter in Khartoum there are public gardens at the Gordon Statue in Khedive Avenue, while at the west end of the town there are the Zoological Gardens. The photograph (Fig. 80) shows the public gardens with the Gordon Statue at the crossing of the avenues and the Palace in the background.

The most important open space, however, is Abbas Square between the second and third class quarters, which is 800 yards long and 200 yards wide. Meantime this square is only partly laid out, but the complete scheme is indicated on the plan (Fig. 84).

In the third class quarter there is the native market, to a large extent simply an open space, in which the merchandise, consisting principally of grain and fire-wood, is laid out.

The provision of future open spaces in Khartoum has already been referred to.

Trees

Trees, which are planted in double rows in the avenues and single rows in the streets, besides providing very desirable shade and improving the amenity, do much to protect the street surfaces and allay the dust nuisance. The following information on tree planting in Khartoum has been kindly provided by the Superintendent of Public Gardens, Mr. F. S. Sillitoe.

There are now in the avenues and streets from 3000 to 4000 trees of the following varieties:—

Albizzia lebbek (Lebbek) is a well-known tree throughout Egypt. It is deciduous, which is a great drawback as it is bare during a part of the winter, but it soon bursts into new growth of a beautiful green colour and its flowers have a delicious perfume. Seed is produced abundantly, in long pods, which, when ripe, it is advisable to remove as they give the tree an untidy appearance.

Albizzia procera, a native of India, is a quicker-growing tree than the former, but is useless unless it has good soil and plenty of water.

Ficus bengalensis (Banyan), also a native of India, is well known on account of its ærial roots, which in this dry climate have scarcely appeared as yet on nine-year-old trees. This is the best of all trees here, but it should not be planted beside buildings, especially if near water, as the roots are so strong and penetrative. The large roots that spring from the base of old trees are also apt to cause inconvenience in the footpaths. The foliage is of a bright colour, and nearly evergreen.

Ficus sycamorus (Gameza) is also a fine shade tree but is of a much duller colour.

Ficus religiosa, with the peculiar long apex to its leaf, has also been tried and found satisfactory.

Kigelia æthiopica ("Sausage tree," on account of its large seed pods which hang on long stems) is a native of tropical Africa, and has proved a fine shade tree if given plenty

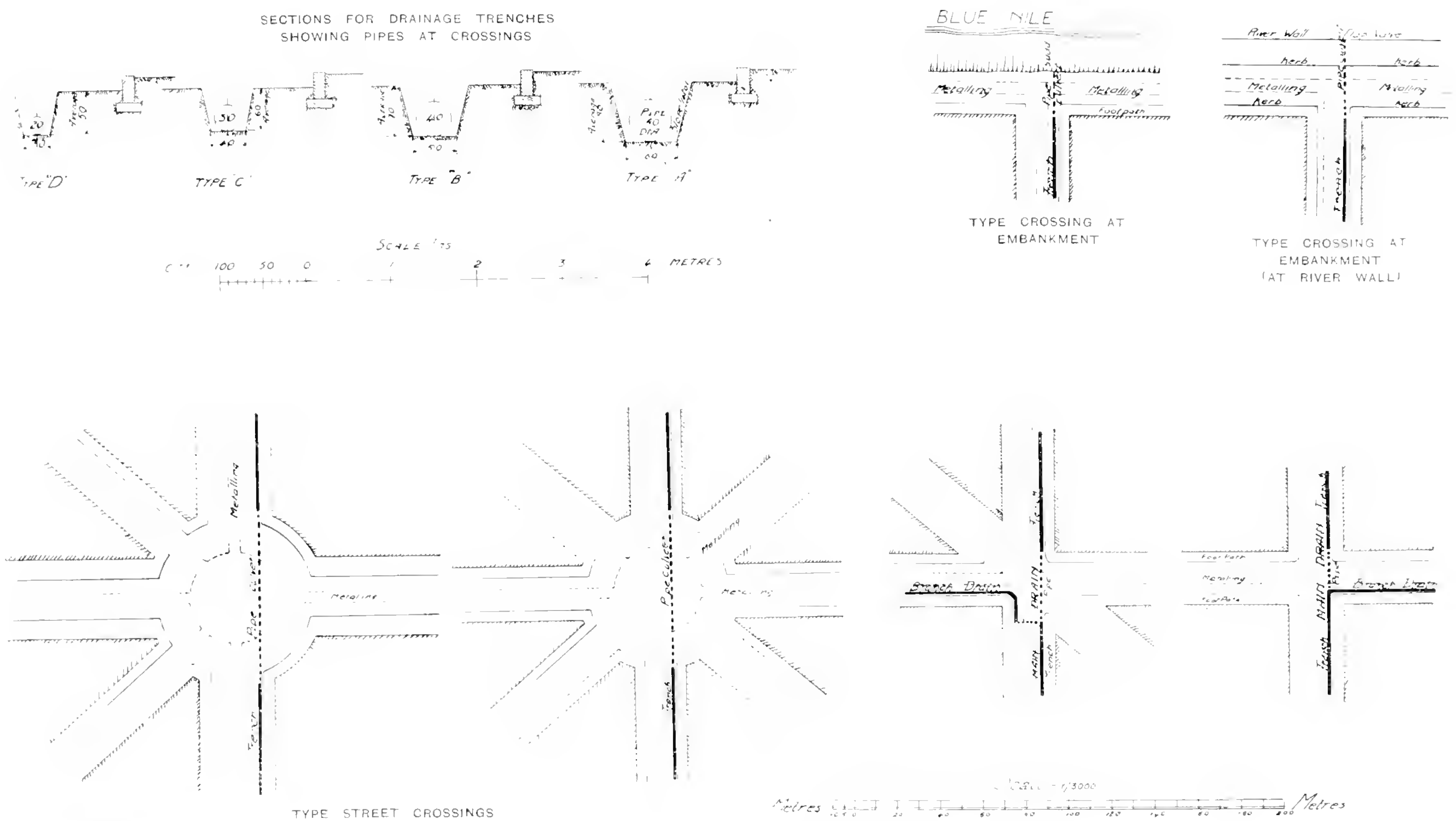


FIG. 56. RAIN-WATER DRAINAGE SYSTEM

of water and fairly good soil. This also applies to *Dalbergia sissoo*, and *Bauhinia purpurea* with its handsome flowers.

Effect of variations in soil on trees

Owing to the variation in the soil met with in Khartoum one cannot always be certain of success in tree planting. The best soil, of course, is found along the river Embankment where the *Albizzia lebbek* and *Albizzia procera* make handsome trees in five or six years. In other parts of the town there is a light soil consisting mostly of drift sand in which, when once established, the Lebbek does well. The most troublesome soil in which to get trees to flourish is in Victoria Avenue, where there is a stiff clay soil full of salts and almost impervious to water. After many trials, *Ficus bengalensis* (Banyan) has been planted and is making rapid progress.

The trees are planted 10 metres apart, and, if in a double row, alternately with five metres between the rows. When planting, it is in most cases advisable to dig a hole one metre deep and refill it with good soil. The trees, if small, require shading for some days until established, and in some parts of the town goats have given considerable trouble, and it is necessary to protect the young shoots from being eaten. Wire netting one metre wide, supported by two strands of telegraph wire, has proved quite a success, although when the growths reach the top of the netting they are often broken by children and animals.

Staking the young trees is most important, and as one has to contend against strong winds and white ants it is difficult to find a cheap and suitable support to prevent their being broken. When quite small a stout bamboo stake is the best support and lasts some time, but when the tree has a fair sized head, a 3 inch × 3 inch telegraph pole 13 feet long, painted with "solignum" or other preservative, is used.

Watering of trees

All the trees were at one time watered by native women who carried the water in jars (burmas) on their heads, a very slow method; but now water-carts drawn by mules and filled at the street stand pipes, have proved much more efficient.

An earthen basin is formed round the tree to retain the water, and in tiled or other footpaths it is necessary to leave a sufficient opening and desirable to provide a grating on top of this basin.

Fig. 83 is a photo of the Embankment roadway, which shows the excellent shade provided by the "Banyan" trees on the left, and also the strong roots already referred to. The trees on the right side of the road are "Lebbek."

III. Buildings

The provision of suitable buildings, both for public and private purposes, is of primary importance. How often one sees in the Tropics buildings of a type quite unsuited to the local conditions, and sometimes even a purely European type may be found. Much may be learnt from a study of the native type of dwelling, and although it may be necessary to modify it considerably to suit the European mode of life, yet many of the underlying principles should be maintained.

Before proceeding to the consideration of the requirements in a dwelling to meet the conditions at Khartoum, it would be well to review the history of building operations there subsequent to the allotment of lands in the new town and the relative regulations issued from time to time, as these have had some influence on existing types.

In the paper[1] already referred to the early building operations are thus described.

[1] "Planning of Khartoum and Omdurman."

FIG. 87. BUNGALOW, KHARTOUM.

FIG. 88. NATIVE HOUSE, KHARTOUM.

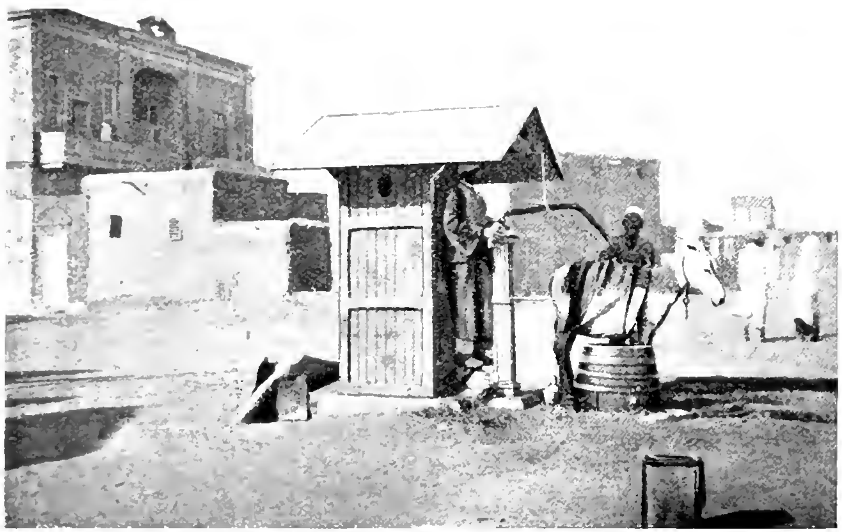


FIG. 89. DISTRIBUTION STATION (STREET FOUNTAIN).

FIG. 90. WATER-CART STAND.

"For the purpose of allotting land for buildings, the city was in the first instance divided into quarters, and to ensure some uniformity in the class of buildings to be erected there was specified in the Regulations issued the minimum value of the building and the class of material to be used in its construction. It was further enacted that, within a certain time after allotment, the buildings were to be erected, and a fence or a boundary wall of a certain value built round the plot in default of which the land would revert to the Government. This procedure was necessary to check mere speculators in land, although in spite of it gambling was rife and prices rose to a ridiculous figure. Building operations were delayed in many cases, and in order to save the land inferior structures were rushed up at the last moment, at famine prices of course. The situation was a difficult one to deal with, as too great severity might have seriously crippled the young city.

System of allotments

"Latterly it has become necessary to provide for a greater control in the detail of the building operations and recently a simple set of detailed Regulations, adapted to the use of the country, were issued. These have worked in a very satisfactory manner, and the inhabitants appear to look upon them as a guarantee against the practices of the 'jerry-builder.'"

Regulations

The regulations referred to are entitled "The Town Building Regulations, 1909," and although primarily drawn up for Khartoum City are arranged to meet the conditions in the towns of Khartoum North and Omdurman.

A copy of these regulations is given in Appendix "A." Section 4 shows how the land is classified, thus dividing the city into quarters, and Section 5, under the head of "General Regulations," describes the class of buildings which may be erected in each quarter.

The General Regulations (Sections 5 to 33) are applicable to all classes of building, but the Special Regulations (Sections 34 to 55) "do not apply to buildings of only one story in height, the walls of which consist entirely or partly of mud or unburnt mud bricks." The third class quarter of the city consists almost entirely of such buildings.

The regulations are based on a well-known model, but modified considerably to meet the local conditions and to avoid undue severity.

Types of houses

In a paper on "Dwelling Houses in the Tropics," by one of the authors in the last Report,[1] reference is made to the fact that white men in the Tropics, besides being well protected from the heat rays of the sun, should also be protected from the light rays which have such a harmful effect on the nervous system. The pigmentation of the skin of a black man cuts off these light rays, and he has, therefore, only to shield himself from the heat rays to be quite comfortable. It is necessary to note this fundamental point in comparing the native house with that suitable for the European. Thus the black man could live with perfect safety under a covering which would be entirely inadequate for the white man.

The native houses in the region of Khartoum, as will be seen from the photo (Fig. 88), have only a few small openings in the walls and are thus well darkened. Provided there is a sufficient roof covering, such a house will be found quite comfortable for a European so far as protection from the sun is concerned. The walls are generally of mud which, although liable to considerable damage during the rains, has a certain advantage over brick or stone in being cooler owing to its lower conductivity, so that it does not to the same extent absorb the heat during the day and radiate it at night.

[1] "Dwelling Houses in the Tropics," by W. H. McLean—*Third Report, Wellcome Tropical Research Laboratories*, Khartoum, 1908.

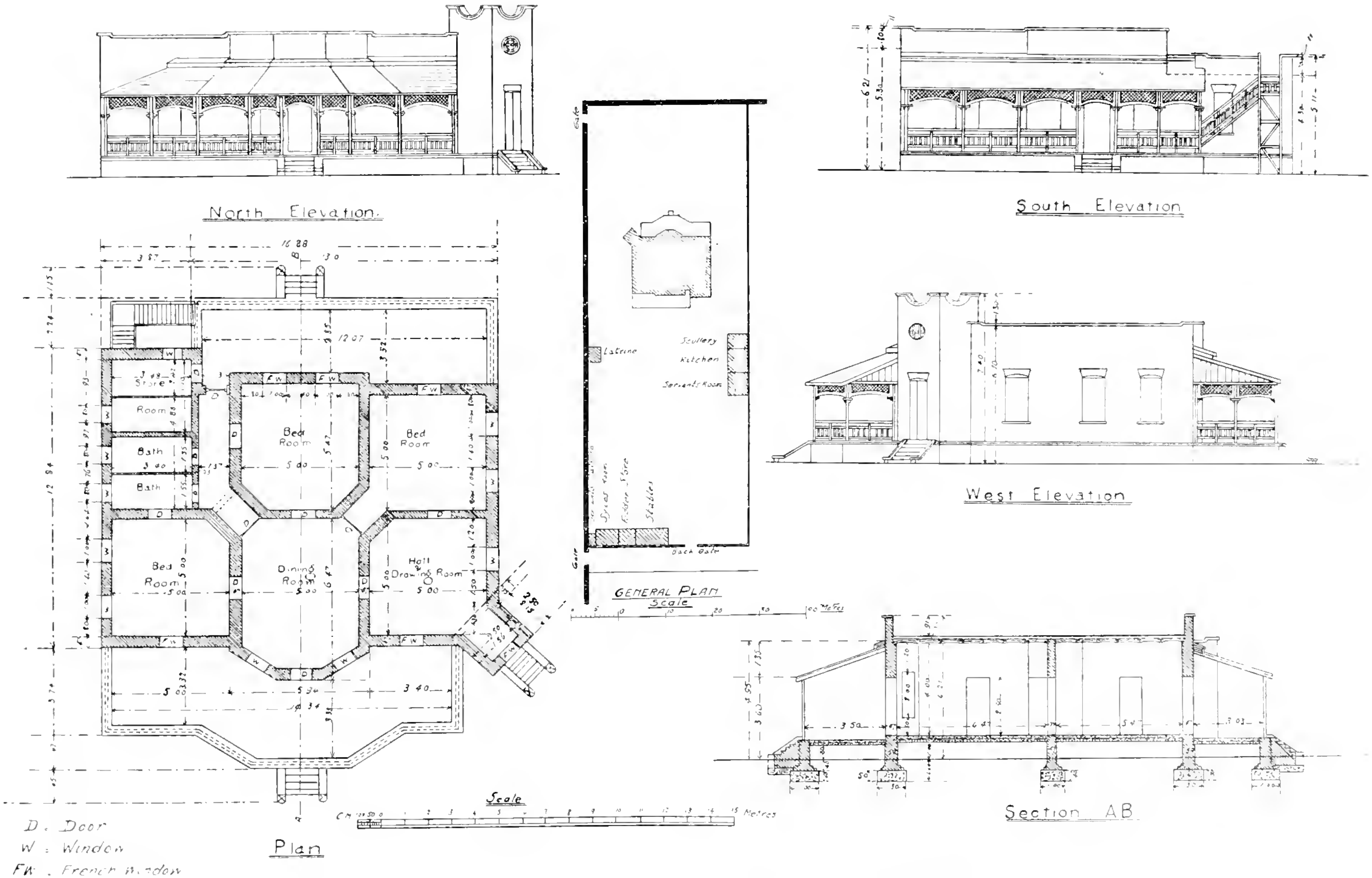


Fig. 91. Plan and Elevation of Bungalow at Gordon College.

So far as circumstances admit, the following points should be observed in the construction of dwelling houses for Europeans in the Tropics:

Points of a dwelling for Europeans

(*a*) The walls should be protected from the sun by verandahs, especially if they are of brick or stone, and have as few openings as possible if not so protected.

(*b*) Verandahs should be not less than 10 feet wide, preferably of timber as being cooler than brick or stone, brought down to within from 4 feet to 7 feet above the floor level, with an air space between roof covering and lining and ventilated at the top.

(*c*) Roofs of house and verandahs should be thick enough to stop both the heat and light rays, and be lined if constructed of timber.

(*d*) Rooms should be arranged as far as possible so that each gets a share of the prevailing winds.

(*e*) Colours should be employed to which our eyes are naturally adjusted, such as the greens, dark yellows and browns, white being avoided, especially for outside decoration, as the glare from it in the Tropics is terrible.

The foregoing points were fully dealt with in the paper on "Dwelling Houses" referred to, and a suggested plan was given which, with slight modification, the authors have had an opportunity of carrying into effect for the Gordon College Staff Residences. Fig. 91 shows the details of one of these bungalows, and Fig. 87 is a photo of the north elevation of the other. Side verandahs, especially on the west, would have been desirable, but the necessary space was not available.

The general type of building in the central area of the city is shown in Fig. 82, which is a view from the War Office looking down Mosque Avenue towards the Mosque. It will be seen that the flat roof is almost universal. In dwellings these flat roofs form convenient sleeping places during the hot weather, but to keep them quite watertight during the rains is a matter of some difficulty.

As the mosquitoes are kept down by the Sanitary Service Mosquito Brigade, mosquito-netting is not required on the door and window openings, but sun shutters or "louvres" are fitted on all windows. The kitchen, servants' quarters and latrines in European houses are generally detached from the main building, the latter being against an outside wall to facilitate removal of the buckets.

Foundations

It is difficult to get a good foundation on alluvial soil, such as Nile mud, unless there happens to be a fair proportion of sand mixed with it, which reduces the expansion and contraction. Section 41 (Foundations) of the Regulations referred to specifies the maximum load to be put on such a soil. The foundation should be carried deep enough to avoid the surface cracks, and reinforcement may be necessary in some cases to prevent cracking of the walls.

Garden irrigation channels should be kept well away from all walls, as, if too near, they may affect the foundation and cause local subsidence and consequent cracking. It may be here noted that the great variation in temperature appears to be deleterious to work built of very rigid materials unless special precautions are taken.

IV. WATER-SUPPLY AND SANITATION

Distribution

Prior to the introduction of the present water-supply in 1909, the needs of the population, both native and European, were provided for by water taken from the Nile and distributed by means of water bags slung on the backs of donkeys, or by water drawn from shallow wells. Khartoum is now supplied from deep wells, the pumping

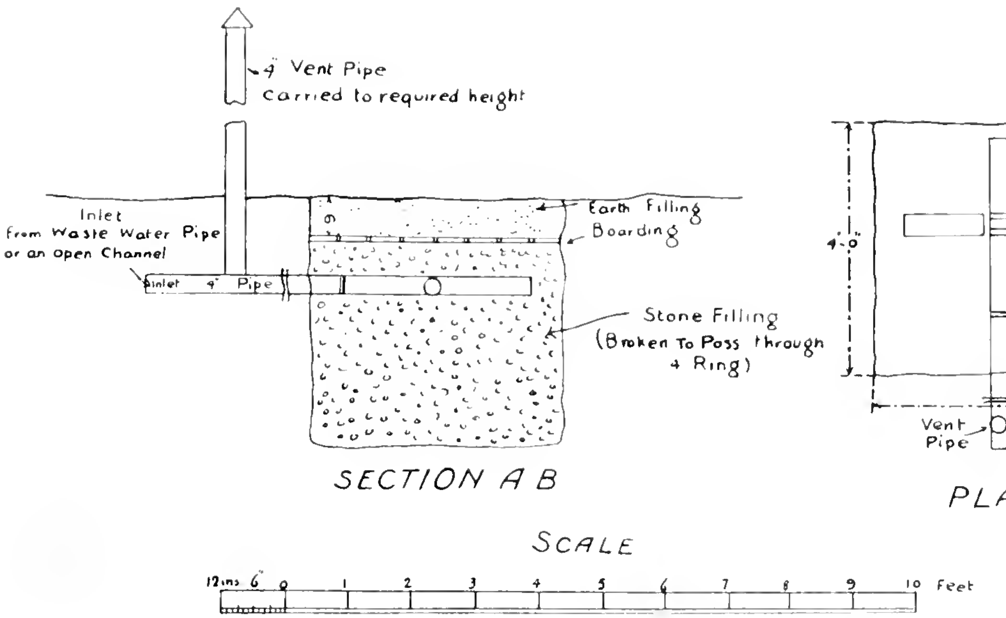


Fig. 92. Percolation Pit

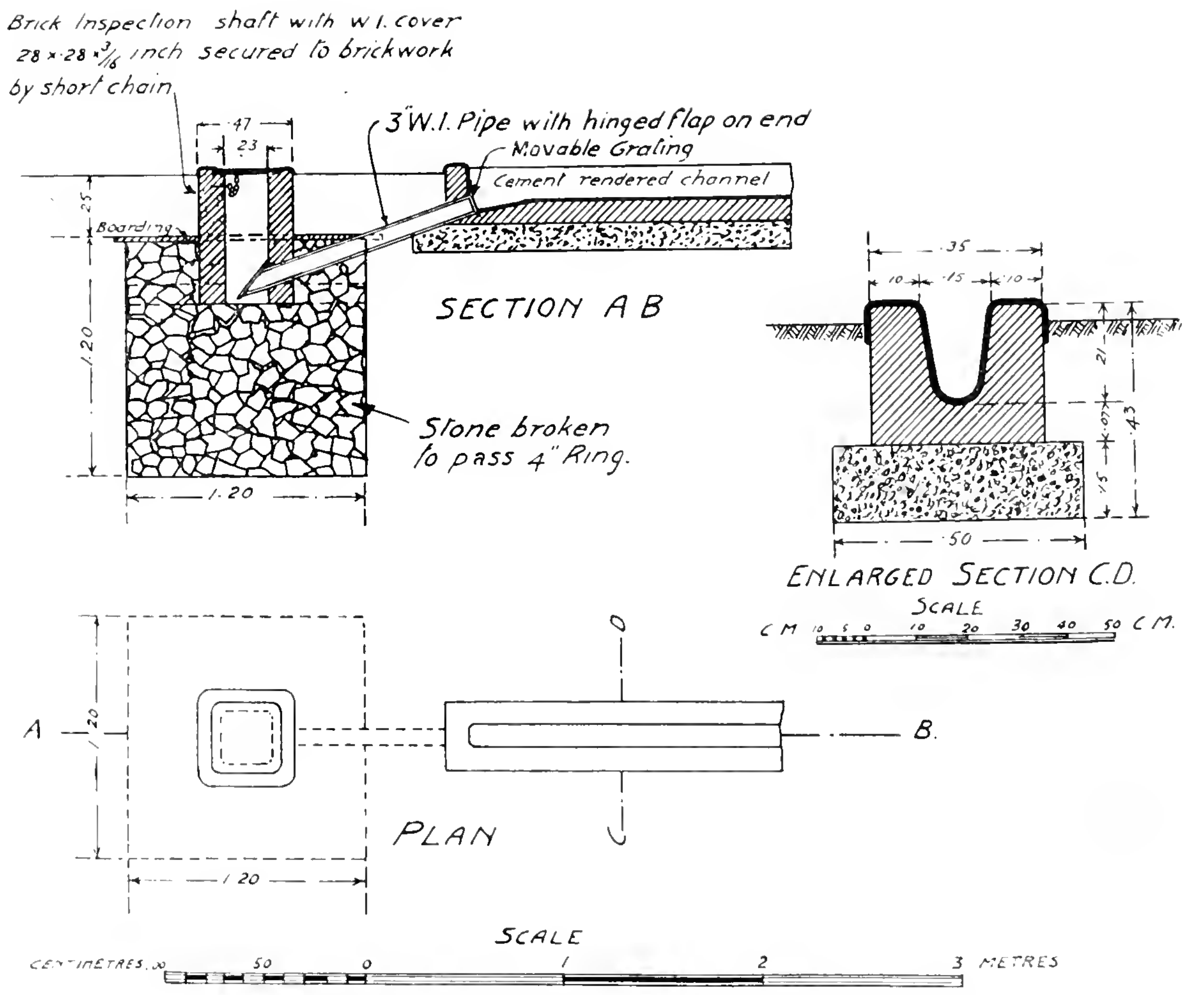


Fig. 93. Percolation Pit. New Type with Mosquito Trap

installation in connection with which is combined with the electric light power station, both of which are administered by the Public Works Department.

Water-supply

The water-supply is laid on to European houses, hotels, etc., and the better-class shops and native houses, while the bulk of the native population is supplied from street fountains. Each of these fountains is fitted with a meter, and a man is placed in charge to collect the payments for water drawn. At first, trouble was caused by water being spilled on the ground and forming an extensive puddle on the unmetalled streets, but this has been much reduced by the use of an armoured hose fixed to the top of the fountain and by sinking a barrel in the ground to catch the drip as shown in the photograph (Fig. 89).

The number of distribution stations of this kind is necessarily limited, owing to the cost of installation and working expenses, and the system is therefore objectionable on account of the danger of pollution of the water during its subsequent distribution by donkey-bags, etc. It has therefore been proposed to erect a large number of small street fountains in the third-class quarter of the city for free use by the public, a water rate being levied on householders.

The trouble caused by spilt water was also experienced in filling carts for street and tree watering, but the arrangement shown in Fig. 90, consisting of a vertical pipe with a bend and a short length of hose at the top, has diminished the waste, and a hole under the street filled with rough broken stone under the macadamised surface allows the spilt water to soak away and keeps the street comparatively dry.

Wells

Before the introduction of the town water a great number of houses obtained their supply from wells sunk in the "hoosh" or yard, very often in close proximity to latrines, stables and other sources of contamination. Since this supply has become available, however, many of the wells, especially in the better-class quarters of the town, have fallen into disuse and been filled up, and even in the native quarters their number is diminishing. Wells are looked upon as objectionable and are discouraged as far as possible. If infrequently used and not properly covered they become breeding places for mosquitoes, and they are at all times liable to contamination, especially from surface water getting into them during the rains. Clause 24 of the Building Regulations (Appendix A) empowers the municipal authority either to forbid the construction of a new well or to order the filling up of an old one, and specifies that all wells must have a proper steining built up one foot above ground to prevent the inflow of surface water, and a close-fitting cover, kept in proper repair, to exclude mosquitoes. Fig. 96 shows the type drawing of a well head which is issued when an order for the repair of an old well or sanction for the construction of a new one is given.

Irrigation

The public and private gardens in Khartoum are irrigated partly by water from the town mains and partly by water drawn from the river by "sakias," or native wooden water wheels worked by bullocks. Most of the gardens lie between the Embankment and Khedive Avenue (*vide* Fig. 84), and the fact that the bank of the river is almost always higher than the land immediately behind it, renders this area particularly well suited for the distribution of the irrigation water by gravitation. Behind Khedive Avenue, where the land begins to rise again, the inconvenience and expense of the separate distribution system that would be necessary for its irrigation by river water possibly justifies the use of the town supply. The trees in the streets were formerly watered by native women water carriers, but the work is now performed by water-carts filled from the street stand-posts. A scheme is at present under consideration for superseding the sakias referred to, by three-inch electrically driven irrigation pumps, which should give

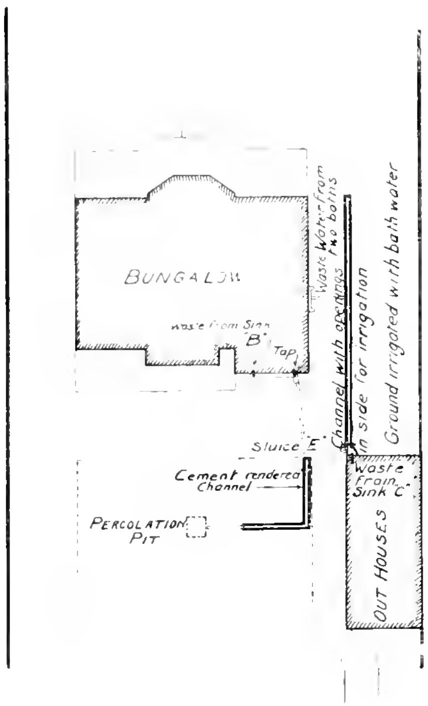


FIG. 94. TYPE WASTE-WATER DISPOSAL SYSTEM

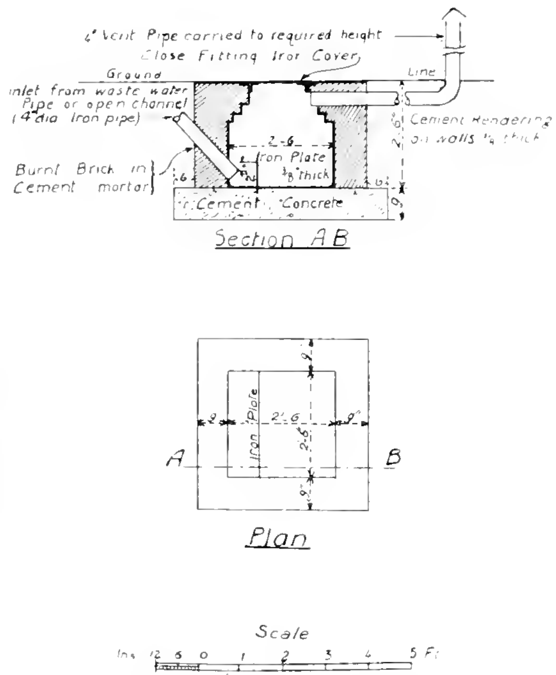


FIG. 95.—TYPE WASTE-WATER PIT

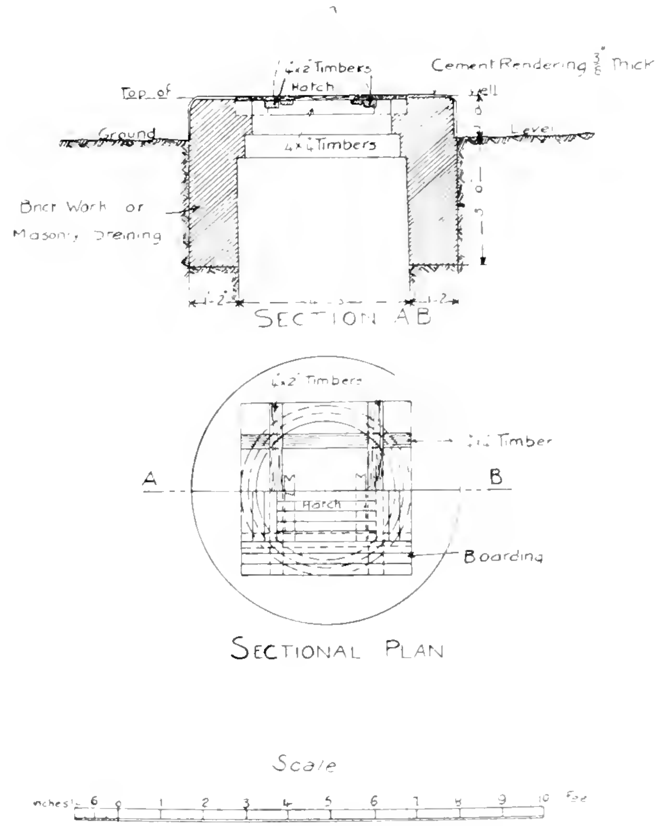


FIG. 96. TYPE WELL HEAD

a more liberal supply than the present arrangement, and would also provide economically for the watering of streets and trees near the river front.

Sanitation

"The Town Building Regulations, 1909," already referred to in detail, contain certain clauses, Nos. 24 to 30, dealing with various sanitary matters. These clauses regulate the construction of wells and closets and the disposal of waste water and will be referred to more particularly under their respective sections. Type drawings, from which figures Nos. 92 to 96 and 100 and 101 have been prepared, are issued to applicants whenever necessary. They are intended simply to illustrate the intention of the Regulations, and compliance with non-essential details is in no way insisted on.

Waste-Water Disposal

In the city of Khartoum there is at present no system of drainage with the exception of trenches, which are dug every year for the removal of surface water during the three months or so of wet weather in the summer, so that the disposal of waste water presents a problem of some difficulty. The drainage trenches referred to are dealt with under Section 11 (Streets). Under the old system of water-supply the consumption was necessarily limited, so that the amount of waste to be dealt with was small and presented little difficulty. With the provision of an ample supply of water from the town mains, however, a new set of conditions were established, and, with the gradual extension of the water service, the increased amount of waste from baths, sinks, cafés and wash-houses, etc., necessitated special arrangements being made for its disposal.

Three methods of waste-water disposal are in use, namely, (1) Irrigation, (2) Percolation Pits and (3) Waste-Water Pits, one or other of which is adopted to suit the requirements of each particular case. They are referred to in Clauses Nos. 25, 26, 27 and 28 of the Regulations and illustrated by Figs. 92 to 95.

(1) *Irrigation*

Where practicable the most satisfactory method of dealing with waste water is to discharge it on to a suitably prepared and cultivated area of ground. In houses which have even a small garden, bath water can be satisfactorily and usefully employed in this way, but the waste from sinks, etc., flowing in small quantities and containing, as it does, a much larger proportion of grease and fatty matter, is apt, unless very carefully attended to, to foul and clog the ground and create a serious nuisance.

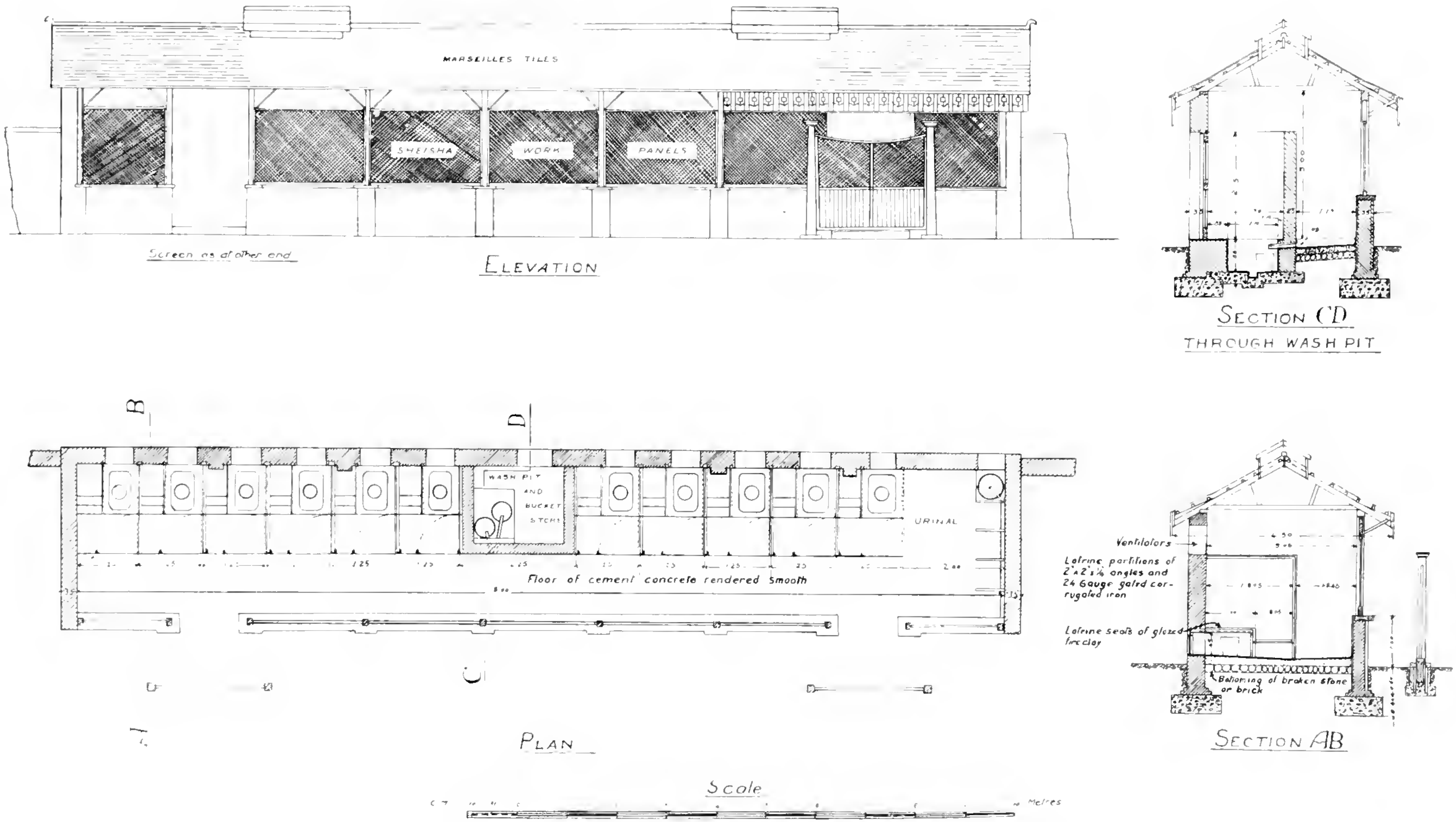
Water-disposal by irrigation

A good example of disposal by irrigation on a larger scale is the system adopted by the Railway Department for dealing with waste from the engine sheds and other sources at the Khartoum Central Station. The waste water is drained to a common sump within the railway property and from there pumped to a main gudwal from which an area of some two acres of cultivated land is irrigated.

Generally speaking the irrigation method is eminently satisfactory if properly looked after, but if neglected it leads to fouling of the ground and the formation of mosquito breeding pools.

(2) *Percolation pits*

Under the Regulations, percolation pits are not allowed to be constructed without the consent of the Medical Officer of Health, as if dug near to a well there is a danger of contamination, and, moreover, unless properly constructed they may form breeding places for mosquitoes. Fig. 92 shows a simple type of percolation pit, consisting



F... 97. PLAN AND ELEVATION OF LATRINES FOR KHARTOUM PRIMARY SCH...

of a hole in the ground about 4 feet square and 4 feet 9 inches deep filled to a depth of 4 feet with broken stone. This is covered over with rough boarding and the surface of the ground restored, the object of the boarding being to prevent the stone becoming choked by surface soil washing down and filling up its interstices. The waste water trickles down through the stone and percolates into the surrounding ground, while the accumulation of grease and other foul matter is rendered inoffensive by bacterial action, as in the case of an ordinary cesspit. If the waste is discharged direct into the pit by a pipe communicating with the sink, a ventilation shaft is required to obviate the risk of foul gases finding their way back into the house, but if the waste discharges into an open channel and thence by a pipe into the pit this precaution is not necessary. In this latter case there is a certain danger of mosquitoes going down the short length of pipe and breeding out in the percolation pit and, to overcome this difficulty, the type of pit shown in Fig. 93 has been designed. In this type the entry of mosquitoes is prevented by means of a self-closing flap on the end of the discharge pipe which terminates in a brick inspection shaft so that the flap valve can be examined and cleared when necessary. This type has not been long in use, but so far has worked satisfactorily.

Construction of percolation pits

Fig. 94 shows the general system of waste water disposal installed for each of the two bungalows referred to under Section III (Fig. 91). The bath waste is discharged into the cement channel A which has openings in the side for irrigation. The waste from the sinks B and C is connected by pipes and channels to the percolation pit and a small sluice is fitted at E so that the bath water may be discharged into the pit when required, either to flush out the channels and pit or when it is not wanted for irrigation purposes.

Care must be taken not to place these pits too near to the foundations of boundary walls or buildings, especially in localities such as Khartoum where the soil is of an alluvial nature and becomes soft and plastic when saturated with water.

(3) *Waste-water pits*

In certain cases in the business part of the town where considerable quantities of water are used and there is no ground available for irrigation and a percolation pit is undesirable owing to the proximity of buildings, waste-water pits have been used. Fig. 95 shows the general arrangement of one of these waste-water pits. They are of water-tight construction, cement-rendered on the inside, and are provided with a water seal and ventilation shaft and fitted with a close iron cover. Their contents are removed daily beyond the town limits by special carts fitted with a discharge pipe and valve in the bottom. As in the case of percolation pits the construction of these waste-water pits has to be approved by the Sanitary Authority, and permission is only given in cases of absolute necessity, as the labour and expense of emptying them is considerable.

It is, of course, recognised that the present system of waste water disposal cannot be indefinitely extended and must be looked upon more or less in the light of an expedient, to be continued until such time as the development of the town and other circumstances warrant the introduction of a proper water carriage sewerage system.

Latrines and Urinals

In "Sanitary Notes," by the Medical Officer of Health, in the Third Report,[1] the type of public latrines in use in Khartoum was illustrated and described, and similar latrines have now been erected at Khartoum North and Omdurman.

A certain number of public urinals have been found necessary, and these, which are a modified Indian type, are illustrated in Fig. 98. They were at first constructed without any wash pit, and it was found that both the latrine floor and the surrounding

[1] *Third Report, Wellcome Tropical Research Laboratories*, Khartoum, 1908.

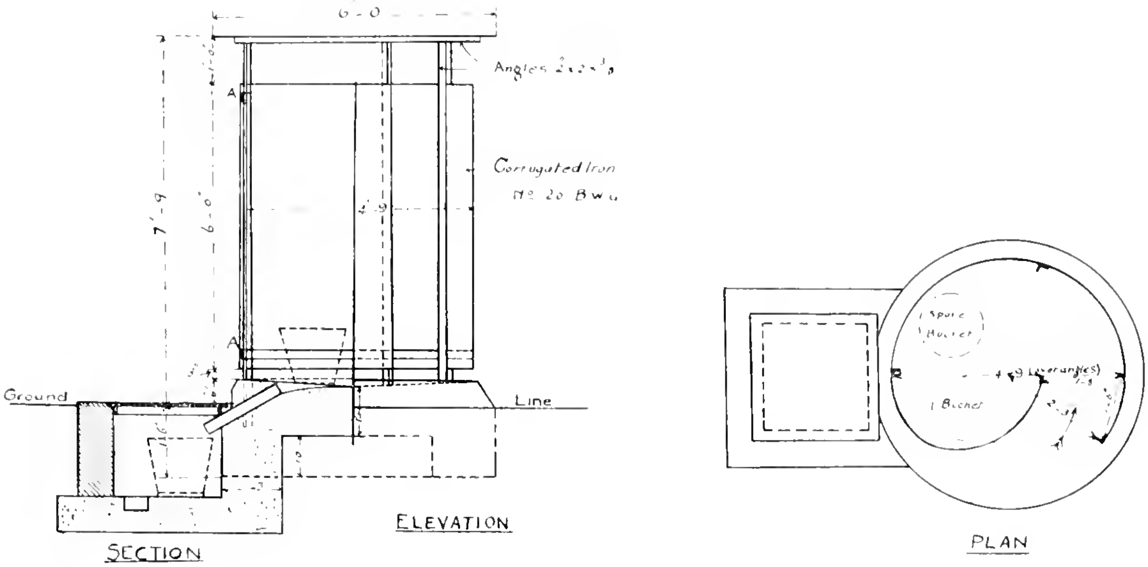


FIG. 98 PUBLIC URINAL WITH WASH PIT

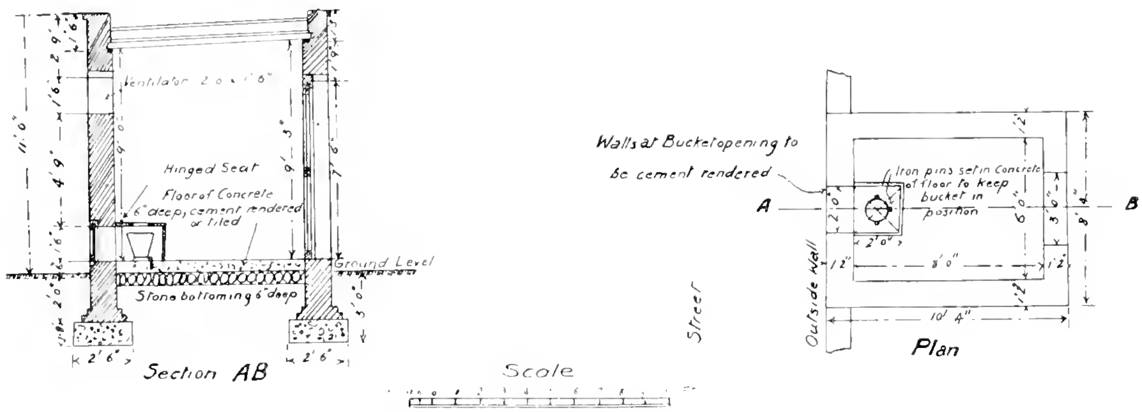



FIG. 99. TYPE EUROPEAN LATRINE

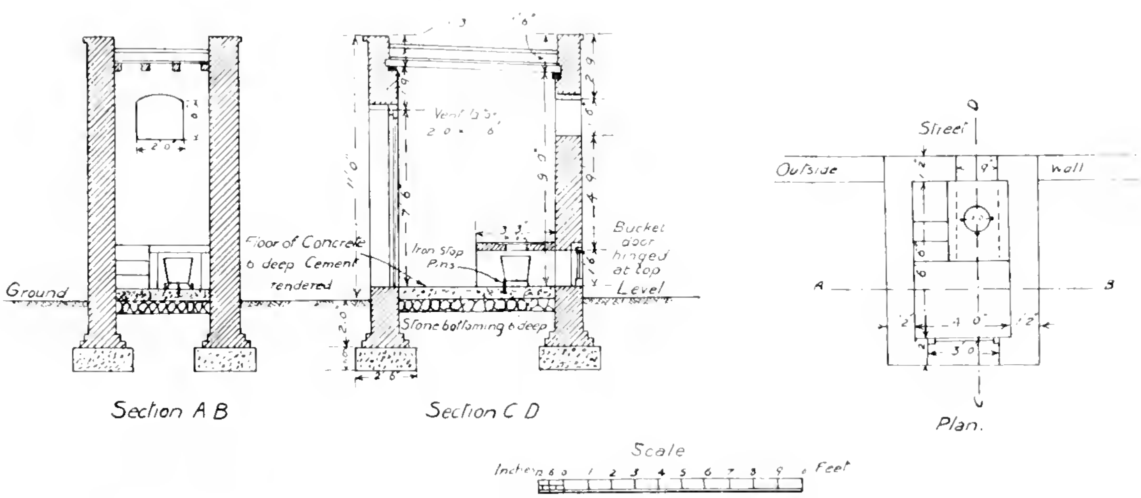


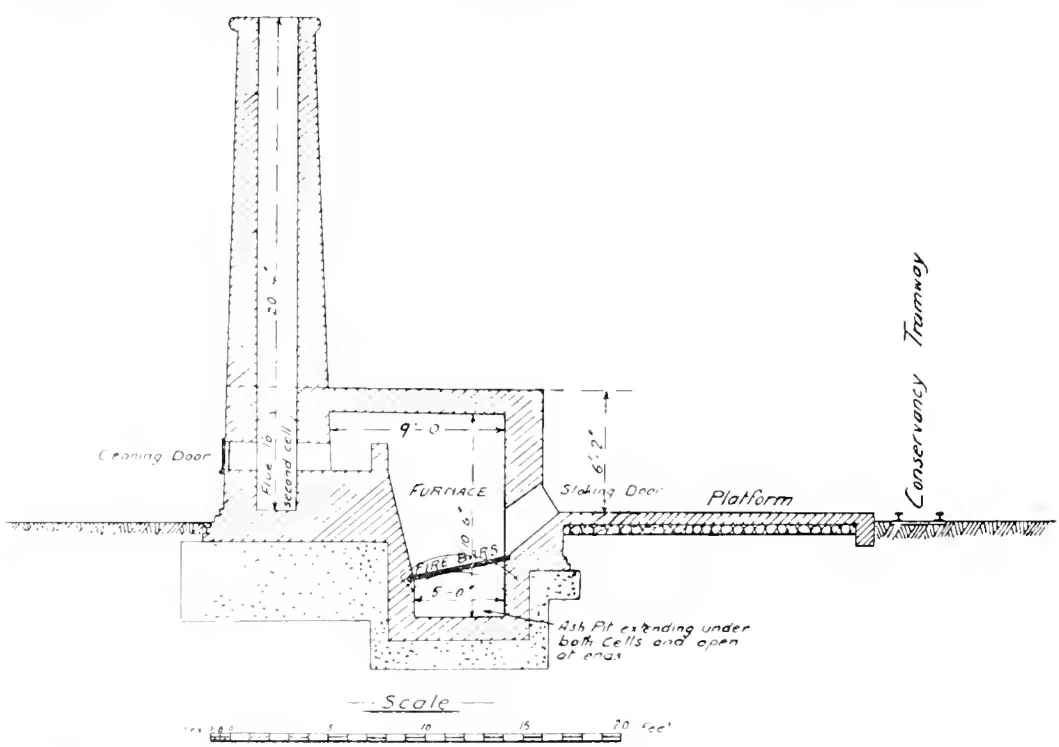
FIG. 100 TYPE NATIVE LATRINE

ground rapidly became fouled, but since the wash pits were put in the type has proved fairly satisfactory, and it is easily and cheaply constructed. A trial is about to be made with special sanitary tiles and disinfectant in urinals, which it is hoped will effect a further improvement.

The combined latrine and urinal, illustrated in Fig. 97, shows the type adopted by the authors for a large primary day school in Khartoum. It has proved a good pattern, well ventilated and easily kept clean, though it would probably be advantageous either to provide a separate wash pit or to bring the main wash pit down to the urinal end, as this requires more frequent cleansing than the latrine proper.

The Type drawings issued by the Municipality for both European and Native Latrines are shown in Figs. 99 and 100. The iron pins set in the floor ensure the bucket being placed properly under the seat, and, with the small clearance of about three inches allowed between the bucket and the under side of the seat, prevent the floor becoming fouled. To avoid the unsightliness of bucket doors opening on to the streets, regulations have recently been issued requiring bucket openings on certain main roads either to be placed in a screened recess or to be closed by a false door of ordinary proportions, so as to avoid making the existence of the latrine unduly prominent.

Conservancy The Conservancy system, as inaugurated in Khartoum in January, 1907, was fully described in the "Sanitary Notes" already referred to. It is further dealt with, and the experiments carried out with a view to the treatment of the sewage in intermittent septic tanks, and the proposed irrigation of the Sewage Farm are described in a paper on "Some Aspects of Tropical Sanitation," read by the Medical Officer of Health at the recent Sanitary Conference, and reprinted elsewhere in this Report. A well of 6 metres diameter is being sunk and a small steam pumping installation established in which it is proposed to utilise the refuse at present being consumed in a two-cell destructor at the farm.



The destructor, as illustrated in Fig. 101, has been in satisfactory operation for some years. Two old fire-tube boilers are built into one of the cells to give a supply of hot water for cleaning the conservancy buckets. The draught in this cell is not very satisfactory, as the tubes of the boilers quickly become choked, but it is sufficiently good to give a supply of hot water, and the second cell, connected directly with the chimney flue, has a good draught, and is capable of dealing with the balance of the refuse.

Appendix

The Town Building Regulations, 1909

Town Building Regulations

Proclamation

Contents

Preliminary

General Regulations

Special Regulations

For buildings other than mud buildings of one story in height

I, Colonel J. J. Asser, Acting Governor-General of the Sudan, hereby proclaim and order as follows:

Preliminary

PRELIMINARY

Title

1. These Regulations may be cited as the Town Building Regulations, 1909.

Scope of Regulations

2. These Regulations shall apply to the City of Khartoum and to the Towns of Khartoum North and Omdurman.

They may also be applied either wholly or in part to any other Town by order of the Governor-General, published in the Sudan Gazette, and subject to such alterations and additions as may be stated in such order.

Interpretation

3. In these Regulations:

the term "Municipal Authority" means the Governor or an Inspector of the Province or the Municipal Engineer or Government Engineer, or other authorized representative of the Governor;

the term "Sanitary Authority" means the Governor, the Medical Officer of Health or Medical Inspector or other authorized representative of the Governor.

Except where otherwise provided, these Regulations shall only apply to new buildings and to additions to and alterations in new or existing buildings.

Classification of land

4. For the purpose of these Regulations land in the City of Khartoum is classified as follows:—

(*a*) Government land,

(*b*) First class land, all land between Khedivial Avenue and Sirdar Avenue,

(*c*) Second class land, all land between Sirdar Avenue, Abbas Avenue (13th Street) and Abbas Square,

(*d*) Third class land, all land south of Abbas Avenue (13th Street) and Abbas Square.

Land in Khartoum North and Omdurman is classified as follows:—

(*a*) Government land,

(*b*) Third class land.

General Regulations

GENERAL REGULATIONS

Class of buildings which may be erected

5. The walls of all buildings erected on first or second class land shall be of stone, burnt brick or concrete excepting boundary walls and outhouses not visible from the road.

No building to be commenced till petition and drawings lodged and permit obtained

6. No person shall commence to erect or alter a building or other structure until he has lodged with the Governor or Inspector at the Government office a petition in the printed form to be obtained at such office and except where otherwise provided, suitable drawings in conformity with these Regulations and obtained a written permit and, if necessary, the alignment from the Municipal Authority.

Alignment

7. All buildings must conform to the alignment fixed by the Municipal Authority.

Boundary walls

8. The owner of each plot must erect and maintain a boundary wall or railing of a height and design approved by the Municipal Authority within six months of being called upon to do so.

Footpaths

9. A width of 15 feet (4·575 metres) on the outside facing a public street of each allotment in the City of Khartoum, must be reserved as a public footpath, and the owner of each allotment will be responsible for the repair of his portion of the footpath and the gutter in front of it.

Notice of commencement of work

10. Every person who shall intend to erect a building or otherwise to execute any work to which any of these Regulations may apply shall, before beginning to erect such building, or to execute such work, send to the Governor or Inspector at his office, notice in writing, specifying the date on which such person will begin to erect such building or to execute such work.

Contraventions of Regulations

11. In every case where a person who shall erect a building, or shall execute any other work to which these Regulations apply, shall, at any reasonable time during the progress or after the completion of the erection of such building or execution of such work, receive from the Municipal Authority notice in writing specifying any

matters in respect of which the erection of such building or the execution of such work may be in contravention of any Regulation, and requiring such person within a reasonable time, which shall be specified in such notice, to cause anything done contrary to any such Regulation to be amended, or to do anything which by any such Regulation may be required to be done but which has been omitted to be done, such person shall within the time specified in such notice, comply with the several requirements thereof so far as such requirements relate to matters in respect of which the erection of such building or the execution of such work may be in contravention of any such Regulation. General Regulations (continued)

Notice of compliance with requirements

Such person, within a reasonable time after the completion of any work which may have been executed in accordance with any such requirement, shall give to the Governor or Inspector at his office, notice in writing of the completion of such work.

Municipal Authority to have access to inspect

12. Every person who shall erect a building or shall execute any other work to which any of these Regulations shall apply, shall at all reasonable times during the erection of such building or the execution of such work, or after the completion of such building and before occupancy, afford the Municipal Authority free access to such building or work for the purpose of inspection.

Notice of completion of work

13. Every person who shall erect a building shall, within a reasonable time after the completion of the erecting of such building and before occupancy, give to the Governor or Inspector at his office notice in writing of the completion of the erection of such building.

Work done in contravention of regulations may be removed

14. If any work be begun or done in contravention of any of these Regulations, the person by whom such work shall be so begun or done shall by notice in writing signed by the Governor or Inspector, and duly served upon such person, be required to show sufficient cause why such work shall not be amended, altered or pulled down, and for this purpose such person shall either submit a statement in writing under his hand or under the hand of an agent duly authorised in that behalf and addressed to and duly served upon the Governor or Inspector, or attend personally or by an agent duly authorised in that behalf before the Governor or Inspector. If such person shall fail to show sufficient cause why such work shall not be removed, altered or pulled down the Municipal Authority shall be empowered to remove, alter or pull down such work at the expense of such person.

Penalties

15. Every person who shall offend against any of these Regulations shall be liable for every such offence to a penalty not exceeding P.T. 50 for each offence, and in the case of a continuing offence to a further penalty not exceeding P.T. 25 for each day after written notice of the offence from the Municipal Authority.

Height of ceilings and ventilation of habitable rooms

16. The minimum height from floor to ceiling of any habitable rooms shall be 10 feet (3·05 metres). Sufficient means of ventilation shall be provided to the satisfaction of the Municipal Authority.

Buildings not to be taken down without authority

17. No person shall take down or remove any new or existing building or part thereof without the written consent of the Municipal Authority.

Removal of dilapidated and neglected building

18. Wherever any building or part thereof is ruinous or so dilapidated as to have become and to be unfit for use or occupation, or is from neglect or otherwise in a structural condition prejudicial to the property in or to the inhabitants of the neighbourhood, the Municipal Authority may order the owner to take down or repair such building or part thereof within a reasonable time to be fixed by the order. If the order is not obeyed the Municipal Authority may enter upon the property and execute the order at the expense of the owner.

For the purpose of this Regulation the expression "building" includes any new or existing building, wall or other structure, and anything affixed to or projecting from any building, wall or other structure.

Scaffolding

19. All walls must have proper scaffolds, which are to be provided with guard-rails where over 10 feet (3·05 metres) in height. The Municipal Authority shall prohibit and stop the erection, use or employment of any scaffolding, staging, shoring, crane or other lifting apparatus which in the opinion of the Municipal Authority is liable to cause damage.

Hoardings and barricades

20. The Municipal Authority may grant the use of a part of a street in connection with the erection, alteration or taking down of any building, and may require that such part be enclosed with a barricade or hoarding to the satisfaction of the Municipal Authority. Such hoarding or barricade must be properly lighted by red lamps from sunset to sunrise. A time limit shall be prescribed by the Municipal Authority during which this permission is granted, and, on special cause shown, an extension of this period may be granted.

U

General Regulations (continued)

Lapse of permit to build

21. A permit to build shall lapse when the work thereby authorised has not been commenced within one year from the date of such permit. If the work authorised by any permit has been stopped or the completion thereof unduly delayed the Municipal Authority may cancel such permit or may order any uncompleted building, alteration or work to be taken down, completed or otherwise dealt with, and the removal of any hoarding or barricade and the restoration of the street.

Streets, footpaths, etc., not to be opened without authority

22. No person shall make any hole or opening in any street or footpath except with the written consent of the Municipal Authority. The duration of such consent shall be specified on the permit. All such holes or openings must be properly barricaded and lighted from sunset to sunrise by red lamps.

Repair of damage to streets

23. Any damage done to any street by or in connection with the laying, altering, maintaining or removing of pipes or the erection or removal of boardings or barricades or otherwise shall be made good by the owner interested in or the person authorising such operations, or may at the option of the Municipal Authority be made good at the expense of such owner or person.

Wells

24. No person shall open a well except with the written authority of the Municipal Authority. All wells must be provided with a properly built masonry steining extending at least 3 feet (·915 metre) below and 1 foot (·305 metre) above ground level, and have a closely fitting cover to the satisfaction of the Sanitary Authority. The Municipal Authority may order the filling up of any existing well and the provisions in section 18, "Removal of dilapidated and neglected buildings," shall be applicable.

Waste-water pipes and channels

25. All waste-water pipes from baths, sinks, and wash-hand basins and all waste-pipes not used for receiving solid or liquid filth shall be carried through an external wall and for a distance of at least 10 feet (3·05 metres) beyond such wall and discharged over an area of land properly prepared for the purpose, or into a "percolation pit" or "waste-water pit" as may be ordered by the Sanitary Authority. All joints and connections of pipes must be properly made. The portion of the pipe outside the external wall must be suitably ventilated. An open masonry channel may be substituted for the portion of the pipe beyond the external wall and such channel must be lined with a smooth impervious material and laid to a sufficient gradient.

Traps

26. All sinks, baths and other water fittings shall be trapped, and trap shall have a water seal of at least 1½ inches (·038 metre). Each trap shall be fitted with a trap screw at the side or bottom for cleansing.

Percolation pits

27. Percolation pits shall be pits of sufficient size filled with brick or stone broken to pass through a 4 inch (·102 metre) ring, and arranged so that the waste water is properly distributed throughout the pit. No percolation pit shall be permitted near to any well. Proper ventilation must be provided.

Waste-water pits

28. Waste-water pits shall not be less than 2 ft. 6 in. (·75 metre) square and shall be constructed with a cement concrete bottom at least 9 inches (·229 metre) thick, and walls brickwork or masonry in cement mortar at least 9 inches (·229 metre) thick. The interior to be finished smooth with cement rendering. All waste-water pits shall be water-tight, properly ventilated, and have a closely fitting cover, and shall be otherwise to the satisfaction of the Sanitary Authority.

Earth closets

29. No dwelling house shall be erected on the first or second class land without a sufficient earth closet in accordance with the requirements of the Sanitary Authority. Any and every earth closet shall be placed in a building which is thoroughly ventilated and has no direct communication with any occupied building, and shall be furnished with a moveable receptacle of a material and pattern approved by the Sanitary Authority, and such receptacle shall be so placed on the ground floor as to admit of ready access from an outside wall. The entire floor of all earth closets shall be of an impervious material, and in the case of native latrines the seat or platform and any steps thereto shall also be of an impervious material. All earth closets are subject to the approval of the Sanitary Authority.

Water closets

30. Water closets shall only be permitted under such conditions as the Sanitary Authority may direct.

Electric wires

31. All electric wires passing through or in proximity to any wood work shall be properly protected by being cased in screwed iron tubing or by other means of insulation to the satisfaction of the Municipal Authority.

Fees for permits and registration of drawings, etc.

General Regulations (continued)

32. Upon every application to the Municipal Authority for a permit to build, a fee of P.T. 15 must be paid.

For the registration of the drawings after approval the following fees must be paid.

In respect of works of the value of £E. 200 and upwards P.T. 100.

In respect of works under the value of £E. 200 P.T. 50.

For the withdrawal of any drawings after approval for the purpose of addition or alteration a fee of P.T. 10 must be paid.

For a permit to open a street or pavement a fee of P.T. 10.

Relaxation of Regulations in special cases

33. The Municipal Authority may dispense with the strict application of these Regulations in special cases where the strict application would cause inconvenience or unusual expense.

Special Regulations

Special Regulations

Exemption of mud buildings

34. The following Regulations do not apply to buildings of only one story in height, the walls of which consist entirely or partly of mud or unburnt mud bricks.

Drawings, etc., to be lodged with Municipal Authority

35. Every person who shall intend to erect or alter a building shall, except where otherwise provided, lodge with the Municipal Authority drawings showing elevations, sections and plans of every floor of such intended building drawn to a scale of not less than one inch to every eight feet or one centimetre to every metre, and showing the position, form, materials and dimensions of the several parts of such building, and of every latrine or earth closet, kitchen, servants' quarters, stables, existing or proposed wells, waste water disposal arrangements and other appurtenances; also detailed drawings drawn to a scale of one inch to every two feet or four centimetres to every metre showing floors and roofs, verandahs and balconies, stairs, iron or steel beams, pillars and principal timbers, the dimensions being marked in figures:

also a block plan of such building drawn to a scale of not less than one inch to every forty feet or two millimetres to every metre, showing the position of the buildings and appurtenances and the boundaries of the petitioner's ground, also the position of the buildings and appurtenances immediately adjoining, with the names of the proprietors and the level of the street in front, with reference to the ground floor level of the intended building:

also such information in writing as may be required on the printed petition form referred to in section 6 regarding the site, construction and other matters.

Drawing to be lodged in duplicate and signed

36. All drawings shall be submitted in duplicate. One set shall be drawn in ink on tracing cloth, and shall be signed on every sheet by the person intending to erect or alter any building, or by his agent, and shall, when lodged, become the property of and be retained by the Municipal Authority.

Arcades

37. The owner of a building plot in the first or second class land may be permitted to erect an arcade over his portion of the footpath, such arcade is to be specially approved in each case, and full drawings must be submitted for approval. Arcades must be in burnt brick, stone or concrete for the first story and no woodwork verandahs will be allowed in their stead.

Permission to build arcades in the third class land may only be granted where houses are built of burnt brick, stone or concrete.

Balconies

38. No balcony which projects over a road or footway shall be permitted which is of a width greater than 3 feet 6 inches (1·067 metres) and of a height less than 14 feet (4·27 metres) above the level of the footpath. In the event of such balcony being supported from below by stancheons fixed into the wall on which they are built, the lower ends of these supports must be at least 8 feet (2·44 metres) above the level of the footpath.

The strength of all balconies must conform to the requirements of the Municipal Authority.

Site of Building

39. The site of every building shall be prepared by removing therefrom all animal and vegetable matter and the Municipal Authority may require the whole of any site to be covered with a layer of concrete. Where on the site of a building there is forced earth or made up ground the walls of such building shall rest upon a layer of concrete of sufficient dimensions to support the same and where necessary the site of the building shall be covered with concrete.

Underground buildings

40. Any portion of a building used as a cellar or otherwise which is below the surrounding ground level shall be of waterproof construction and provided with an efficient means for preventing flooding from surface water.

Special Regulations (*continued*)

Foundations

41. The foundations of all walls shall be of concrete, squared stone or burnt brick laid in cement or other suitable and substantial material and shall be laid at such depth as to secure a solid bed or stratum for building on. Except where such foundations are in contact with an existing building or rest upon solid rock they shall project beyond the face of the wall on each side to the extent of one-half of the thickness of the wall or to such greater extent as the Municipal Authority may consider necessary. Where a building is on alluvial soil such as Nile mud which is likely to be affected by the rise and fall of the river the load to be put on such a soil must not exceed one ton per square foot (one kilo. per square centimetre approximately) of foundation. Where any foundations are laid at a lower level than the foundations of a wall contiguous thereto such contiguous wall shall be underpinned and supported in a satisfactory manner. Where such contiguous wall has been built with projecting foundations or footings the person building against the same may in absence of any contract or agreement with respect to the laying of such foundations or the removal of the projections thereof require the owner of such wall to cut off the footings of the foundations at and along the line of boundary and failing such owner complying with such requisition the person building may himself cut off such footings and charge the owner with the cost of the operation in so far as such cost exceeds the ordinary cost of excavating for a foundation of similar dimensions on such a site. The diminution of the footing of every wall shall be formed in regular offsets.

Walls to be solid

42. Every wall built of stone, burnt brick or other similar material shall be properly bonded and solidly put together with mortar and all return walls and all partition walls built of brick or stone shall be properly bonded to the walls adjoining but where a new building is erected against an existing building it shall not be necessary to bond the walls thereof into the existing building. The top of every wall shall be securely rendered or weathered or otherwise protected so as to prevent the access of damp or water to the wall.

Walls not to overhang

43. No part of any wall fronting or abutting on any street shall overhang or project into such street except for architectural ornaments such as cornices or string courses and for such a maximum projection of 18 inches (·457 metre) may be allowed.

Any cornices or projections which overhang the ground of an adjoining proprietor shall be cut off by the owner thereof when required to enable such adjoining proprietor to build and failing his doing so may be cut off by such adjoining proprietor at the owner's expense.

Dimensions of external and party walls

44. Every external and party wall shall be built in accordance with the following tables, and in every case the thickness prescribed shall be the minimum thickness of which any such wall may be constructed.

TABLE "A"

Thickness of walls of domestic buildings when built in good sound hard bricks, burnt or artificial, or other blocks of hard and incombustible substance.

Height	Length	Thickness in cms.	Length	Thickness in cms.
Up to 8 metres	Up to 10 metres, if not more than 2 stories in height ..	 22½	Exceeding 10 metres, if more than 2 stories, wall below topmost story ... ... remainder	 34 22½
Up to 10 metres	Up to 11 metres, wall below 2 topmost stories ... .. remainder	 34 22½	Exceeding 11 metres, wall below topmost story ... ... remainder	 34 22½
Up to 12 metres	Up to 11 metres, wall below 2 topmost stories ... ... remainder	 34 22½	Exceeding 11 metres, one story ... ... rest of wall below topmost story ... remainder	 45 34 22½
Up to 16 metres	Up to 10 metres, one story ... ... rest of wall below topmost story ... remainder	 45 34 22½	Exceeding 15 metres, one story ... ... one story .. .. remainder	 56½ 45 34
	Up to 15 metres, two stories .. .. remainder	 45 34½		

Provided always that if any story exceeds in height 16 times the thickness prescribed for its walls, the thickness of each external wall, and of each party wall, throughout that story will be increased to one-sixteenth part of the height of the story, and the thickness of each external wall and each party wall below that shall be proportionately increased.

Special Regulations (*continued*)

TABLE "B"

Thickness of walls in domestic buildings built in local sandstone, the beds or courses being horizontal.

Height	Length	Thickness in cms.	Length	Thickness in cms.
Up to 8 metres	Up to 10 metres,		Exceeding 10 metres,	
	from base to top wall	40	below topmost story	45
			remainder	40
Up to 12 metres	Up to 10 metres,		Exceeding 10 metres,	
	below topmost story	45	one story	55
	remainder	40	rest of wall below topmost story	45
			remainder	40
Up to 15 metres	Up to 10 metres,		Exceeding 15 metres,	
	one story	55	one story	65
	rest of wall below topmost story	45	one story ...	55
	remainder	40	remainder	45
	Up to 15 metres,			
	two stories...	55		
	remainder	45		

Provided always that if any story exceeds in height 10 times the thickness prescribed for its walls, the thickness of each external wall, and of each party wall throughout that story, shall be increased to one-tenth part of the height of the story, and the thickness of each external wall and each party wall below that story shall be proportionately increased.

Dimensions of cross walls

45. Any internal party or cross wall not supporting roof or floor beams may be thinner to the extent of one-fourth than the dimensions prescribed for an external wall.

Iron columns

46. Where any of the main walls within a building are supported by or rest upon iron beams or columns at the ground story such beams or columns shall be surrounded and suitably protected against fire by plaster or cement or other fireproofing material ¾ inch (·019 metre) thick.

Openings and recesses in walls

47. If any openings or recesses are left or made in any wall to an extent greater than one-half of the superficies of the wall of any story, or if any openings or recesses are left or made which extend into two or more stories the wall between such openings shall be strengthened by sufficient pilasters, buttresses or counterforts or otherwise, and in every such case a sufficient pier or other support shall be provided at the corner or angle of any two streets on which any building abuts or within 3 feet (·915 metre) thereof. For the purposes of this regulation a recess includes any part of a wall which is of less than the thickness prescribed for a wall of that description.

Damp course

48. Every wall of a building, if built of brick, stone or concrete and resting on the ground, shall, if required by the Municipal Authority, have a damp course throughout its entire thickness, and such damp course shall be of a durable material impervious to moisture. The damp course shall be below lowest floor level and at least 6 inches (·152 metre) above the surface of the ground.

Protection of timber from white ants

49. All timber posts and beams shall be properly protected from the attacks of white ants.

Beams and lintels

50. Every beam shall have a sufficient bearing at each end arranged so that the load is properly transmitted to and distributed over the wall by means of a beam block or otherwise.

Wood lintels shall have a depth of at least 1 inch (·025 metre) for every foot (·305 metre) span of opening and shall be coated with preservative.

Strength of buildings

51. Buildings of unusual construction or for special purposes must be made of sufficient strength, and all buildings must be designed and constructed so that the completed structure, exclusive of the materials of which it is composed, shall be able to carry as a safe load the weights following, viz.:—

Dwelling houses	100 lbs. per square foot of floor	(489 kilograms per sq. metre)
Halls, Schools and Public Buildings	150 lbs. ,, ,, ,, ,, ,,	(733·5 kilograms per sq. metre)
Warehouses and Workshops ...	200 lbs. ,, ,, ,, ,, ,,	(978 kilograms per sq. metre)

A roof must be so constructed as to carry safely a load of 50 lbs. per sq. foot of surface (244·5 kilograms per sq. metre) exclusive of the materials of the roof itself. A flat roof which is intended to be used as a floor must be designed to carry the load prescribed for a floor.

Special Regulations (*continued*)

Smoke flues in buildings

52. No pipe or flue for conveying smoke or other products of combustion shall be placed in any new or existing building nearer than 6 inches (·152 metre) to any timber or other combustible substance.

Ground floor level

53. Unless under special conditions the ground floor level of all dwelling houses shall not be less than 12 inches (·305 metre) above the mean level of the adjoining street.

Parapets and roof access

54. If required, buildings shall be provided with a hatchway on the roof or other means by which in case of fire access may be had to the roof from the upper story of the building.

Every roof which is intended to be used as a floor shall be provided with a suitable access stairway and shall have a parapet wall at least 2 feet 6 inches (·762 metre) in height.

Stairs to be supported

55. Every stair having an open well hole shall be sufficiently supported by iron or steel beams.

(*Signed*) J. ASSER,
LEWA,
Acting Governor-General

Khartoum,
September 30, 1909

Forms and Notices

FORMS AND NOTICES USED IN CONNECTION WITH THE BUILDING REGULATIONS

Petition Form No.

(Referred to in Section 6 "Town Building Regulations, 1909.")

SUDAN GOVERNMENT

KHARTOUM PROVINCE

Building Petition

TO THE GOVERNOR,
KHARTOUM PROVINCE,
KHARTOUM.

the undersigned desiring approval for the erection of certain buildings do hereby lodge the undernoted schedule of particulars of the same as required by the "Town Building Regulations."

Questions	Answers
1.—Name (in full), address and occupation of Person for whom the buildings are to be erected.	
*2.—Number of drawings deposited (if any).	
3.—Situation of buildings (class of land, street number, etc.).	
4.—Nature of site; distance to any Well in vicinity.	
5.—Description of buildings and of the materials to be used in construction of same.	
6.—Number of stories giving heights.	
7.—Thickness of walls.	
8.—Level of ground floor with reference to surface of street.	
9.—Names of the adjoining proprietors.	
10.—Area of building plot of land.	
11.—Estimated cost of work.	£E

dated *day of* *19*

Signature (in full)

Address

Petition granted:— *Occupation*

date *Witness*

For Municipal Authority.

* Except in the case of buildings of only one story in height the walls of which consist entirely or partly of mud or unburnt mud brick, drawings must be deposited in accordance with sections 35 and 36 of the "Town Building Regulations, 1909" (see "extract" on back hereof).

Forms and Notices (*continued*)

(Printed on back of Form)

Extract from "Town Building Regulations, 1909"

35.—Every person who shall intend to erect or alter a building shall, except where otherwise provided, lodge with the Municipal Authority drawings showing elevations, sections, and plans of every floor of such intended building drawn to a scale of not less than *one inch* to every *eight feet* or *one centimetre* to every *metre* and showing the position, form, materials and dimensions of the several parts of such building and of every latrine or earth closet, kitchen, servants quarters, stables, existing or proposed wells, waste water disposal arrangements and other appurtenances; also detailed drawings drawn to a scale of *one inch* to every *two feet* or *four centimetres* to every *metre* showing floors and roofs, verandahs and balconies, stairs, iron or steel beams, pillars and principal timbers, the dimensions being marked in figures.

Also a block plan of such building drawn to scale of not less than *one inch* to every *forty feet* or *two millimetres* to every *metre* showing the position of the buildings and appurtenances and the boundaries of the petitioner's ground also the position of the buildings and appurtenances immediately adjoining with the names of the proprietors and the level of the street in front, with reference to the ground floor level of the intended building.

Also such information in writing as may be required on the printed Petition Form referred to in Section 6, regarding the site, construction and other matters.

36.—All drawings shall be submitted in duplicate. One set shall be drawn in ink on tracing cloth, and shall be signed on every sheet by the person intending to erect or alter any building, or by his agent, and shall, when lodged, become the property of and be retained by the Municipal Authority.

NOTICE OF CONTRAVENTION OF THE "TOWN BUILDING REGULATIONS, 1909"

Municipal Engineer's Office,

Gordon College,

KHARTOUM

M

Sir,

I hereby give notice that you have contravened the "Town Building Regulations, 1909," with respect to work covered by your Building Petition No. dated 191 as hereinafter set forth and you are hereby required to comply with the aforesaid regulations in accordance with section 11[1] thereof and in the manner hereinafter specified within days from the date of this notice, in default of which you will be liable to the penalties specified in the aforesaid regulations.

The matters in respect of which contravention of the regulations has been committed are

and in order to comply with the regulations you are required to

I have the honour to be,

Sir,

Your most obedient servant,

Municipal Engineer.

[1] See extract from the "Town Building Regulations" on back hereof

Forms and Notices *(continued)*

(Printed on back of Form)

Extract from the "Town Building Regulations, 1909"

Contraventions of Regulations

11. In every case where a person who shall erect a building, or shall execute any other work to which these Regulations apply, shall, at any reasonable time during the progress or after the completion of the erection of such building or execution of such work, receive from the Municipal Authority notice in writing specifying any matters in respect of which the erection of such building or the execution of such work may be in contravention of any Regulation, and requiring such person within a reasonable time, which shall be specified in such notice, to cause anything done contrary to any such Regulation to be amended, or to do anything which by any such Regulation may be required to be done but which has been omitted to be done, such person shall within the time specified in such notice comply with the several requirements thereof so far as such requirements relate to matters in respect of which the erection of such building or the execution of such work may be in contravention of any such Regulation.

NOTICE REGARDING DILAPIDATED OR NEGLECTED BUILDINGS

Municipal Engineer's Office,

Gordon College,

KHARTOUM

M

Sir,

I hereby give notice that in accordance with section 18* of the "Town Building Regulations, 1909," the situated at of which you are the owner or reputed owner is in a state of

and you are hereby required to

within days from the date of this notice, in default of which you will be liable to the penalties specified in the aforesaid regulations.

I have the honour to be,

Sir,

Your most obedient servant,

Municipal Engineer.

* See extract from the "Town Building Regulations" on back hereof.

(Printed on back of Form)

Extract from the "Town Building Regulations, 1909"

Removal of dilapidated and neglected buildings

18. Wherever any building or part thereof is ruinous or so dilapidated as to have become and to be unfit for use or occupation, or is from neglect or otherwise in a structural condition prejudicial to the property in or to the inhabitants of the neighbourhood, the Municipal Authority may order the owner to take down or repair such building or part thereof within a reasonable time to be fixed by the order. If the order is not obeyed the Municipal Authority may enter upon the property and execute the order at the expense of the owner.

For the purpose of this Regulation, the expression "building" includes any new or existing building, wall, or other structure, and anything affixed to or projecting from any building, wall, or other structure.

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