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ANNALS

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THE TERMINAL STRUCTURES OF ORTHOPTEROID INSECTS: A PHYLOGENETIC STUDY

E. M. Walker,
Toronto.

PART II.

The Terminal Abdominal Structures of the Male.

The external genitalia of male insects are so variable in structure even within the limits of a single family, that it is a very difficult matter to trace the homologies of their component parts; and much detailed study of many types from all orders must be done before the subject can be placed upon a satisfactory foundation. The difficulties experienced in the present work in comparing the various types of Orthoptera alone have been such that it was found desirable to give a relatively large amount of time and space to this order, and as a result the other orders have necessarily been somewhat sacrificed. Some of them, such as the Plecoptera and Dermaptera, have been but superficially treated, owing to lack of material. It is hoped that these neglected groups will receive their due share of attention at another time.

In addition to the gentlemen to whom acknowledgments were made in the Introduction to this paper, I have to thank Mr. Morgan Hebard and Dr. R. J. Tillyard for the loan or gift of specimens, and Prof. C. R. Crosby for the loan of books from the Library of Cornell University.

My chief regret in connection with the present investigation is that much of the literature on the subject has been inaccessible

to me or was received too late to be of use in the preparation of Part I.*

Since this part was published I received copies of two short papers by L. Chopard, entitled "Notes préliminaires sur la conformation de l'extremité abdominale des Orthoptères" and "Note préliminaire sur la conformation de l'organe copulateur des Orthoptères," published in 1917 and 1918, respectively. Still later, when the present work was nearly finished, I received a copy of the same author's fuller treatise entitled "Recherches sur la conformation et le développement des derniers segments abdominaux chez les Orthoptères," published in 1920. In this extensive and valuable work a very large number of forms are discussed and much of my own work has been anticipated. The general conclusions as to the typical structure of the terminal segments in Orthopteroid insects and the male homologies of the parts of the ovipositor are quite in accord with my own, but naturally there are some matters on which our views are not quite in agreement. Some reference has been made to these in the following pages, but unfortunately Mons. Chopard's work was received too late to give it the consideration that it deserves.

GENERAL MORPHOLOGY.

As in the female Pterygote insect, there is also in the male usually a single genital aperture, which, however, has a different position, namely in the membrane between the ninth and tenth abdominal sterna,† though sometimes apparently on the ninth sternum itself. This aperture is typically formed by an invagination of the body wall, into which open the two primitive ejaculatory ducts, the invagination forming a common terminal passage, which itself is usually termed the ejaculatory duct. In the Ephemerida and Dermaptera, however, this invagination does not take place, and although in the latter order the genital aperture is frequently single, it is due either to the abortion of one of the openings or to the fusion of the terminal parts of the two ducts. The aperture is usually borne upon an outgrowth, the penis or aedeagus, whose walls may be more or less

* Ann. Ent. Soc. Amer., XII, No. 4, Dec., 1919, pp 267–316. with Pls. XX–XXVIII.

† I. e., the sterna of the 9th and 10th abdominal segments, whether the sternum of segment 1 is present or not.

chitinized or wholly membranous. Where two apertures are present there are likewise two penes (Ephemerida) or a more or less deeply bipartite penis (Dermaptera), but it is probable that in these orders the penis or penes are not strictly homologous with those of other orders; in fact it appears as though the penis may have developed independently in several orders. A slightly bipartite penis has been described as occurring also in certain Plecoptera (Crampton, '18). The bifid termination of the penis in some Acrididæ simulates this condition slightly, but is in no way comparable to it. Among the Apterygota we find double penes in Eosentomon of the Protura (Prell, '13) and a slightly bifid penis in certain genera of Lepismoidea, such as Nicoletia (Escherich, '04), but the former is perhaps not strictly homologous with the other case cited, as it is found upon the eleventh instead of the ninth segment. The occurrence of double penes is probably a very primitive condition, as paired genital apertures are frequent in the more primitive Arthropods, such as the Crustacea and Diplopoda.

The penis is frequently eversible and in the everted condition the chitinized terminal part of the ejaculatory duct may project in the form of a spine, the *virga*. This structure is most typically seen in the Dermaptera, and in such forms as have a bifid penis the virga is likewise duplicated. It also occurs in certain Blattids, and according to Crampton, in some Plecoptera. The membranous eversible wall of the penis is the *glans* or *praeputial sac*.

There is also, primitively, a pair of chitinous processes, the parameres, arising near the base of the penis or from its walls, and having typically a lateral or dorsolateral position. They are well illustrated by the Dermaptera and certain Ephemerida, and it is probable that the titillators of most Orthoptera (although not all the structures so-called) are their homologues. It is uncertain, though in the writer's opinion probable, that the parameres of the Thysanura are morphologically identical with those of the pterygote insects. Crampton ('20) has apparently confused the penes of the Ephemerida with the parameres of other insects under the term "penis valves." Chopard ('18) expresses the view that in the Orthoptera (including the Blattoidea, Mantoidea and Phasmoidea) there are two pairs of processes, which he terms the "valves dorsales" and the "valves ventrales," between which the genital aperture

opens, the latter being sometimes borne upon a penis, sometimes not. The structure which he thus designates as dorsal and ventral valves are not always, in my opinion, homologous in these various groups, nor even, in many cases, within the Orthoptera, s. s. The basis for this opinion will be evident after the discussion of the various orders.

The parameres are frequently sunk into invaginations of the body wall, or a common invagination (most Orthoptera), from which they can usually be protruded. The infoldings thus formed may be considerably prolonged into the haemocoele as chitinized apophyses for the insertion of muscles, and sometimes only the invaginations and apophyses are present, the freely projecting part of the parameres having disappeared, or secondary processes may develop from the walls of the invagination. In the Blattoidea, Mantoidea, Grylloblattoidea and Phasmoidea the genital aperture, which may or may not be borne upon a penis, lies between two asymmetrical lateral lobes, which apparently represent the parameres, and I have therefore termed them *paramere lobes*. They usually bear at least one chitinous process, and where several occur, one appears to be the main process, the others accessory parts. I have, as a general rule, considered the main process to represent the terminal part of the true parameres, but this is to be regarded as merely a tentative hypothesis. Possibly a comparative study of the musculature will throw some light on the homologies of these puzzling structures. In the Blattids there is often but one well-developed process on each side, one of these, right or left, being modified into a strong copulatory hook, which can be completely retracted into a membranous sheath.

Between the base of the penis and the paraprocts (laminæ subanales) there is present in some groups (many Phasmoidea and Orthoptera, some Ephemerida) another sclerite, having the form of a more or less projecting plate. It is by no means evident, however, that the plates situated here in these different groups are homologous structures, and it therefore seems hardly justifiable to designate them by a common term. In the Phasmoidea we have the "vomer sous-anal" of Pantel, which this author regarded as belonging to the 10th sternum, but which, in my opinion, probably arises from the membrane between the ninth and tenth sterna. It projects caudad and appears to form a fourth anal valve. In *Callibaetis ferrugineus*

of the Ephemerida there is a somewhat similar plate, but it appears to be exceptional in this order; while in the Orthoptera a somewhat analogous structure, clearly belonging to the same intersternal membrane, is found in a majority of the species. It functions, however, not as an anal valve, but as a part of the genitalia. This is the part I have called the *pseudosternite*. It has been confused by various writers with the "epiphallus" or "titillators" (parameres). Crampton ('18), e. g., identifies this structure in the Acrididæ and Gryllidæ with the "epiphallus" or parameres of the Tettigoniidæ, and Chopard ('18) makes the same error with regard to the Acrididæ, but in the Gryllidæ he considers it a distinct structure, which he terms the "pseudépiphalle." In the latter family it has also been termed the "anchre" by de Saussure and Zehntner ('94) in the genus Gryllotalpa, on account of its anchor-like form in that genus.

Various other structures concerned in copulation are frequently present. Claspers may be developed from the cerci (Dermaptera, Odonata, many Orthoptera); the coxites, or coxites and styli (Grylloblattoidea, Ephemerida); the paraprocts (Odonata Zygoptera, some Orthoptera of the family Tridactylidæ); titillators, copulatory hooks and similar appendages appear upon a great variety of structures, e. g., the 9th sternum (Embiidina, some Blattoidea); the 10th tergum (Embiidina, Grylloblattoidea, some Plecoptera); the supra-anal plate (some Plecoptera); the paraprocts (some Plecoptera and Blattoidea, a few Orthoptera of the family Tridactylidæ); the left cercal basipodite (some Embiidina); and finally from the vicinity of the genital aperture, including the pseudosternite, the parameres and the penis itself (Dermaptera, Ephemerida, Blattoidea, Mantoidea, Orthoptera, etc.)

Other chitinous structures are present in particular groups, the most noteworthy of these being connected with the development of the spermatophore sac in the Orthoptera. These will be considered in the account of this order.

The terga and sterna of the terminal abdominal segments in Orthopteroid insects are also subject to considerable variation apart from that of the more essential genitalic structures, some of these modifications being similar to those found in the females of the same species. Thus we find that in the Orthoptera the supra-anal plate is nearly always well developed in both sexes, while in the Blattoidea, Mantoidea and Isoptera

it is vestigial or absent and its place is taken by the 10th tergum. The cerci, when not modified as claspers in the male, are usually similar in the two sexes.

The 8th sternum* is unmodified in the male, as it does not underlie the genital aperture, but the 9th sternum is generally much enlarged and is usually termed the subgenital plate, as it occupies a position in relation to the genitalia analogous to that of the 8th sternum in the female. As this implies a homology that does not exist, the term "hypandrium"† has been recently proposed by Crampton for the male subgenital plate. He does not, however, use it in a strictly morphological sense, but to designate the terminal ventral sclerite, whether this represents the entire sternum or only a part. When the 9th sternum, e. g., is transversely divided, as in the Ephemerida and the Acrididæ, it is the distal part only that is called the hypandrium, but when it is undivided, as in most Orthoptera, Blattoidea, Mantoidea, etc., the entire sternum becomes the hypandrium. As thus used the term is therefore open to objection, as it tends to obscure the homologies of the parts concerned, although it is a convenient one to retain for descriptive purposes.

The 9th sternum is primitively divided into three plates, a basal *sternite* and two disto-lateral *coxites*, each of the latter bearing a terminal stylus. This primitive condition is well exemplified by *Grylloblatta*, especially in the immature stages (Pl. VII, Fig. 66) and certain Ephemerida, such as *Blasturus nebulosus* (Pl. I, Fig. 2), although in the latter the styli (or coxites?) are secondarily segmented. In most Ephemerida, however, the coxites are fused but remain separate from the sternite, so that the former have the appearance of another sternum (*coxale*) and have, in fact, been mistaken for the 10th sternum (Eaton, '88; Morgan, '13). A similar structure is met with in the Phasmoidea and Acridoidea, except that in these groups the styli are wanting. In most groups, however, the sternum is a single large plate, with or without styli, which when present are borne at the distal margin of the plate. Such a sternum thus consists of the united coxites and sternite and has therefore

* I. e., the sternum of the 8th abdominal segment; in reality it is generally the 7th actual abdominal sternum.

† Incorrectly described as the "ventral portion of the tenth abdominal segment." (Crampton, '18, p. 50).

been termed a *coxosternum* (Verhoeff, '03). Coxosterna bearing styli occur in the Blattoidea, Mantoidea, Isoptera and the Orthopterous family Tettigoniidæ, while coxosterna without styli are present in the Dermaptera, Plecoptera, Embiidina and many other Orthoptera, besides various orders not considered here.

The 10th sternum is generally indistinguishable in the adult state, but in many Plecoptera, Phasmoidea and Odonata it is chitinized, though often not distinctly marked off from the tergum, so that the segment is ring-like. In some cases at least (Phasmoidea, Odonata) this appears to be a secondary chitinization, correlated with the secondary elongation of the segment. Chopard ('17) maintains that the inferior or infero-external surfaces of the paraprocts also belong to the 10th sternum, while the superior or supero-external surfaces represent the 11th sternum, this view being based (1) upon the fact that the tergum of seg. 10 articulates with the lateral margins of the paraprocts, and (2) that these two surfaces of the paraprocts are often separated from one another by a distinct angle and may differ in coloration or degree of chitinisation. It is true that the 10th sternum becomes "absorbed" in the ventral faces of the paraprocts, as has been determined in various species of Orthoptera by one of my students, Miss Norma Ford, who is engaged in a study of the abdominal musculature of Orthopteroid insects, but the 10th sternum does not form the entire ventral surface of the paraprocts and sometimes only a very small part of it.

Chopard ('17) first regarded the supra-anal plate as the tergum of seg. 11, but in his later and more extensive work ('20) he accepts Heymons' view that an eleventh segment is present in the embryo, between the 10th and the supra-anal plate. But, whereas Heymons believes that no part of the 11th segment persists after embryonic life, except the cerci, Chopard considers the sternum of that segment to be represented in the paraprocts, as described above, and considers the supra-anal plate to be a telson, without a sternal counterpart. As my own investigations have been confined to the study of the postembryonic stages I have nothing of value to contribute towards the solution of this problem. I may point out, however, that the paraprocts do not represent the sternum of Heymons' 11th segment, and if this segment is recognized at all it should be recognized in its entirety, including both tergal and sternal regions.

HOMOLOGIES OF THE MALE AND FEMALE ORGANS.

As already pointed out in Part I, the lateral gonapophyses or dorsal valvulæ of the female are prolongations of the coxites of the 9th segment, the styli when present being borne upon their apices; but, except in the Thysanura and many Odonata, sooner or later becoming lost or absorbed during development. The anterior and posterior gonapophyses are homoplastic outgrowths, belonging to the 8th and 9th segments respectively, and, as found in their most primitive condition, in the Thysanura, they are borne upon, or near, the inner margins of the corresponding coxites, close to the bases of the latter.

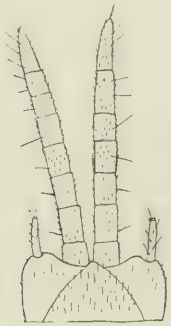

FIG. 1

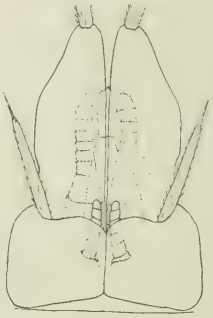

FIG. 2

Fig. 1. *Nicoletia* (*Anelpistina*) *meinerti* Silv., 8th sternum of female. (From Berlese, after Silvestri).

Fig. 2. *Machilis polypoda*, 8th and 9th sterna of male. (From Berlese, after Silvestri).

In the Machiloidea and Lepismoidea the coxites of segment 9 are similar in the two sexes and the sternite has practically disappeared, except in a few Lepismids, such as *Nicoletia*, in which there is a well developed sternite in the female only (Escherich, '05), (Text fig. 1). The posterior gonapophyses are represented by the parameres, which are best developed in the Machiloidea and such Lepismoidea as *Nicoletia* and *Atelura* (Escherich, l. c.) As a rule no structures corresponding to the anterior gonapophyses are present in the male, but Silvestri (nec Berlese, '06) shows clearly in a figure of the male of *Machilis*

polypoda (Fig. 2), two pairs of parameres, of which the smaller anterior pair arises from the 8th segment in a position corresponding nearly with that of the anterior gonapophyses of the female. Verhoeff '10 also refers to both pairs of parameres as the male homologues of the two pairs of female gonopods (anterior and posterior gonapophyses), having abandoned his earlier attempt ('03) to show that the anterior pair of parameres are fused in Machilis and Lepisma to form the penis.

Female Gonapophyses.	*Male Homologues.*
Ant. gonapophyses or ventral valves—	true or posterior parameres, or "telopodites" of seg. 9.
Post. gonapophyses or inner valves—	anterior parameres or "telopodites" of seg. 8. (Present only in certain Machiloidea).
Lat. gonapophyses or dorsal valves—	coxites of seg. 9 (gonocoxites), (with styli), or equivalent parts of the 9th coxosternum.

Male gonapophyses are not always of similar origin in the various orders. In the Odonata the two plates covering the genital aperture are homologues of the lateral gonapophyses of the female, as shown by their development (Van der Weele, '06) and are therefore vestigial coxites.

The question as to whether the parameres of the Thysanura and those of Orthopteroid insects* are homologous or not is more difficult to decide. The former are primarily attached to the 9th coxites, having a more or less posterior position, close to the intersegmental membrane. They are thus ventral to the penis. Those of Pterygote insects, in what appears to be their most primitive form, arise from the walls of the penis (Dermaptera), or from the same situation together with parts of the intersegmental membrane (some Ephemerida), having generally a lateral or dorso-lateral position, but sometimes a ventral one. This difference of position throws some doubt on the homologies of these structures with those of the Thysanura, but such a shifting of position is by no means unusual, and as

* These have been also termed "penis-valves," (Crampton, '20d).

they seem to be characteristic of a very primitive type of genitalia, they are probably structures of ancient origin, whose representatives we should expect to find in the Thysanura. It seems best, therefore, not to distinguish these structures by different terms until further light is thrown upon their origin.

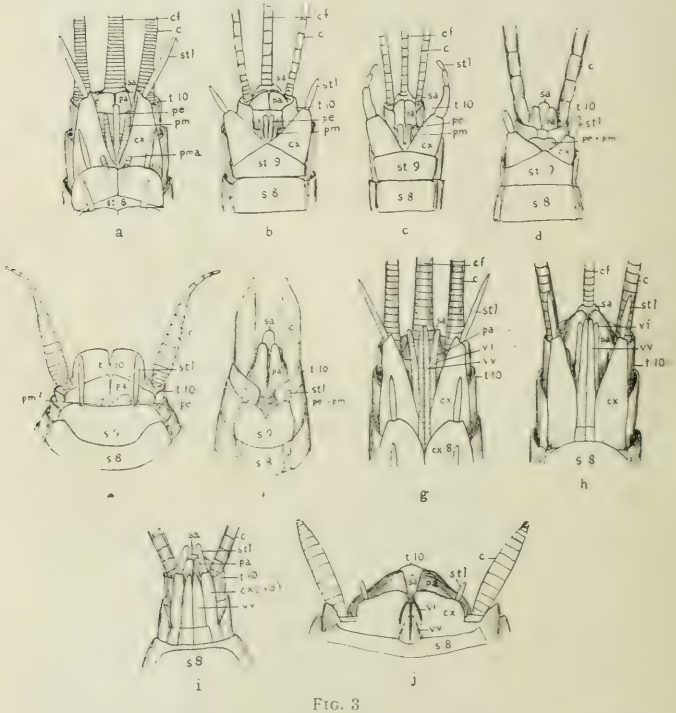

FIG. 3

Fig. 3. Ventral views of terminal abdominal segments, illustrating homologies of male and female structures (semi-diagrammatic). a, *Machilis*, male; b, hypothetical Pterygote type male; c, Ephemerid male; d, *Grylloblatta*, immature male; e, Blattid, male, based on *Periplaneta;* f, Tettigoniid immature male of *Neoconocephalus;* g, *Machilis*, female; h, hypothetical Pterygote type, female; i, *Grylloblatta*, immature female; j. Blattid, immature female of *Parcoblatta;* vd, dorsal valvulæ; vi, inner valvulæ; vv, ventral valvulæ. For other lettering, see page 71.

SPECIAL MORPHOLOGY.

In describing the male genitalia and associated parts in the various orders it will be convenient to take them in a different sequence from that followed in the discussion of the female organs.

Ephemerida.

This group is remarkable for several reasons. The prolongation of the supra-anal plate into a jointed caudal filament or cerciform appendage ("telofilum," Crampton), similar to that of certain Thysanura has been already referred to in Part I. The cerci are longer than in the females, but are otherwise similar. The paraprocts are unchitinized and are covered by the 10th tergum, there being no distinct 10th sternum.

The 9th sternum is very large and is usually divided transversely into two separate plates, of which the distal one is prolonged into a pair of processes, divided into several segments and serving as claspers. These processes are generally considered to be jointed styli, but it is possible that the terminal segments alone represent the styli, the remaining segments belonging to the coxites, which are also represented by the distal of the two sternal plates (the *coxale*), the proximal one being the sternite. The fact that these structures serve as claspers in copulation and that in Grylloblatta the coxites are apparently claspers lends some support to this view. Moreover they contain muscles, which in the Thysanura and Orthopteroid insects only reach the bases of the styli. In some cases the coxites are completely separate, as in *Blasturus nebulosus* Walk. (Pl. I, Fig. 2) or *Callibaetis ferrugineus* Walsh. (Pl. I, Fig. 4), i. e., the distal plate is divided by a median suture. In others (*Heptagenia* spp.) a tripartite division is slightly indicated, the two stylus-bearing parts being indistinctly separated by a median area.

There are two penes, whose walls may be wholly membranous or accompanied by parameres. In *Callibaetis ferrugineus*, e. g., (Pl. I, Fig. 4) these take the form of slender chitinous bands, extending from the lateral margin of the 10th tergum obliquely mesad and cephalad to the bases of the penes, thence curving along the lateral margins of the penes

to their apices. Retraction of the penes is accompanied by the distal part of the parameres.

In this species there is also a sclerite (vo) resembling the "subanal vomer" of the Phasmoidea, consisting of a transverse band of chitin immediately in front of the paraprocts, which is elevated in the middle into a rounded shelf-like projection. On each side the chitin is expanded into a thin plate, which extends to the basal portions of the parameres. In *Blasturus nebulosus* (Pl. I, Fig. 3) and *B. cupidus* each penis bears a single hook arising ventrally near the apex and curved proximad. These have been termed "subappendiculæ" by Crampton, but they appear to represent the distal parts of parameres. Parameres have also been described in *Heptagenia venosa* by Peytoureau ('95) who termed them "aiguillons." In other genera, such as Hexagenia, they are wholly absent.

Dermaptera.

In the Earwigs the large forcipate cerci are associated with modifications of the neighboring sclerites, although the penis retains an apparently primitive structure. The only exception is the aberrant parasitic form *Hemimerus talpoides* Walk., in which the cerci are simple and styliform. Segmented cerci occur in the immature stages of *Dyscritina* and *Diplatys*, (Burr, '11, Zacher, '11), a fact that indicates the more primitive nature of this type of structure.

Correlated with the unusual development of the cerci is the enlargement of the 10th tergum, but there is no marked abbreviation of two preceding terga, such as occurs in the females, and all the terga are free. The 9th sternum is well developed, undivided and without styli. The paraprocts and so-called "opisthomeres" or segments of the supra-anal plate are similar to those of the female. The latter may vary in number from two to four, and as the larger numbers occur only in primative genera, it would appear that they are part of the expression of this primitive condition. They cannot be considered as vestigial metameres, as there is no evidence for the existence of more than eleven true metameres in the abdomen of any insects, but they may possibly represent the vestige of a jointed, caudal filament, like that of the Ephemerida.

In the superfamilies Protodermaptera and Paradermaptera the penis is double or deeply bipartite, the two ejaculatory ducts

opening separately, and being thus merely continuations of the vasa deferentia. In the Eudermaptera there is but one penis, apparently due to the complete suppression of the other. In *Forficula auricularia* L. the vasa deferentia unite at the base of the penis with a small sac, from which a single ejaculatory duct leads to the apex of the penis. There is, however, a vestigial second ejaculatory duct, which has no external opening, indicating an originally bipartite penis. In *Hemimerus talpoides* the sole representative of the aberrant suborder Hemimerina, there is a single penis, which when everted possesses two apertures. The vasa deferentia unite to form a single short ejaculatory duct, which near the termination of the penis divides again.

In all the Dermaptera there is a single pair of unsegmented, chitinized parameres, which generally arise from the dorsal and lateral surface of the penis or penes, proximad of the praeputial sacs, although sometimes their position is ventral, as in Hemimerus (Heymons, '12). The parameres exhibit great variation in length, form and details of structure. Apart from the parameres and virga, which is often present in the form of a very slender eversible spine, the penis may be entirely membranous or chitinized in part.

Plecoptera.

In the Stone-flies the general form of the terminal segments and cerci is similar in the two sexes. The ninth sternum of the male is more or less enlarged to form a hypandrium, but is undivided and devoid of styli. The tenth segment is frequently ring-like, owing apparently to the meeting and fusing of the tergal margins in the mid-ventral line rather than to the fusion of terga and sterna, since in some forms the tergal margins are but narrowly separated. The tenth tergum is sometimes produced caudally, or elevated, or mesially divided, in which case the two parts, or "hemitergites," may bear hooks, as in *Arcynopteryx americana* (Klapalek, '12, Fig. 18), or they may be prolonged cephalad over the preceding terga, which are grooved to receive them. I have not found a distinct tenth sternum in any of the forms examined.

The supra-anal plate may be insignificant or almost vestigial, or it may, on the other hand, exhibit remarkable modifications. In *Capnia vernalis* Newp. (Pl. II, Figs. 11–13) it is prolonged

into a huge spout-like organ, which is bent upwards and forwards over the terga of the ninth and tenth segments. This structure (spc) consists of a tubular process with a spear-shaped extremity and rests in another more flattened trough-like piece. The two are received into a mid-dorsal groove on segments 9 and 10 and their free extremities are apparently received into a notch under cover of the elevated and slightly produced edge of the 8th tergum. If we examine the ventral surface of this peculiar structure, which is evidently a sperm-conveyor, we see that its base is marked off from the rest of the supra-anal plate by a transverse suture, under the edge of which is the proximal opening into the lumen of the sperm-conveyor. Leading from the opening of the ejaculatory duct is a groove with thickened sides, which passes between the flat paraprocts and along the ventral surface of the supra-anal plate, to the opening of the sperm-conveyor. This is evidently a seminal groove, along which the spermatic fluid is conducted from the ejaculatory duct into the sperm-conveyor through the proximal opening of the latter. There is no true penis in this species.

In the Pteronarcinæ and some, at least, of the Perlinæ (Perlodini) there is a somewhat similar modification of the supra-anal plate, differing from that of *Capnia*, however, in that the median part is deeply invaginated into a pocket, so that there is no prominent, projecting external structure. In some species of *Pteronarcys*, according to Smith ('17), this structure serves as a sperm-conveyor, while in others it is apparently modified for another function, that of a "probe-like organ in opening up the genital passages of the female." In the Perlodini its function is generally, if not always, more of the latter nature, serving apparently as a titillator or copulatory hook. In both groups the structure is similar enough to indicate a common origin.

In *Isogenus frontalis* Newm. (Pl. II, Figs. 14–17), which I have taken as an example of this type, there is a deep, narrow, median invagination of the tenth tergal region, as well as the supra-anal plate. The tenth tergum is thus divided into two "hemi-tergites," each of which is somewhat thickened at its mesocaudal angle, where it bears a few denticles. In other species of this group these angles may be raised into hook-like projections (e. g., *Arcynopteryx americana*, Klapálek, op. cit.) The invaginated part of the tenth tergum forms a large median

apodeme (m ap). The supra-anal plate (Fig. 16) consists of a pocket, whose walls are partly membranous, partly differentiated into separate sclerites, which are moved by intrinsic muscles (vide Smith, op. cit.) On each side of the opening of the sac is a somewhat triangular plate, termed by Smith the *para-genital plates* (pg) which seem to be the homologues of the two dorsal basal parts of the supra-anal plate of *Capnia*. In the mouth of the sac can be seen a median chitinous hook (mst) and a pair of lateral rods or styles (lst). These are termed by Smith the median and lateral stylets. They are all connected at base with a strong bar, which bounds the sac in front and joins the base of the median apodeme of the tenth tergum. The copulatory hook, or median stylet, is the "titillator" of other species, of such genera as *Arcynopteryx* and *Skobeleva* (Klapálek, '12), in some members of which it has the form of a long slender spine.

The supra-anal plate is subject to still other modifications, such as, e. g., in *Acroneuria brevipennis* (Crampton, '18), in which it bears a pair of well-developed hooks, while in other forms, such as *Isoperla* sp. (Pl. II, Fig. 18) it is wholly without special modifications, and even imperfectly differentiated.

As it is evident that these modifications have developed within the order, no attempt need be made to homologise them with similar structures found in other orders. Crampton ('18) has compared the appendage of the supra-anal plate (sperm-conveyor) of *Capnia* to the slightly similar horn-like projection of the tenth tergum in certain Odonata (*Ischnura*) and remarks that although not strictly homologous "it is unnecessary to apply different names to the two structures, which are practically the same in their nature and position on the tergal region of the segment bearing them." So far from being "practically the same," they are not only borne by different segments, but are adapted to wholly different functions, that of Capnia being a sperm-conveyor, while that of Ischnura is a brace which fits upon the mesosternal lamina of the female in copulation. Crampton also labels the furcate appendage of the supra-anal plate of *Scudderia furcata* Brunn. with the same abbreviation as he uses for the structures just mentioned, though this is also quite different in nature from either of the others, being a development within the Tettigoniid subfamily Phaneropterinæ.

The paraprocts are generally well developed, chitinized and fused with the bases of the cerci, although in the nymphs of some forms and also the adults of others they may be more distinctly separated. Frequently they bear copulatory appendages in the form of hooks, as in *Isoperla* sp. (Pl. II, Fig. 18), or of long processes which fit together into a spout-like organ (*Dictyopterygella*, teste Klapálek, '12). Crampton's figure of *Acroneuria brevipennis* shows a pair of small hooks on the paraprocts in addition to the larger ones borne by the supra-anal plate.

Owing to lack of material I have been unable to study satisfactorily the penis of the Plecoptera. When present it is usually single, but according to Crampton, the bipartite form occurs in some forms, such as *Nemoura completa* Walk. (l. c., Pl. II, Fig. 16). In this figure processes resembling parameres are represented. In some cases it is membranous and eversible, in others it is partly chitinized, and it may be provided with a virga, as in *Perlesta flavida* (Crampton, l. c., Pl. II, Fig. 14). In *Perla tristis* Hag. it is a large, stout structure of simple rounded form, with a rather large terminal aperture, (Pl. II, Figs. 19, 20). The distal part of the ejaculatory duct has longitudinally folded walls and is darker than the rest of the organ. There are no parameres nor other chitinous parts.

Embiidina.

The only species, males of which I have studied, is the widely distributed *Oligotoma saundersii* Westw., but the numerous figures in Enderlein's monograph of the order (Enderlein, '12) afford a basis for a more general survey of the genitalia of this group.

The most primitive form is undoubtedly the large South American *Clothoda nobilis* Gerst., which is remarkable for the symmetry of the terminal abdominal structures, and for the lack of the various copulatory processes, so strikingly developed in all the other genera. In most of the Embiids there is a shortening of the ninth abdominal tergum and an enlargement of the tenth, somewhat suggestive of the Dermaptera. In *Clothoda* the tenth tergum is short, symmetrical and entire, while in all the other genera it is more or less enlarged and deeply divided into two asymmetrical parts (hemitergites), which are sometimes completely separated. In the great

majority of forms each hermitergite bears a more or less hook-like copulatory appendage, but these may differ very greatly in form and position. In *Oligotoma saundersii*, e. g., the dextral hook is much longer and differently shaped from the sinistral one (Pl. I, Figs. 9 and 10).

The ninth sternum is entire and without styli, and, except in Clothoda, is asymmetrical, the apex being well to the left of the median line and bearing another copulatory process. The asymmetry also involves the cerci, which are two-segmented, without including the basipodites. These sclerites are generally inconspicuous, but in *Clothoda* they are well developed, extending mesad in the form of freely projecting plates, somewhat suggestive of the paraprocts of certain Plecoptera, such as *Perla*. One might, in fact, be tempted to interpret the latter as greatly enlarged cercal basipodites rather than as true paraprocts. In Oligotoma the left basipodite bears still another copulatory appendage on its inner side. These various copulatory appendages converge on the left side of the middle line, their position suggesting that in copulation the abdomen of the female is grasped by the male from the right side.

Of the supra-anal plate, paraprocts and penis I have been able to find nothing in *Oligotoma*. They must be extremely vestigial if present at all, although the paraprocts are quite distinct in the females of this order.

It is altogether probable that the special characteristics of the male Embiids, i. e., the asymmetry and the development of the various copulatory appendages, have been evolved within the history of the group itself, since its most primitive living member, *Clothoda*, is lacking in these very features. Accepting this view it is useless to attempt to homologise these processes with those of similar function occurring in other orders.

The male genitalia of the Embiidæ offer little or no evidence as to their relationships with other orders, but there is nothing in their structure to conflict with the view held by MacLachlan, Crampton and others that their nearest affinities are with the Plecoptera. In fact, in the development of copulatory appendages from a great variety of parts, they at least show similar tendencies to the Plecoptera, especially in the division of the tenth tergum into hermitergites, each bearing a hook, a feature which has already been noted in the case of the Plecopteran genus *Arcynopteryx*, and is by no means confined to that genus.

Orthoptera.

In the Orthoptera there is a tendency toward a shortening of the posterior terga, which is most marked in the Acridoidea, while the anal plates are usually well developed but very variable in form. The supra-anal plate is frequently fused with the tenth tergum, but not overlapped nor replaced by the latter as in the Blattoidea, Mantoidea and Isoptera, although in certain Tettigonoidea (Ceuthophilus) the ninth tergum (more rarely the 8th) projects over the tenth and supra-anal plate, thus having the appearance of being the last dorsal segment. The cerci are with rare exceptions unsegmented and short, being frequently modified as claspers. A small cercal basipodite is usually present. The ninth sternum is generally entire, forming a hypandrium, but in the Acridoidea it is divided by a transverse suture, as in the Phasmoidea, the distal plate probably representing the fused coxites. Secondary subdivisions may also occur in some Tettigonoidea. In this superfamily styli are generally present, but they are absent in all the other groups.

Owing to the peculiar and often extremely complex structure of the genitalia it will be convenient to deal with these separately after having discussed the other structures with which we are concerned.

The Terminal Segments, Cerci and Styli.

Tettigonoidea. In most of the long-horned grasshoppers the abdominal segments are not greatly specialized, the terga and sterna being distinct and separate, the latter rather feebly chitinized, and the spiracles occupying the pleural membrane. There is usually relatively little shortening of the 9th and 10th, although sometimes, as in *Ceuthophilus*, the 10th is small, subvertical and concealed by the projecting 9th tergum, which is thus commonly but erroneously termed the supra-anal plate by systematists. The true supra-anal plate is of variable size, but generally inconspicuous, and frequently fused with the tenth tergum in the adult insect. It is not divided transversely, or otherwise, as in many Acrididæ. The paraprocts are commonly lobe-like and but little chitinized. The ninth sternum is typically undivided, though indications of the coxites are sometimes seen in the more or less bifid caudal

margin of many forms, this feature being particularly noticeable in young nymphs and sometimes, as in species of *Ceuthophilus*, secondary subdivisions are present. Styli are present in the majority of genera, though frequently absent, as in many of the Rhaphidophorinæ, which in this respect, and also in the more convex and upturned ninth sternum, the unmodified cerci and the structure of the genitalia, approach the Grylloidea. The cerci are generally short, unsegmented and modified to serve as claspers in copulation, but in the Rhaphidophorinæ, with few exceptions, they do not function as such, being like those of the female, comparatively long, flexible and tapering, and covered with sensory hairs. In some species of this family, such as *Pristoceuthophilus cercalis* Caud., the cerci have a few small terminal segments, but this character, though an interesting exception to the general rule in the Orthoptera, is probably an atavistic one. A small cercal basipodite is sometimes, but not always, present. In the large membranous area between the paraprocts and the ninth sternum is the penis, which is described below.

In *Cyphoderris monstrosa* Uhl., (Pl. IV, Figs. 35, 36) an aberrant species, usually placed in the Stenopelmatinæ, a most remarkable modification of the genital structures is present. The ninth sternum is bent vertically upwards and closely applied to the end of the abdomen, which it covers below the paraprocts. Into the narrow pocket thus formed opens the genital passage, whose folded, membranous lips are the only representative of the penis, there being no chitinized parts. There is, however, in place of the titillators or parameres, a large process arising from the 9th sternum. It projects somewhat backward and is then sharply bent downward, terminating below in a pair of divergent spines. The dorsal surface also bears minute spinules. In a nearly full-grown male nymph of this species there is no indication of this structure, and the sternum, though bent up, is less closely applied to the body. In both adult and nymph there is a pair of stout, flattened styli, which, from their position, are at first sight, somewhat suggestive of titillators.

Grylloidea. In the crickets the abdominal segments are similar to those of the Tettigonoidea, except that the ninth sternum is smaller, more narrowed caudally, and envelopes the genitalia more closely, there being a smaller outlet for the

genital cavity; and there is no trace of styli. The inner surface of the sternum is covered by a much folded glandular epithelium. The cerci are not modified as claspers, and are longer, flexible, with long hairs and sensillæ, although unsegmented. There is a small external cercal basipodite. In all these respects they are approached by the Tettigoniid subfamily Rhaphidophorinæ. The anal plates are generally more prominent and heavily chitinized than in the Tettigonoidea. The supra-anal plate is undivided and is sometimes, as in *Gryllus* and *Nemobius*, indistinctly separated from the tenth tergum.

More important characters are found in the genitalia (q. v.)

Tridactyloidea. The outstanding characteristics of the males of this group, apart from the penis, are the weakening and infolding of the posterior abdominal terga, particularly those of segments 8, 9 and 10, which are more or less concealed by the overlapping 7th tergum, the dorsal lengths of segments 8 and 9 being greatly reduced by the obliquity of their hind margins; the styliform and sometimes two-jointed cerci, the long moveable processes of the paraprocts and the absence of true styli.*

In *Tridactylus apicalis* Say the terga are mesially grooved with steeply sloping sides, and the 9th is divided and concealed by the 8th, except towards the lateral margins. The 10th is much larger but is likewise divided by the median groove, and the supra-anal plate is also sulcate with only the lateral margins strongly chitinized. The paraprocts are chitinized and bear a pair of slender, styliform processes, like those of the female. The sterna are wider than the terga, the 9th forming a flattened and undivided hypandrium.

In *Ripipteryx* the general characteristics of the terga are similar but with marked variations according to the species.

* Crampton ('20d) considers these styliform appendages as probably true styli, belonging to seg. 11, the paraprocts representing the coxites of that segment. If these processes were true styli we should expect to find them in some other groups of Orthopteroid insects besides the Tridactylidæ, as well as in the Thysanura, in which styli sometimes occur on nearly all of the abdominal segments. It is noteworthy, however, that even in such Thysanura as *Machilis*, in which the styli are seen in their most primitive and best developed condition, they are absent from the 10th segment and paraprocts. The development of styliform processes in connection with the genitalia is very common in insects and the presence of these processes in this single small group of Orthoptera is an insufficient basis for speculation as to their origin.

In *R. carbonaria* Sauss., the only species I have examined, the 9th tergum, is the only one that is divided. The 10th and supra-anal plate are both of large size, though somewhat sulcate and weakened mesially. The 9th sternum forms a large, somewhat convex hypandrium, and is almost completely fused with the tergum. The cerci are simple and styliform with a distinct basipodite. Just beneath each is a chitinous hook, which apparently belongs to the paraprocts, but is perhaps developed from the cercal basipodite. It is also shown in de Saussure and Zehntner's figure of *R. cyanipennis* (op. cit., Pl. XVII, Fig. 34). The long processes of the paraprocts in *R. carbonaria* Sauss. and *R. forceps* Sauss., are remarkable for their modification as copulatory forceps. They are long and stout, with thickened apices, abruptly bent inwards.

In *R. mexicanus* Sauss., according to the figure of de Saussure and Zehntner (l. c., Pl. XVII, Fig. 30), the cerci are indistinctly divided into nine segments, but it seems probable, on comparison with other species, that this segmentation is not a primitive condition. In this species and others, such as *R. cyanipennis* Sauss., the processes of the paraprocts are not modified to serve as claspers.

Acridoidea. In the locusts the hind margins of the last two or three abdominal terga are increasingly oblique caudad, this obliquity being associated with a marked shortening of their mid-dorsal lengths, as compared with their lateral margins. These features, together with the large, more or less upcurved ninth sternum, result in a general upturning of the end of the abdomen, the opening of the genital cavity facing dorsad instead of caudad. In respect of the shortening and obliquity of the terga, the group may be compared with the Tridactyloidea, the resemblance to which is greatest in the Acrydiidæ (Tettigidæ), but is even here not very marked.

The segments are all separate in the Acrydiidæ, but in the Acrididæ the 9th and 10th terga are laterally fused, as in the females. A median furcate appendage, the *furcula*, is sometimes borne by the latter, as in *Melanoplus*. The large, usually triangular supra-anal plate is primarily divided by a transverse suture, as in the female (see Part I), but in the adults this division is frequently lost.* The peculiar subdivision of

* Chopard ('20) has given good reasons for considering this transverse suture to be the true boundary between the 9th and 10th terga, the apparent boundary being a secondary ridge.

this plate in the Acrydiidæ, described in the account of the females, is present also in the males; and the cerci in this family are also similar in the two sexes. In the Acrididæ they are usually larger in the male, serving as claspers in copulation, although often but little modified. In the Acridinæ and Oedipodinæ, e. g., they are small, simple and styliform, while in the Locustinæ they assume a considerable variety of forms, sometimes being forcipate, as in the Old World genus *Calliptamus*, but never, so far as I am aware, armed with teeth or spines, as in the Tettigonoidea. There is a distinct cercal basipodite in all of the forms examined. The paraprocts are broad and flat as in the females.

The structure of the ninth sternum is very peculiar. It is very large, externally convex and upturned, and divided transversely as in the Phasmoidea, the distal plate, commonly known as the subgenital plate, possibly representing the fused coxites. This plate has sometimes been mistermed the tenth sternite. Its margin forms the rim of a deep genital cavity, roofed over by a fold of integument, the *pallium*, which is continuous with the sternal margins, and together with the paraprocts, usually completely conceals the genitalia, although in some species in which the penis is very long the pallium is pushed up into a conical form, the tip of the penis being exposed. In the Acrydiidæ the pallium is more firmly chitinized than in the Acrididæ, its dorsal surface being covered with a pair of plates separated by a median groove. In *Acrydium* (*Tettix*) and *Paratettix* there lie in this groove two slender rods, which terminate near the front margin in a pair of small hooks, resembling titillators and probably serving a similar purpose, the usual titillators (parameres) being absent in this family (Pl. VI, Fig. 60). In *Tettigidea* (*T. lateralis parvipennis* Harr., Pl. VI, Figs. 58, 59) these hooks are absent, but the pallium is still more heavily chitinized than in *Acrydium*, being a decidedly plate-like structure, divided into right and left parts by a median suture. Morphologically the pallium is part of the primitive floor of the genital cavity. Styli are absent in the Acridoidea, although there are some forms, like *Acrydium*, in which two small tubercles on the caudal margin of the ninth sternum are somewhat suggestive of vestigial styli.

The Genitalia.

The male genitalia of the Orthoptera exhibit an even wider range of variation than do those of the females, but, as in the latter, a fundamentally similar plan of structure can be traced in these organs throughout the order, except in a few cases in which they are very degenerate. This plan of structure is characteristic of the Orthoptera *sens. str.*, and is widely different from other orthopteroid groups. Its most distinctive feature is the presence of a pouch or sac into which the ejaculatory duct opens and from the roof or walls of which the parameres arise. The sac has the function in very many forms of a spermatophore sac, and this is probably its primitive purpose.

The penis is commonly large and prominent and its orifice is generally wide with folded walls, there being usually a pair of ventral lobes, or sometimes a single one. The titillators, or parameres, as I believe them to be, are primitively dorso-terminal in position, but their bases are usually more or less retracted, so that they may appear to have no relation to the dorsal surface, being in some cases almost completely concealed from view.

Owing to the shifting of the genital area from a ventral to a posterior position by the elongation of the ninth sternum the penis comes to lie under the paraprocts, and is also typically under cover of a projecting plate, the *pseudosternite*, which forms an arch over its base and serves for the origin of muscles concerned in its movements. This arch is often prolonged on each side into a pair of arms, the *rami*, partly encircling the penis at its base, and more or less produced inwardly into processes, which may be termed *endapophyses*, for the attachment of muscles concerned in the movements of the penis. Sometimes the endapophyses may be separated from the pseudosternite and are present in many forms (Tettigoniidæ), in which the latter has disappeared. In the Acridoidea these structures are further complicated, but their peculiarities need not be considered here.

In addition to the structures just described there may be mentioned also a pair of glandular pouches, lined with chitin, which open separately or by a common duct into the ejaculatory duct, close to its termination in the spermatophore sac. It is sometimes represented by a single sac and is probably connected

with the formation of the spermatophore, as it is absent in the Acrididæ and Tridactylidæ, in which apparently no spermatophores are formed.

Tettigonoidea. With the exception of the aberrant Stenopelmatine *Cyphoderris monstrosa* Uhl., and probably other Stenopelmatinæ, in which the penis is degenerate, the male genitalia of the Tettigonoidea, as represented by the forms studied, may be divided into two types, the one represented by the Rhaphidophorinæ, the other by the Decticinæ, Conocephalinæ, Copiphorinæ, Phaneropterinæ, Tettigoniinæ, Meconeminæ and probably by most of the other subfamilies.

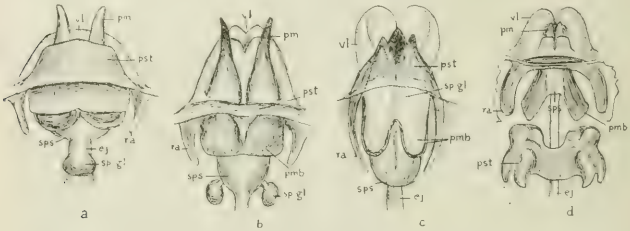

Fig. 4.

Fig. 4. Genitalia of male Orthoptera, dorsal views (diagrammatic); a, Tettigoniid, based on *Ceuthophilus* (parameres partly everted); b, Tettigoniid, based on *Neduba;* c, Gryllid, based on *Gryllus;* d, Acridid, based on *Dissosteira*. For lettering, see page 71.

The first type is the more primitive and may be illustrated by the genus *Ceuthophilus*. Figs. 22–25 show various views of the penis of *C. lapidicola* Burm. In this type the penis is almost entirely membranous, as are also the parameres, which in *C. lapidicola* are only slightly chitinized proximally along their mesial surfaces, the narrow chitinized areas coalescing at base to form a single sclerite. In the resting condition (Fig. 22) the posterior wall of the penis is invaginated, forming the spermatophore sac, into the lower part of which the ejaculatory duct opens (gp). The upper part is marked off from the lower by a slight transverse fold (fps), above which is seen the plate formed by the united bases of the parameres (pmb), which being partly inverted, are otherwise invisible in this position. The fold (fps) corresponds to the floor of the "paramere sac" in Neduba, etc. (see p. 27). In Fig. 25, of Pl. III, which was

drawn from a potash preparation, they are shown in a completely inverted position, but this is a position that is prevented in life by the mass of muscles which surround the spermatophore sac.

The mouth of the spermatophore sac is bounded below by a single, large ventral lobe, which is slightly chitinized and densely spinulose. In the retracted condition a deep transverse pocket is formed beneath the ventral lobe.

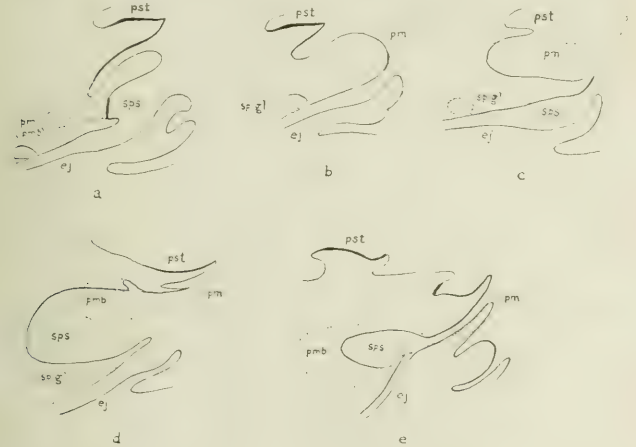

FIG. 5.

Fig. 5. Genitalia of male Orthoptera, diagrammatic median sagittal sections. The dotted lines indicate structures not in the median plane. a, *Ceuthophilus*, retracted; b, same, everted; c, *Neduba;* d, Gryllid, based on *Gryllus;* e, Acridid, based on *Dissosteira* and *Melanoplus*. For lettering, see page 71.

On the roof of the penis there is a pair of small openings with chitinized margins, leading into narrow tubules (Fig. 25), which appear in sections to be partly glandular, but whose lining cuticle is minutely pubescent. In sections of specimens with everted parameres they are drawn backwards into the cavities of the latter. These structures have apparently no homologues in the other types of Orthoptera studied.

Over the base of the penis is the large hood-like pseudosternite, the concavity of which forms a sort of sheath into which the penis is retracted. The rami are not very distinctly developed externally, though connected with one another ventrally by a feebly chitinized arch. Their internal projections or endapophyses, however, are large and prominent.

In the everted position, the penis of this species (Pl. III, Figs. 23, 24), protrudes considerably from beneath the pseudosternite and the pocket beneath the ventral lobe is straightened out. The spermatophore sac is obliterated and the parameres appear as large divergent cornua, which as already stated, are only feebly chitinized proximally along their mesial surfaces.

In this position Ceuthophilus illustrates well what appears to be the primitive, dorso-terminal position of the parameres in the Orthoptera.

Fig. 26 is a posterior view of the end of the abdomen of *C. aridus* Brun., in which the roof of the invaginated penis is strongly retracted and folded ventrad in such a way as to expose the under surface of the pseudosternite. This has been forcibly elevated to show the lower margin, which is bent into a little arch, beneath which the ejaculatory duct passes, covered also, of course, by the thin, collapsed roof of the penis. Although this figure differs greatly in appearance from those of *C. lapidicola* the genitalia are essentially similar in the two species, as far as can be seen in the retracted condition.

Fig. 27 is a similar view of *C. maculatus* Harr., with the genitalia everted. The parameres are very small and there appear to be no openings on the roof of the penis. The pseudosternite is a heavily chitinized gable-like structure, with a median projection, and is prolonged ventrad into distinct rami. It is quite suggestive of certain Gryllidæ such as *Gryllotalpa*.

The second type of genitalia differs from the first in the following features:

1. The absence of the pseudosternite, or its reduction to a very slight membranous fold.*

* A well developed pseudosternite, together with typical parameres, is figured by Chopard ('20) in *Thyreonotus corsicus* Ramb., a Decticine. Chopard, however, regarded both structures as part of the "epiphallus." The case is important in giving further conclusive evidence that the pseudosternite and parameres are different structures, a view that might otherwise be denied by those who would fail to recognize as parameres the introversible processes of Ceuthophilus.

2. The non-introversible chitinized parameres, whose bases are prolonged cephalad so as to reduce greatly, or even obliterate, the roof of the penis, and to occupy a sac of their own, the *paramere sac*, above the spermatophore sac.

3. The median division of the ventral lobe into two folds, which are membranous and not pubescent.

This type may be illustrated by *Neduba carinata* Walk., a member of the Decticinæ. Posterior, dorsal and lateral views of this species are given in Figs. 29, 30 and 31.

The pseudosternite is practically absent, only a slight, membranous fold being found in its place. The parameres are large cornua with slender, upcurved apices and stout bases, arising from the walls of the paramere sac, the floor of which is also somewhat chitinized. The paramere sac is comparatively large, the spermatophore sac rather small, at least when contracted, and the intervening fold is produced into a pair of short processes which are chitinized ventrally. The ventral lobes are, as usual in this type, wholly membranous. The glandular pouches, opening into the ejaculatory duct at its distal end, are of considerable size.

Of the same general type are the genitalia of *Conocephalus* (*C. brevipennis* Scudd., Figs. 32, 33). They differ from those of Neduba in the form of the parameres, which are represented by a pair of thick, muscular ridges, arising from the floor and sides of the paramere sac. Along the edge of each ridge is a chitinized bar, which meets its fellow in front but diverges caudad, and curving ecto-dorsad around the end of the ridge, terminates in a short spine. These bars are covered with fine spinules. The ventral lobes are of large size and folded inwards to allow considerable expansion of the spermatophore sac. The septum between the paramere sac and the spermatophore sac is simple and unchitinized. The endapophyses are small and concealed beneath the penis, but have distinct inward processes. The glandular pouches opening into the ejaculatory duct are of large size and are lined with chitin.

In the last nymphal instar of *Conocephalus* (Fig. 34) the penis has a simpler tubular form; the parameres, represented merely by the slightly chitinized, dorso-terminal edges of the orifice, being as yet not at all retracted, so that there is no paramere sac at this stage. The ventral lobes are divided into a larger outer and a smaller inner part. The former is dis-

tinctly chitinized at the margin, though it is apparently the part which in the adult becomes wholly membranous and bent inwards. The small, inner parts are less chitinized and are readily recognizable also in the adult.

In *Neoconocephalus ensiger* Harr., *Scudderia curvicauda* DeGeer and other species of Scudderia the parameres have no projecting spines. In *S. curvicauda* they are reduced to a pair of rounded tubercles on the floor of the paramere sac, densely beset with spinules. They represent a highly specialized type.

Grylloidea. The crickets are most remarkable for the complex structure of the spermatophore and its sac. As an example of the family we may first take the common field cricket, *Gryllus assimilis* Fabr. The adult genitalia of this species are shown in Figs. 37–39.

The pseudosternite is readily recognized from its general resemblance to that of *Ceuthophilus*. As in this genus it is a hood-like structure overarching the penis, but it is much more closely connected with the latter than in *Ceuthophilus*, forming what is virtually its chitinized dorsal surface. It terminates in three prongs (pc) which doubtless serve as the titillators and is connected laterally with the slender rami, which pass ventro-cephalad to the floor of the genital cavity. These are not produced into endapophyses. The ventral lobes are large flexible whitish flaps, enclosing a concavity in which the ampulla of the spermatophore rests after it has passed out of the spermatophore sac. The latter is a deep rounded pocket, whose roof and floor are formed of a single strip of thin chitin, bent around the end of the sac and projecting over its mouth in a pair of slender spines (vs), placed closely together. When the spermatophore is in place the filament is curved upwards around the end of the sac, and backwards along the middle of the upper surface, its lateral expansions covering the floor, and serving to anchor it. A narrow median groove in the roof, terminating between the two projecting spines, is the site where the duct is formed.

Upon the roof of the spermatophore sac and beneath the pseudosternite are two arcuate bars, meeting one another in the middle line and continuous laterally with a pair of bars, which appear on the inner surface of the sac near its mouth. These curved bars are formed as evaginations of the roof of

the spermatophore sac, as can be seen clearly in transverse sections. From their muscular connections they appear to represent the bases of the parameres, and may be termed endoparameres (Fig. 37, *pmb*). With the parameres may also be associated the lateral bars already mentioned, and perhaps also the two lobes supported by triradiate sclerites, which are situated just beneath the lateral prongs of the pseudosternite, and which are also in close connection with the lateral bars (*ectoparameres*, Figs. 38, 39, pm).

At first sight it would appear as though the spermatophore sac were the homologue of the paramere sac of the Tettigonoidea, but the latter structure is developed merely as a result of the enlargement and inward extension of the paramere bases, in consequence of their function as protrusible titillators, whereas in the Gryllidæ the parameres possess no such modification and have no bases other than the roof of the spermatophore sac itself.

The paired glandular pouches, which open into the ejaculatory duct near its termination, are similar to those of most Tettigonoidea, though somewhat smaller.

The last nymphal stage of *Gryllus* shows some peculiar features. Figs. 40 and 41 are ventral and ventro-posterior views of the genitalia at this stage. The pseudosternite resembles that of the adult, except that its three prongs are very short and blunt. The ventral lobes appear as a flat, bilobed, chitinous flap, covering the site of the genital aperture, which has not yet appeared. Between the pseudosternite and the ventral lobes is the space that later becomes invaginated to form the spermatophore sac. The chitinous layer which lines the latter, and also the median groove and the two terminal points are already indicated, the last-named structures being relatively much larger and stouter and not yet separated into two parts. They are separated from the pseudosternite by a larger space than in the adult. There is at this stage no indication of the parameres.

It may be questioned whether the structures which I have identified as the parameres are the true homologues of these processes in the Tettigonoidea. They are the structures called "titillators" by de Saussure and Zehntner, while Chopard refers to them as the underside of the "pseudépiphalle" (pseudosternite) and recognizes no homologues of the titillators or parameres ("epiphallus"). My reasons for identifying these

structures with the parameres are (1) their origin as evaginations of the wall of the spermatophore sac (cf. *Ceuthophilus*), and (2) their muscular connections, which are comparable to those of other groups of Orthoptera.

In *Nemobius fasciatus* DeGeer the male genitalia are surprisingly unlike those of *Gryllus*, considering how nearly related the genera are in other respects (Pl. V, Figs. 42, 43). The pseudosternite is partially retracted and adherent to the overlying integument. It has no median process, but has two pairs of lateral ones, of which the upper may represent the median process of *Gryllus*, the lower ones the lateral processes of that genus. Between the lower pair is another pair of more flexible processes, evidently the homologues of the ectoparameres of *Gryllus*. The pseudosternite extends down on each side at base, but is not narrowed into distinct rami.

The remarkable feature of this form, however, is the spermatophore sac, which is really not a sac at all, as it does not become invaginated, but is merely longitudinally sulcate. At the distal end the plate which lines the "sac" is greatly contracted and has a very narrow channel, but farther proximad it is considerably expanded and much more broadly sulcate. The endoparameres take the form of long slender rods, which are divergent towards their free ends. They have the same origin as in *Gryllus*, viz., as evaginations of the wall of the spermatophore sac. As a result of the form of the spermatophore sac the ventral lobes are far forward and completely hidden, the entire spermatophore sac lying behind them. They are also relatively smaller and less distinctly separated from one another than in *Gryllus assimilis*.

In *Nemobius carolinus* Scudd. the genitalia are very similar to those of *N. fasciatus*, but in the European *N. sylvestris* Fab., according to Lespes ('55 b) there is some approach to *Gryllus* in the longitudinal curvature or slight invagination of the spermatophore sac.

In the tree-cricket *Oecanthus nigricornis* Walk. the genitalia are like those of *Gryllus* in most respects, (Pl. V, Figs. 44–46), differing chiefly in the following features: The pseudosternite has a pair of prominent internal projections just mesad of the bases of the endapophyses. These are only slightly indicated in *Gryllus*. The median prong is represented by a pair of processes close together, while the lateral prongs are

almost obsolete. The ectoparameres are broad, rounded and prominent, and are closely connected with the endoparameres, which are long, thin plates, extending forward almost to the end of the spermatophore sac, and are wholly separate from one another. They are lateral rather than dorsal in position, being formed by an infolding of the integument on each side of the spermatophore sac, whereas in *Gryllus* the infolding, though partly lateral, is mainly dorsal, the two endoparameres coalescing in the middle line. In *Oecanthus* the entire endoparamere is a chitinized plate, in *Gryllus* only the arcuate edges are chitinized. The anterior extremities of these plates in *Oecanthus* are free and each bears a slender outwardly projecting spur.

The spermatophore sac of *Oecanthus* is long and compressed, but formed by an invagination similar to that of *Gryllus*. The roof of the sac is, however, much longer than the floor, the mouth being very oblique. The ventral lobes are similar to those of *Gryllus*.

In *Gryllotalpa*, according to de Saussure and Zehntner ('94) the pseudosternite has somewhat the form of an anchor (hence the term "anchre" of these authors), being produced laterally into a pair of long arms which are evidently the rami. The distal prongs are lacking in this genus.

Tridactyloidea. *Ripipteryx carbonarius* Sauss. is the only species whose genitalia were studied (Pl. V, Figs. 47–50). On first examination there appear to be no chitinous parts, as these are almost wholly retracted, but in a cleared preparation a structure of some complexity was revealed. This structure is elongate and much depressed and consists of two flattened sacs, dorsal and ventral, connected at their posterior extremities. The ejaculatory duct, which is distally rather wide, with distinctly chitinized walls, opens into the anterior end of the ventral sac, which thus seems to be the homologue of the spermatophore sac. No trace of lateral glandular pouches is present. The dorsal sac is covered with a thin plate, which is little chitinized except along the lateral margins, which are produced cephalad into a pair of long, slender rods, apparently for the insertion of muscles, and at its posterior extremity, where there is a small plate or more heavily chitinized part of the roof of the sac, which barely projects over the genital aperture. The roof of the dorsal sac is evidently the pseudosternite but is so deeply retracted as to be almost wholly an

internal structure. As in many Orthoptera, such as *Gryllus*, *Nemobius* and *Ceuthophilus*, the posterior, more exposed part is more heavily chitinized than the anterior, concealed portion. The lateral chitinized margins are also exposed towards their bases and represent the rami (cf. *Nemobius*), while the long, slender, internal processes are the endapophyses. The floor of the dorsal sac represents, of course, the roof of the penis. There appear to be no traces of parameres.

On the whole the gentialia of *Ripipteryx* appear to approach those of *Ceuthophilus* more than any other of the types studied, though the pseudosternite recalls that of *Nemobius* to some extent. The simple dilatation representing the spermatophore sac suggests that of *Ceuthophilus*, or other Tettigoniids, and the deep pocket between the pseudosternite and the penis roof is also suggestive of this genus. Both of these are primitive characters. The long horizontal endapophyses, on the other hand, are more like those of the Acrididæ, though the resemblance may be quite superficial. The striking similarity between the female genitalia of *Ripipteryx* and the Acrididæ is certainly not paralleled by the male genitalia.

Acridoidea. In the family Acrididæ the genitalia are remarkable for: (1) the great development of the muscles and the chitinous parts which serve for their attachment; (2) the upright or subvertical position of the terminal part of the penis and parameres, correlated with the upcurved, cup-like form of the ninth sternum; (3) the small size of the outlet of the penis; (4) the deeply retracted bases of the parameres (endoparameres), in the form of heavily chitinized wing-like expansions, and the vestigial spermatophore sac, of which they form the lateral walls; (5) the anterior position and complex form of the pseudosternite; (6) the large and strongly chitinized endapophyses, connected dorsally but separated from the pseudosternite; (7) the absence of the glandular pouches of the ejaculatory duct; and (8) the deep pocket between the penis and the floor of the genital cavity.

To illustrate the genitalia of this family we can take the common Black-winged Grasshopper or Carolina Locust (*Dissosteira carolina* L.) (Pl. VI, Figs. 51–54). In order to expose the penis it is necessary to remove the pallium or fold of integument covering the genital cavity behind the paraprocts. The terminal part of the penis is now seen near the posterior

end of the genital cavity, and having a subvertical instead of a horizontal position, due to the general upturning of the extremity of the abdomen.

Under the flattened paraprocts lies the pseudosternite, a transverse, heavily chitinized plate of complex form (Fig. 52). It is thus widely separated from the genital aperture, having a position comparable to that of *Ceuthophilus* when the penis of the latter is fully everted.

Immediately in front of the extremity of the penis and partly concealed by a membranous fold a strong transverse arch (ar) may be seen, having a horizontal position. This bar curves forward on each side, passing beneath the surface and continuing far forward beneath the pseudosternite, with which it is connected by strong muscles. The two arms of this arch, from their muscular connections, appear to represent the endapophyses, but have lost their connections with the pseudosternite, the proximal part of the rami being absent. Connected with the arch is a pair of chitinized lobes (ra) flanking the penis and meeting caudad in the median line. From their muscular connections, as determined by Miss Norma Ford, who is now engaged in a comparative study of the abdominal muscles of Orthopterous insects, these lobes appear to represent the distal parts of the rami. There is also a pair of conical elevations arising from the penis roof, where it passes into the rami. These are not structures of morphological importance, however, as they are not of general occurrence in the Acrididæ.

Continuous with the upper (morphologically posterior) edges of the rami are the ventral lobes (vl), two slender, suberect, valve-like processes, beset with minute spinules. They are straight, close together, and bound the genital aperture behind. They are covered in front by the *dorsal lobes*, (dl), a bilobed flap, which is an extension of the penis roof.

The inner surface of the ventral lobes is continuous, in this species, with the apices of the parameres (ectoparameres, pm). These pass ventrad a short distance, then bend sharply dorsad and again ventro-cephalad, expanding into a pair of divergent, wing-like plates (the endoparameres, pmb), which lie beneath and between the endapophyses, with which they have powerful muscular connections.

Lying between the endoparameres, where they most closely approach one another, is a small sac, formed, like the paramere

sac of the Tettigonoidea, by the inward prolongation of the endoparameres, but having also a strong resemblance to the spermatophore sac of the Gryllidæ. It opens into the ejaculatory duct, which is also dilated ventrally at the junction. The sac and ventral dilatation appear to represent a vestigial spermatophore sac (sps) and are here considered as such. The wing-like expansions of the endoparameres have essentially the same relation to the spermatophore sac as in the Gryllidæ, especially in such genera as *Nemobius* and *Oecanthus*. They extend far beyond the end of the sac, however, the latter being of comparatively small size and doubtless quite functionless.

The distal parts of the penis, including the rami, rest in the concavity of a single large lobe, which may be called the *subventral lobe*. It is separated from the floor of the genital cavity by a flattened space, the *subgenital sac*, which extends far forward beneath the penis.

The plan of structure just described for Dissosteira was found to be essentially the same in various species of Acridinæ, Oedipodinæ and Locustinæ and is doubtless general throughout the family.*

The variations in details of form, however, particularly of the pseudosternite and the parts surrounding the outlet of the penis, are numerous and often striking, even within the limits of a genus, and in certain genera, such as *Melanoplus*, they would afford useful taxonomic characters if they could be more readily seen in dried specimens.

The pseudosternite bears two pairs of ventral apophyses, to which muscles from the ninth tergum and sternum are attached and is elevated into a variety of prominences, cristate, spinous or tuberculate (ppst), according to the species. In *Melanoplus* there is a pair of anterior dorsal crests, which vary in size in different species, being, e. g., moderately high in *M. bivittatus* Say (Figs. 55, 56) and extremely high in *M. femur-rubrum* DeGeer.

In this genus the ectoparameres are free (Fig. 57) and are enclosed by the ventral lobes, which are not valve-like as in Dissosteira, but broad and collar-like, surrounding the outlet of the penis. They are flexible, but little chitinized, and are

* This excludes the Acrydiinæ, which are here considered as a distinct family, Acrydiidæ.

covered with minute, regularly arranged spinules. They are continuous with the dorsal lobes, which are black and more heavily chitinized, with sharp, excavated margins, apparently serving as titillators. In *M. femur-rubrum* the dorsal and ventral lobes are comparatively free from one another and the former project dorsad in the form of slender, sharp-pointed processes of irregular form, while in *M. bivittatus* (Figs. 55, 56), the dorsal lobes are much shorter and are folded within the ventral lobes in a complex, scroll-like fashion. There is a strongly chitinized bridge connecting the dorsal lobes with the arch of the endapophyses. In place of the subventral lobe there is only a pair of soft, irregular folds of integument. The expanded bases of the endoparameres are much more strongly divergent than in *Dissosteira*.

The genitalia of the Acrydiidæ are astonishingly unlike those of the Acrididæ, though occupying a similar position, the outlet of the penis having a suberect position and the poststernite lying far forward under the paraprocts. It is evident that the genitalia of this family have undergone a marked degeneration of structure. Three genera were examined: *Tettigidea* (*T. lateralis parvipennis* Harr.), *Acrydium* (*A. ornatum* Say and *A. granulatum* Kirby) and *Paratettix* (*P. cucullatus* Burm.)

In *Tettigidea* the pseudosternite is V-shaped, recalling that of *Ceuthophilus maculatus* Harr., except that, instead of the upright position of the latter, the arch is tilted forward so as to be almost horizontal. It becomes evident on seeing the pseudosternite in this form, that the forward tilting of this sclerite has taken place in all the Acridoidea and is an expression of the same process of shifting that has brought about the upright position of the genital outlet. The recurved apex of the pseudosternite in *Tettigidea* is armed with a group of spines.

Behind and between the arms of the pseudosternite are two narrow plates, which curve inward and terminate behind in a pair of lobes on each side of the genital aperture. These plates appear to be the rami, but the endapophyses, so strongly developed in the Acrididæ are entirely absent. The genital aperture is wide with folded membranous walls, and near the termination of the ejaculatory duct is a dilatation which represents the spermatophore sac. There are no traces of the

parameres. In contrast to the loss of the chitinous parts in the genitalia proper the pallium is strengthened by two distinct plates, separated by a median groove.

In *Acrydium* and *Paratettix* the rami are absent and the pseudosternite is more slender with a much smaller median process, but the pallial structures are more complex than in *Tettigidea*, there being between the pallial plates a pair of slender bars, each terminating in front in an upcurved hook, which probably has some function in copulation.

Phasmoidea.

In the stick-insects and their allies the terminal abdominal terga of the males are all well developed and the 10th tends to replace the supra-anal plate, which is often vestigial or obsolete. In *Timema californicum* Scudd. (teste Crampton, 1, c., Pl. 5, Figs. 53, 65) the latter is distinct and only partly overlapped by the 10th tergum; in *Diapheromera femorata* Say it is a small and membranous lobe, while in *Anisomorpha buprestoides* Stoll. (Pl. VIII, Fig. 71), it is wholly absent. The paraprocts are well developed in *Timema*, of fair size in *Anisomorpha*, rather small in *Diapheromera*. In these genera they are little, if at all, chitinized, but, according to Chopard ('20), who examined a large number of forms, they are commonly chitinized except on their mesal surfaces. The cerci are short, unsegmented and often modified as claspers (*Diapheromera*). The sternal region of the terminal segments preserves its primitive horizontal position, that of the 9th and 10th being in about the same plane, so that the genitalia are ventral in position, as in the Dermaptera, not terminal as in the Orthoptera, Blattoidea, etc. The 9th sternum is commonly divided into two parts, a proximal plate, usually short, and a distal plate, which is a more or less free flap, or "hypandrium," covering the genitalia. As in the Acridoidea and Ephemerida the proximal plate is probably the true sternite, the distal plate the united coxites. There are no true styli. In *Timema* and *Anisomorpha* the 9th sternum shows its more primitive form, in that it is broadly connected with the tergum, both basally and laterally, but in *Diapheromera* and many other genera the sternite forms a short stalk, bearing the perfectly free hypandrium, which forms a cup-like receptacle for the genitalia. In such forms the posterior and greater part of the sternal area is uncovered by any part of the true sternum.

On this part we find the genitalia, so that it must be considered as belonging properly to the intersternal membrane between segments 9 and 10, although it underlies the 9th tergum.

This area in its distal part may be more or less chitinized (the "post-sternite" of Crampton) or may bear a projecting plate, the *subanal vomer* ("vomer sous-anal" of Pantel), (Fig. 71, vo). Pantel considered the vomer to belong to the 10th sternum, but it appears to me to arise from the membrane just in front of this segment.

The elongation of the 9th tergum without a corresponding development of the true sternum has a parallel in the Odonata, in which the genitalia likewise have the appearance of belonging to the sternum itself, rather than the intersternal membrane.

The large size of the 10th sternum is likewise probably due to secondary elongation of the segment, and the primitive 10th sternum may be almost entirely absorbed in the bases of the paraprocts (vide p). Sometimes the cleft between the paraprocts is continued cephalad as a more or less distinct groove almost or quite to the base of the 10th sternal region.

The male genitalia of the Phasmoidea form an irregular, asymmetrical mass, suggestive in a general way of the Blattoidea, Mantoidea and Grylloblattoidea. I have studied the male genitalia of only two species, *Diapheromera femorata* Say and *Anisomorpha buprestoides* (Stoll.).

In the former (Figs. 74, 75) the genitalia form a prominent, asymmetrical structure slightly divided, especially on the ventral face, by an oblique groove, on the left side of which the ejaculatory duct opens. This duct is directed slightly dextrad, and opens directly on the ventral surface, there being no invaginated pouch as in the Orthoptera, and no virga. The dorsal surface of the genitalia is covered by a chitinous plate (dpl) from which a blunt cornu (possibly the paramere) arises on the left side (pm?). There is no such process on the right side, but on the postero-ventral surface, next to the median groove, there is a pair of plates, which apparently form a sort of clasper (cl), and from which an apophysis (ap) for the attachment of muscles projects inwards. The presence of this clasper on the left side is suggestive of the Mantids, certain Blattids and *Grylloblatta*. The left lobe is ventrally thin-walled, a feature which is also somewhat suggestive of *Grylloblatta*.

In *Anisomorpha buprestoides* (Figs. 72, 73) the genitalia form a shorter mass, which is sunk into a pocket formed by the enclosing hypandrium. There is practically no fissure dividing it into right and left halves, the two parts of which it is composed being evidently primarily dorsal and ventral (dpl, vpl), though actually placed so obliquely that the dorsal part is dorso-dextral, the ventral part ventro-sinistral. The greater part of the genitalia is flexible with unchitinized walls, but the dorsal surface is considerably chitinized and this sclerite plainly corresponds to the dorsal plate of *Diapheromera*. It has a prominent sinistral angle which represents the sinistral cornu of *Diapheromera*, and there is a somewhat thickened longitudinal part which seems to represent the primitively median dorsal region. The opening of the ejaculatory duct is well to the right, but lies in a wholly membranous area, there being no clasper like that of *Diapheromera*.

Since the present study was made Chopard ('20) has published descriptions and figures of the genitalia of a number of Phasmids, many of which are much more complex and more suggestive of the Blattids than the forms described above. He recognizes in their typical composition four genital valves, of which the two superior sometimes (e. g., *Anisomorpha*) unite to form a single dorsal plate, while the two inferior valves may unite to form a single ventral plate. The genitalia are extremely variable, being in some cases wholly membranous, in other cases very strongly sclerified, while in still others they are partly membranous with many separate plates and processes, very suggestive of the Blattids.

The genitalia of the Phasmoidea thus resemble those of the Grylloblattoidea, Mantoidea and Blattoidea (with exceptions in certain details) in that they appear to consist primarily of right and left lobes (or pairs of lobes), asymmetrical in size, form and position, partly membranous and partly chitinized, with the opening of the ejaculatory duct lying between them and not borne upon a conspicuous penis. In the two forms described here the opening of the ejaculatory duct is directed somewhat dextrad, as in the other groups mentioned, and in *Diapheromera* there is a dextral clasper with an internal apophysis, a feature also somewhat common in the Blattoidea and Mantoidea.

Grylloblattoidea.

The sole member of this order is *Grylloblatta campodeiformis* Walk., the male genitalia of which have been described in detail by the writer ('19).

In the adult male the ninth segment, particularly the sternum, is large, while the tenth is small, though prominent. The intersternal area on which the genitalia are situated is thus vertical, as in the Orthoptera, Blattoidea and Mantoidea.

Viewed from above (Fig. 62) the terminal segments appear symmetrical or nearly so, but from below (Fig. 63) or behind (Fig. 64) a pronounced degree of asymmetry is apparent. This asymmetry involves the ninth sternum, the tenth tergite and the genitalia.

The ninth sternum is remarkable for the retention of the primitive division into sternite and coxites. The sternite is of about the same size and form as the tergite, from which it is separated only by a suture. It is nearly symmetrical, although the left side is slightly shorter than the right. The coxites, although of equal length, are very different in size and form. The left coxite is broadly triangular and strongly convex. Its base extends from the tergo-sternal suture to a point well to the left of the middle line. The right coxite is confined to the right side, having a much narrower base. It is also triangular, but bears a strong spur from its upper margin, directed meso-caudo-dorsad. Both coxites are moveably articulated with the sternite and bear well-developed styli upon their apices.

The tenth tergum is narrowed beyond the bases of the cerci to a truncated apex, but does not form a freely projecting plate. It is continued ventrad around the bases of the cerci, terminating below in a pair of free, unequal arms, which nearly meet one another in the middle line. The left arm is the longer and is wholly chitinized, except at the apex, which is slightly expanded into a little disc or pad. The right arm is chitinized only at the base and is without the terminal pad. It has the appearance of a functionless structure. The tenth sternum is obsolete in the adult.

The cerci are exactly like those of the female, being long and cylindrical and divided into eight distinct segments. There is a small, ventro-mesial, cercal basipodite. The supra-anal

plate is extremely vestigial, distinctly more so than in the female, though prominent enough in the nymph. The paraprocts are also rather small and membranous.

The genitalia are bulky and very irregular. As in certain Phasmoidea, Blattoidea and Mantoidea there are two large lobes, (paramere lobes, rl, ll) separated by an oblique fissure, extending from about the mid-ventral line to the middle of the left side at the base of the tenth tergum. Both lobes project somewhat beyond the margins of the coxites, the exposed parts of their ventral surfaces being somewhat chitinized. There is no chitinized dorsal surface as in the Phasmids, but just below the paraprocts there is a narrow transverse chitinous plate, divided lengthwise into two parts, each of which is elevated at the right extremity into a rounded backward projection. This may represent the dorsal plate of the Phasmids, the projections being perhaps homologous with the right cornu or paramere, but it might not unreasonably be also compared with the pseudosternite.

The right lobe bears upon its dorso-caudal surface a heavily chitinized prominence (cl), divided into two parts, which are irregularly folded and bear several blunt tooth-like processes. This prominence, together with the processes mentioned in the preceding paragraph, and the spur of the right coxite, with which they are closely associated, appear to form a clasping apparatus, in which the left arm of the tenth tergum may perhaps be included.

The left lobe is wholly membranous, except a small ventral chitinized area, but it is produced into a long, thin-walled, tubular sac, which is doubtless normally invaginated, when not in use.

The presence of the chitinous prominence on the right side, but not on the left, is suggestive of the Phasmid, *Diapheromera* (q. v.), and the eversible sac of the left lobe much resembles that of many Blattids, such as *Blattella* and *Parcoblatta*, except that in the latter the sac forms a sheath for a protrusible hook, while in *Grylloblatta* no such hook is present, and it is therefore difficult to conjecture as to what its function may be.

The opening of the ejaculatory duct could not be found in the single adult male of *Grylloblatta* available for study. It will almost certainly be found in the fissure between the two lobes. The mesoventral angle of the left lobe is produced into

a process, which lies in a fold of the right lobe. This process is slightly grooved mesially, the groove being continued along the interlobar fissure. Possibly this is a seminal groove, the process bearing it being a sort of rudimentary aedeagus, similar to many blattids, such as *Periplaneta*. In this genus, and in other Blattids, Mantids and Phasmids, the ejaculatory duct is more closely associated with the left lobe than the right.

Nymph. In the immature male of *Grylloblatta* the coxites are more nearly alike in size and form, although the asymmetry is evident in the specimens studied. These evidently belong to two successive instars, the later of which appears to belong to about the penultimate stage.

In the younger nymph (Fig. 66) the tenth segment is relatively large, its sternal surface being nearly in the same plane with that of the ninth. The supra-anal plate and paraprocts are much larger and more prominent than in the adult. The left coxite is distinctly larger than the right and the latter shows no trace of the spur present in the adult. The tenth tergum is symmetrical and without free prolongations of the ventrolateral margins. Between these margins is a distinct, though small and membranous, tenth sternal area. In the intersternal membrane are two oval, slightly elevated areas, which are the rudiments of the two genital lobes.

In the older nymph (Figs. 67, 68) the tenth segment is relatively somewhat smaller and the tenth sternal area almost obliterated by the closer approximation of the ventro-lateral margins of the tergum. The supra-anal plate and paraprocts have decreased in size. The genital area is no longer horizontal but subvertical in position, and the genital lobes are much larger and separated by an oblique fissure, as in the adult, but there are as yet no chitinous processes nor eversible sac. The ninth sternum, coxites and styli have not changed appreciably, though there is a slight increase in their asymmetry.

Blattoidea.

In the male cockroach the abdominal terga, cerci and cercal basipodites are essentially like those of the female. The eighth and ninth terga are abbreviated, while the tenth replaces the aborted supra-anal plate and is often considerably prolonged caudad. It is however, narrowed on the sides, terminating beneath the bases of the cerci. The ninth sternum forms a large

hypandrium, much like that of many Tettigonoidea, and usually bears styli upon its hind margin. It is a coxosternum, sternite and coxites being completely fused. It is often very asymmetrical, sometimes bearing a lobe or process on one side but not on the other, and the styli are often unequally developed and asymetrically placed. The paraprocts are broad and depressed and are usually chitinized beneath, at least in part; the chitinized portions meeting the margin of the tenth tergum and thus appearing to represent the tenth sternum, with which they have been identified by Chopard ('17).* They are frequently strongly asymmetrical and may bear a hook on one or both sides. The upper surface and sometimes a pair of mesial lobes are membranous.

The genitalia are strongly asymmetrical and show a wide range of variation. They consist, essentially, of an ædeagus or penis, upon which the ejaculatory duct opens, sometimes at the base, sometimes upon a retractile spine (virga); and two outgrowths or processes, primitively dorso-lateral to the penis, each of which bears one or more chitinous parts. These are usually very differently developed on the right and left sides, and their relative positions seem to be primarily similar to that of the two lobes in *Grylloblatta*, *i. e.*, they are obliquely shifted, so that the right process overlaps the left. In what appears to be the most primitive form met with in the types studied (dextral process of *Blattella*), their structure consists of a freely projecting shaft, whose base has been deeply sunk into the hæmocoele, to serve as an apophysis for the attachment of protractor and retractor muscles, while from the folds surrounding the pocket thus formed secondary chitinizations for the attachment of muscles may also develop. Such a form of process is protrusible and retractile to a certain extent, but apparently cannot be completely ensheathed. In the left process of *Blattella*, however, we have a modification of this form, in which the shaft has the form of a hook and can be completely withdrawn into a deep membranous pocket or sheath whose walls are without secondary chitinizations, and which is not prolonged into an apophysis, the muscles being attached directly to its base.

* See p. 7.

The opposite extreme is seen in *Blatta* or *Periplaneta*, in which there are two lobes, separated by an oblique fissure, each bearing several chitinous plates, prolonged into a variety of peculiarly shaped processes, none of which are capable of being invaginated. In such cases it is exceedingly difficult to determine which of these processes are homologous with those of *Blattella*, or even the homologies of the right and left lobes of the same species; but the complex folding of the lobes suggests that the various plates and processes have arisen secondarily as chitinizations of the folds surrounding the sheath of the primary process. As these two processes arise primitively dorso-lateral to the aedeagus, as can be seen in the nymph, it seems reasonable to consider them tentatively as the parameres of which some representative would be expected to occur in so generalized a group as the Blattoidea.

The following species were studied in detail: *Blattella germanica* L, *Parcoblatta pensylvanica* DeGeer, *Blaberus atropos* Serv., *Periplaneta brunnea* Burm., *P. fuliginosa* Brunn. and *P. americana* (L.).

Blattella germanica L. (Pl. IX, Figs. 80–83). In this species the tenth tergum is produced into a large flexible flap, the ninth sternum is very asymmetrical and the styli are unequal in size, close together and both to the left of the middle line. The paraprocts are asymmetrical and divided into two parts, a small membranous, pubescent lobe, next to the anus, and below this a transverse chitinous strip, which meets the edge of the tenth tergite and bears a prominent hook. The dextral hook curves upward and is simple, the sinistral hook curves downward and is bifid. The penis is large and somewhat conical and the ejaculatory duct opens upon a long, straight, retractile spine or virga.

The dextral paramere consists of the following structures: An irregular pocket with folded walls, which is produced internally into a long slender apophysis, whose outer extremity is bifurcated. Articulating with its outer branch and forming a prolongation of the ectodorsal edge of the pocket is a projecting blade or shaft, and connected with the inner branch is a chitinous strip, forming the ventro-mesial edge of the pocket. A rounded lobe with a chitinous margin is folded into the pocket on its inner side and serves for the origin of protractor muscles, which are inserted into the inner side of the

apophysis. The projecting blade appears to be the primary part of the paramere, whose base has been invaginated for the insertion of muscles, while the folded edges of the invagination have become chitinized for muscular attachment.

The sinistral paramere* is a large hook, which, when not in use, is completely retracted into a membranous sheath. Muscles are inserted directly into the inner end of the hook. When protruded this is a very conspicuous structure, extending beyond the edge of the ninth sternum.

Parcoblatta pensylvanica DeGeer (Figs. 84–88). The genitalia of this species are essentially smiliar to those of *Blattella germanica*. The ninth sternum is but slightly asymmetrical, but the paraprocts are strongly so. Each is divided into an outer hook and an inner lobe. The dextral hook is a large, heavily chitinized structure, whose base meets the edge of the tenth tergite. The sinistral hook is much feebler and is scarcely chitinized. The relative sizes of the lobes is reversed, the sinistral being much the larger. The penis is similar to that of Blattella, the ejaculatory duct very slender and opening near the apex of the slender, slightly curved virga.

The sinistral paramere resembles that of *Blattella* except in the lack of a prominent shaft, which is reduced to a mere angular flap, overhanging the opening of the pocket. The sinistral paramere is a retractile hook, like that of *Blattella*, but much shorter and stouter. When retracted the curved end of the hook is generally slightly exposed, as in Fig. 84.

Blaberus atropos Serv. In this large roach the ninth sternum is somewhat asymmetrical, the styli of similar size and widely separated. The paraprocts are less sharply divided into outer chitinized and inner flexible parts, and only the dextral hook is present, this being short, blunt and strongly curved. The penis is very different from that of the two preceding types, being a large, fleshy outgrowth, deeply channeled above and bearing numerous spinules on the inner surface of the channel near its extremity. Lying in the channel is an irregularly chitinized process, probably a modification of the virga, but the ejaculatory duct does not open upon it, but at the base of the aedeagus and is a much wider passage than in *Blattella* and *Parcoblatta*. The dextral paramere is much like the sinistral

* Chopard ('20) identifies this process incorrectly with the penis (p. 98, Fig. 15).

one of these genera, consisting of an eversible hook, whose sheath forms an irregular membranous prominence which is continued sinistrad with a long membranous fold under the paraprocts to the corresponding dextral prominence. The latter is much smaller and bears an irregularly folded structure with chitinous edges, which in general appearance is suggestive of the dextral paramere of *Parcoblatta*, but which is probably more nearly comparable to the sinistral structure of *Periplaneta* in a very aborted condition.

In this species is seen something of the tendency met with in *Blatta*, *Periplaneta*, the Mantidæ and *Grylloblatta* of the dextral paramere (or paramere-bearing outgrowth) to overlap the sinistral one.

PERIPLANETA. In this genus the paraprocts are symmetrical but the genitalia are strongly asymmetrical and exceedingly complicated. The paraprocts are dorsally but little chitinized, but are covered ventrally by large plates, which are separated only by the anal fissure, and simulate closely a divided sternum. They are without the hooks met with in the other forms described.

The paramere lobes are both large and prominent, particularly the sinistral, and are separated by a very oblique fissure, from which a large fleshy lobe representing the penis (the "lame mediane" of Peytoureau, '95)* emerges below and is directed obliquely dextrad. The wide ejaculatory duct opens upon its membranous dorsal surface, near the apex. The ventral surface is somewhat chitinized.

The three species of *Periplaneta* examined differ greatly in the details of the genitalia, but agree in general structure.

The dextral paramere is fundamentally similar to that of *Blattella*, but is much more complex and its parts more heavily chitinized. In *P. fuliginosa* Serv. the basal apophysis is short and broad, and concave on its inner face. The shaft is an irregular, curved sclerite, divided into proximal and distal parts, the former strongly folded and articulating with the apophysis with which it is connected by muscles. The distal part is bifurcate, the upper branch short and terminating in several irregular teeth, the lower long and slender and tapering to a point. The chitinized inner fold of *Blattella* and *Parcoblatta* is

* The process termed the penis by Peytoureau is a part of the sinistral lobe. Peytoureau, however, observed correctly the position of the genital aperture.

developed into a large bivalved prominence (Pl. X, Figs. 91–93), which perhaps serves as a clasper* (cf. *Stagmomantis*). Strong muscles connect the upper valve with the apophysis, as in Blattella, though their action is probably quite different, appearing in the case of *P. fuliginosa* to elevate the valve.

In *Periplaneta brunnea* Burm. the two processes representing the distal part of the shaft are modified into a pair of hooks, as shown in Fig. 96, and the clasper is also of different form. In *P. americana* L. the upper of the processes (the short one in *P. fuliginosa*) is the well-known "bird's head" process, termed by Crampton "fimbrilobus." It is a broad, flat structure, clearly belonging to the dorsal surface of the paramere lobe, and has the form shown in Fig. 99. The other process, so strongly developed in *P. fuliginosa* and *P. brunnea*, is reduced to an insignificant hook. The parts representing the clasper are of simpler structure and more easily recognized as the chitinized walls of the pocket from which the apophysis is formed.

The sinistral paramere lobe (Figs. 94, 95) is apparently not comparable in detail with the dextral. In *P. fuliginosa* it is divided into three principal processes, a dorsal, a ventro-lateral and a ventro-mesial. As seen from the left side (Fig. 95) the dorsal and ventro-lateral processes appear separated by a deep distal cleft. The dorsal process is chitinized along the side, terminating in a sharp point, but is membranous above and on the oblique inner surface. The ventro-lateral process is well chitinized and is the long, slender titillator (pm) which curves dextrad and dorsad, tapering to a pointed apex. The ventro-mesial part is free from the dorsal process only distally, where it terminates in a rounded lobe and a slender spur or hook. The dorso-mesial surface also bears two smaller, sharp-pointed processes and above these two membranous lobes.

In *Periplaneta brunnea* Burm. the same parts are recognizable but differ more or less in form, particularly the ventro-mesial process, which terminates in a long, straight spine, and the dorso-mesial sclerites, which, instead of bearing straight spines, are low tubercles covered with minute spinules.

In *P. americana* L. the ventro-lateral process is stouter and tipped with a hook, the ventro-mesial process is somewhat

* The "tuberculum" of Berlese.

similar and also resembles that of *P. fuliginosa*. The part which represents the dorsal process is bent up sharply distad and terminates in a large chitinous knob. The dorso-mesial surface is marked by two longitudinal furrows and bears another large chitinous tubercle.

Although it is impossible to determine with certainty from the few types studied which of the various processes borne by the sinistral lobe in *Periplaneta* is the homologue of the eversible hook of *Blattella* and *Parcoblatta*, it appears probable that it is the long ventro-lateral process, this being the longest, most independent, and apparently the most constantly present of these parts. It is also lodged within a furrow formed by the other two parts, which may therefore be possibly looked upon as secondary outgrowths from the paramere sheath.

By reason of the resemblance of the sinistral lobe of *Periplaneta* to that of the Mantids, and the non-retractile character of all its processes, it is probably a more primitive type than that of *Blattella* and *Parcoblatta*, in spite of its complexity of structure. The symmetrical paraprocts and hypandrium, and possibly the more elongate joints of the cerci may also be marks of primitive organization.

Mantoidea.

The male Mantids are very similar to the Blattids with respect to their genitalia and other abdominal structures.

Only three species were studied: *Stagmomantis carolina* L., *S. floridensis* Davis and *Mantis religiosa* L.; and these are all essentially similar in the parts with which we are concerned, so that, unless stated otherwise, the following remarks will apply in particular to one species, *S. carolina*.

The terga, cerci and anal valves are similar to those of the female, the tenth tergum, as in the Blattids, replacing the supra-anal plate, which, however, remains as a membranous vestige. In some newly hatched Mantids of an unknown species from Japan it is quite distinct and only partly overlapped by the tenth tergite (Pl. XI, Fig. 109), a fact which has been pointed out recently by Chopard ('17).

The ninth sternum is a somewhat elongate plate, symmetrical and bearing large styli upon its hind margin. This margin is but little excavated in the adults of any of the species seen, but in the young nymphs referred to in the preceding

paragraph a deep V-shaped notch separates the two coxites, though these are at all stages fused with the sternite. In all these respects the Mantid nymphs resemble those of the Tettigonoidea.

The genitalia (Pl. XI, Figs. 105–107) are strongly asymmetrical and consist of two paramere lobes, whose relative positions are similar to those of Periplaneta.

The dextral lobe is very much smaller than the sinistral, which it overlaps slightly, being little developed except dorsally. It may be compared in some measure with that of such Blattids as *Blatella* and *Parcoblatta*. A slender basal ventral piece (pmb) evidently represents the basal apophysis of the Blattids, although not actually internal; and as in Blattella and Parcoblatta, though less distinctly so, it is bifurcated at base, the lower branch curving sharply around and terminating in the small, heavily chitinized ventral prominence, while the other branch ends in a similar process just above it. These two structures serve as a clasper in copulation, as I have ascertained in the case of a female specimen, whose genitalia are still connected with those of a male, although all but the end of the abdomen of the latter is missing, having doubtless been eaten by the female, as is the habit of many Mantids. The clasper is possibly homologous with that which appears as such in some Blattids, such as *Periplaneta*.

The upper jaw of the clasper is continuous above with the large, dorsal, shelf-like flap (df) which is readily compared with the dorsal plate (base of shaft) in the dextral paramere of Blattidæ (cf. *Periplaneta fuliginosa*, Fig. 100).

The sinistral paramere lobe bears a distinct resemblance to that of Periplaneta, especially as seen from the left side (cf. Figs. 95, 108), in which position parts representing the dorsal and ventro-lateral processes of *Periplaneta* are seen, though in the case of the Mantid the latter would be more appropriately termed the ventral process, as its broad chitinized base forms the entire ventral surface of the lobe and extends far over upon the right side, where it meets the narrow ventral portion (apophysis) of the dextral lobe. The process itself is bent dorsad in *Stagmomantis*, but in *Mantis religiosa*, in which it is much longer and more slender, it is directed dextrad. The dorsal process curves strongly to the left and in *S. carolina* is bifurcate. It appears to arise from beneath the dorsal plate,

but it is closely connected with the latter and in other species seems to form a part of it.

This dorsal plate bears some resemblance to that of the right side and is probably its homologue, though not a free flap as in the latter case.

The inner surface of the lobe is for the most part membranous, but there are two small, though heavily chitinized, plates, which lie close to the mouth of the ejaculatory duct. In *S. floridensis* one of these is prolonged into a flagellum, while in *Mantis religiosa* they are both short and spinulose. These parts appear to represent the small sclerite which occupy a similar position in Periplaneta. There is no evident representative of the ventro-mesial process, unless it be one of these. The ejaculatory duct is a large tube passing between the two lobes, which are virtually wrapped around it. It opens upon the inner, membranous surface of the sinistral lobe, immediately beneath the two small, dark, inner sclerites. There is only the feeblest indication of an ædeagus.

Isoptera.

The same two species of "termites" were studied as in the case of the females, viz., *Termopsis angusticollis* Hagen and *Leucotermes flavipes* Kollar. The results of this study supplement those obtained from the females in showing that the Isoptera are most nearly related to the Blattoidea and Mantoidea, and form with these groups a distinctly natural assemblage.

The general appearance of the end of the male abdomen in *Termopsis angusticollis* Figs. 76, 77), is similar to that of the female, but, as in the Blattids and Mantids, differs in the presence of styli. The character of the segmentation agrees closely with these groups. The last three tergites are, like those of the female, curved slightly ventro-caudad, all being much shortened laterally. The tenth is considerably enlarged and takes the place of the supra-anal plate, which is not present as a distinct structure. Close to the ventro-caudal margins of the tergites are the spiracles. The cerci are similar to those of the female.

The sternal region is quite blattoid in structure. The sternum of the ninth segment forms a large, undivided, subgenital plate, bearing a symmetrical pair of styli on the caudal

margin. The genital cavity is much smaller than in the Blattidæ and contains no chitinized parts. In neither of the forms could I find a penis of any sort, merely a median genital aperture with membranous walls. The absence of external genitalia is without doubt a secondary condition. The points of resemblance to the Blattids and Mantids are so numerous as to leave no doubt that the Isoptera are closely related to them, and this belief carries with it the assumption that external genitalia were present in the common ancestor of these groups. The genitalia of this ancestral form were probably asymmetrical, since they are of this type in *Grylloblatta*, a form that is somewhat more primitive than the members of the other three groups.

Zoraptera.

An interesting paper by Crampton on the external anatomy of *Zorotypus hubbardi* Caudell has recently appeared (Crampton, '20), in which some details of the terminal segments of both sexes are given. The general appearance of these segments recalls the Isoptera, to which order Crampton regards the Zoraptera as nearly related, and it is stated by this writer that "the terminal segments in general and of the winged females in particular are quite Isopteroid." He does not specify in what respects they are Isopteroid, and a study of his figures does not confirm the statement. The ninth tergum in both sexes is much reduced and bears a horn-like projection in the male; the tenth appears to form with the supra-anal plate and paraprocts a continuous sclerite. The cerci are short and unsegmented.

More important than these, however, are the sternal characteristics. The ninth sternum of the male, so conspicuous in the Isoptera, is seemingly absent or represented only by a membranous lobe, while the eighth, according to Crampton's figure, takes the place of it as a subgenital plate. In the female the eighth sternum is well developed, not reduced and concealed by the seventh as in the Isoptera, Blattids and Mantids, while there is an additional sclerite below the anus, not represented in these groups.

The male genitalia (Figs. 78–79) resemble those of the Mantids, as pointed out by Crampton. The sinistral process appears to be the same as that which I have considered to be

probably the sinistral paramere in the Blattid *Periplaneta*, or the Mantid *Stagmomantis*, but the large dextral lobe is not certainly its fellow of the opposite side, but may belong to the same lobe, since in the Mantids the sinistral lobe is greatly developed and bears two processes or more, while the dextral is greatly reduced. It may, therefore, be possible that both hooks shown in the figure belong to the left side and that the dextral lobe does not show or may be absent.

Odonata.

In the dragonflies the general elongation of the abdominal segments includes the terminal ones, although the tenth is small as compared with the others, except the first.

The ninth sternum covers much less than the entire sternal region of the ninth segment, there being a considerable area posterior to the genitalia, which is morphologically part of the membrane between the ninth and tenth sterna, though it may be more or less chitinized and appears to be part of the sternum itself. The genitalia thus appear to be situated upon the ninth sternum rather than upon the succeeding intersternal area. In other words the ninth sternum has not kept pace with the elongation of the tergum and the genitalia thus appear to be shifted cephalad.

The ninth sternum is not modified as a subgenital plate, but there are two small, flat plates on each side of the genital aperture and partly overlapping it. In the nymphs of the suborder Zygoptera and in those of certain Anisoptera such as the Aeshninæ these plates are readily seen to be homologous with the lateral gonapophyses (dorsal valves) of the female, as pointed out by Van der Weele ('06), and are therefore coxites. In the young nymphs of some Zygoptera vestigial styli are borne at their apices, though these disappear later.

In the ninth sternum is thus preserved the primitive division into sternite and coxites.

The genital aperture is surrounded by a chitinous ring and may be slightly elevated upon a small papilla, but there is no functional penis morphologically comparable to that of other insects, the copulatory organs being situated upon the sterna of the second and third segments and having no homology with the genitalia of other orders. The problem of the origin of these

accessory genitalia is an exceedingly difficult one but is outside the scope of the present paper. Their structure has been ably dealt with by Schmidt ('15).

The 10th segment has a remarkably well developed sternum, which, however, often shows a tendency to fuse with the tergum, although its boundaries may be clearly defined.

Behind the 10th segment are two paired processes and an unpaired one, which upon anatomical grounds alone would be unhesitatingly interpreted as the cerci, paraprocts and supra-anal plate. In the Anisoptera what appear to be the cerci and supra-anal plate are the structures termed by systematists the superior and inferior appendages, these structures serving as claspers in copulation. In the Zygoptera the homologue of the inferior appendage is rudimentary in the adult, but bears the median caudal gill in the nymph, while the structures called the inferior appendages in the adults and which bear the lateral caudal gills in the nymph are apparently the paraprocts. In the adults of Anisoptera they are inconspicuous and do not function as claspers as they do in the Zygoptera.

This interpretation of these parts, which seems obvious to the comparative anatomist, is denied by Heymons and others on embryological grounds, the apparent paraprocts being interpreted as the true cerci, while the apparent cerci are regarded as secondary structures, termed "cercoids." Three small papillæ, a dorsal and two ventral, which surround the anus in the nymphs of some dragonflies, are considered to be the true supra-anal plate (telson) and subanal plates (paraprocts); the apparent supra-anal plate being the 11th tergite. I believe that further investigations will show that the former, more obvious interpretation is the correct one. It has full support from the standpoint of comparative myology, as determined by Miss Norma Ford, whose results, however, are not yet published. Moreover, if we adopt Heymons' view we are forced the improbable conclusion that the 11th segment is an embryonic structure in all insects except the Odonata, while in this order it is highly developed and morphologically exactly replaces the 12th segment of other insects.

Summary of the Characteristics of the Orders.

based on the terminal abdominal structures of the males.

Ephemerida. Terminal segments (9–10) well developed; ninth sternum consisting of sternite and coxites, which may be separate or united, and bear long jointed styli; supra-anal plate feebly developed, but a telofilum present, generally long and multi-articulate like the cerci; paraprocts but little developed and largely or wholly membranous; genitalia consisting of double symmetrical penes, with or without parameres; virga absent in the forms studied; post-sternum present or absent.

Dermaptera. Terminal segments all distinct, none reduced; the tenth tergum greatly enlarged; ninth sternum forming a large, undivided hypandrium without styli; cerci very large, forcipate, unsegmented (except in immature stages of some genera); supra-anal plate divided into two or three segments, the second and third perhaps representing a vestigial telofilum; paraprocts in the form of thin, flat, free plates, occupying the sternal region of segment 10, there being no true tenth sternum in the types studied; penis elongate, bifid or double, with paired apertures, or single with one aperture; a virga or virgæ present; also a pair of parameres, usually lateral or dorso-lateral arising from the walls of the penis.

Embiidina. Terminal segments distinct, the ninth tergum shortened, the tenth large, somewhat asymmetrical and divided more or less completely into hemitergites bearing dissimilar copulatory processes; ninth sternum forming an asymmetrically triangular hypandrium, terminating in a copulatory process, without separate coxites or styli; cerci two-jointed, slightly asymmetrical, with rather large basipodites, of which the left may bear a copulatory process; the various copulatory processes converging toward the left side; supra-anal plate and paraprocts undeveloped (or vestigial); penis absent.

In the primitive genus *Clothoda* the parts are symmetrical, the tenth tergum undivided, the basipodites very large and projecting inward and the copulatory processes all absent.

Plecoptera. Terminal segments well developed, but not elongated, the ninth and tenth often more or less annular;

ninth sternum undivided and without styli, usually but little modified as a hypandrium; cerci typically elongate and multi-articulate; supra-anal plate extremely variable, sometimes simple and indistinctly separated from the tenth tergite, sometimes modified to form complex copulatory organs, which may be freely projecting and bent forwards to occupy a groove on the dorsum of the terminal segments, or concealed in a pocket which divides mesially the 10th tergum; paraprocts usually large and often fused with bases of cerci, frequently bearing copulatory hooks; penis, when present single (rarely bifid?), eversible, with or without a virga; sometimes with parameres.

Orthoptera. Terminal segments more or less shortened; ninth sternum enlarged to form a hypandrium, sometimes divided by a transverse suture, with or without styli; cerci moderate or short, unsegmented (with rare exceptions, v. *Tridactylus*), often modified as claspers; with a small basipodite; supra-anal plate generally well developed, sometimes divided into a separate 11th tergite and telson (Acrididæ), not concealed by the tenth tergum; paraprocts variable, rarely (Tridactylidæ) bearing cercus-like processes; penis generally large, the ejaculatory duct emptying through a spermatophore sac, into which (typically) the bases of the parameres are retracted; a pseudosternite typically present, forming a collar over dorsum of penis and prolonged ventrad into a pair of rami, from which arise inward projections or apophyses for muscular attachment. Numerous modifications of this plan occur.

Phasmoidea. Terminal segments elongated, the genitalia being ventral instead of posterior in position; ninth sternum transversely divided, a small sternite being separated from a large, more or less-flap-like hypandrium (united coxites), without styli; cerci short, generally modified as claspers; supra-anal plate usually vestigial or absent, paraprocts moderate or prominent; penis apparently situated on the ninth sternal region, in reality on the elongated and secondarily chitinized interval between the ninth and tenth sterna, stout, asymmetrical, more or less distinctly divided into right and left lobes, the right overlapping the left, the ventrally placed genital aperture thus directed somewhat dextrad; dorsal surface somewhat chitinized and bearing in some forms a pair of cornua (parameres?).

Grylloblattoidea. Terminal segments not elongated, the tenth small but prominent; its lateral lobes prolonged ventro-mesad into a pair of asymmetrical copulatory arms; ninth sternum very large and asymmetrically divided into sternite and coxites bearing styli, the coxites probably serving as claspers; cerci segmented as in the female, with small basipodite; penis large, divided into two asymmetrical lobes, the right overlapping the left, the genital aperture probably in the intervening fissure; dextral lobe bearing an irregular, chitinous process; sinistral lobe with no chitinous process, but with an eversible membranous sac; a pair of plates bearing dextral copulatory processes near the dextral coxite, which bears an additional process; the processes together forming a clasping apparatus on the right side.

Blattoidea. Terminal segments slightly abbreviated, but the tenth tergum prolonged into a flap which serves as a supra-anal plate; ninth sternum forming a large, undivided, but styligerous hypandrium; cerci of moderate length, flattened, multi-articulate; supra-anal plate disappearing in early nymphal life; paraprocts flattened, generally more or less chitinized beneath and often bearing asymmetrical copulatory hooks, or a single dextral hook; penis asymmetrical, consisting of a median lobe or process, directed more or less dextrad, bearing the genital opening, which is sometimes situated on a retractile virga, and two dissimilar lateral lobes, of which the dextral tends to overlap the sinistral, these lobes bearing the parameres (?) and frequently other accessory chitinous processes. One of the parameres may be modified into a retractile copulatory hook; the dextral lobe may bear a clasper.

Mantoidea. Terminal segments but little abbreviated, the tenth tergum forming a flap which serves as a supra-anal plate; ninth sternum forming a very large, but undivided hypandrium, bearing styli; cerci of moderate length, less flattened than in the Blattoidea, multi-articulate; supra-anal plate vestigial and membranous; paraprocts broad, somewhat flattened, unchitinized in the types studied; penis strongly asymmetrical, consisting of two dissimilar paramere lobes, the sinistral very large, the dextral small and overlapping the sinistral; ejaculatory duct wide, opening on the mesial surface of the sinistral lobe, with which the vestigial penis-lobe is

fused. Sinistral lobe with a dorsal plate and two copulatory processes or titillators, of which the ventral represents the paramere (?), and one or two accessory processes; dextral lobe with a dorsal plate and a small ventral clasper.

Isoptera. Terminal segments scarcely abbreviated; the tenth tergum prolonged, serving as a supra-anal plate; ninth sternum forming a large undivided hypandrium, bearing styli; cerci short, of two to several segments; true supra-anal plate absent as a distinct structure; paraprocts broad and somewhat flattened, but little chitinized; penis absent or reduced to a small membranous lobe, the genital aperture single and median; no copulatory processes present.

Zoraptera. Ninth tergum abbreviated; tenth fused with supra-anal plate and paraprocts; cerci short and unsegmented; ninth sternum absent or membranous, the eighth apparently taking its place as a hypandrium; penis consisting chiefly of two asymmetrical processes, the sinistral a slender titillator, the dextral a large lobe bearing a subapical dorsal hook; position of genital aperture unknown.

Odonata. Terminal segments elongated, the genitalia ventral in position; ninth sternum consisting of sternite and two separate, rudimentary coxites, without styli; the membrane between the ninth and tenth sterna somewhat chitinized so as to appear to belong to the ninth sternum; tenth sternum distinct; true or primitive penis very small and simple, without parameres (replaced by secondary penis on sternum of segment 2); cerci short and unsegmented; supra-anal plate elongate and projecting (Anisoptera) or small and inconspicuous, (Zygoptera); paraprocts rather large, without appendages (Anisoptera), or with copulatory processes (Zygoptera). In nymphs of many genera indications of a possible twelfth segment are present.

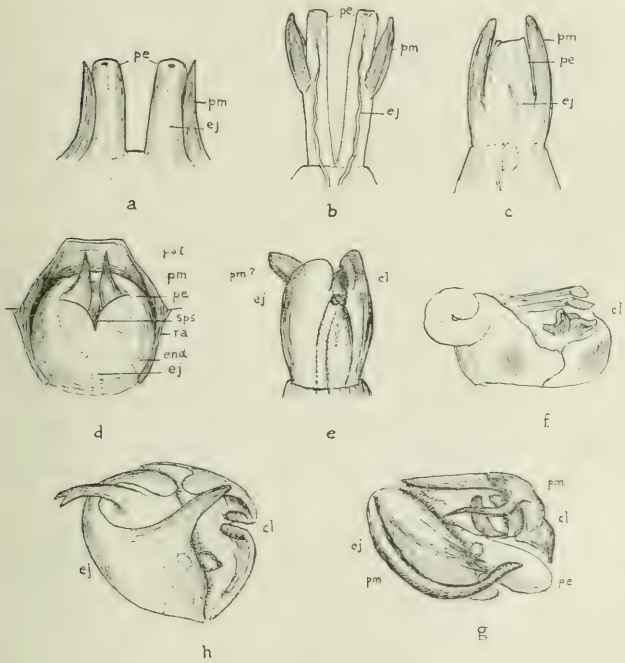

FIG. 6.

Fig. 6. Diagrams of male genitalia of Orthopteroid types of insects. a, Ephemerida, based on *Callibaetis;* b, Dermaptera, based on *Anisolabis;* c, Dermaptera, based on *Forficula;* d, Orthoptera, generalized type, based mainly on *Ceuthophilus;* e, Phasmoidea, *Diapheromera;* f, Grylloblattoidea, *Grylloblatta;* g, Blattoidea, based on *Periplaneta;* h, Mantoidea, based on *Stagmomantis*. For lettering, see page 71.

CONCLUDING REMARKS ON THE PHYLOGENY OF ORTHOPTEROID INSECTS.

In any attempt to unravel the relationships of a group of organisms it is obvious that the entire structure of the body should be taken into account. It would be beyond the scope of this paper, however, to do this for the Orthopteroid orders of insects, but it may be useful to examine the results of our studies of the terminal abdominal structures from this point of view, taking into consideration, at the same time, results obtained and opinions held by other workers on various regions of the body.

Few will deny, I think, that the Pterygota are descendants of either a single species of winged ancestor, or a group of nearly related forms in which the wings were evolved under similar conditions from homologous parts. The evolution of wings is a unique and anomalous development in the Arthropoda, and their invariable presence on the same two body segments with the same fundamental structure and plan of venation makes it exceedingly improbable that they have arisen independently in more than one group of nearly allied forms. Accepting this view, we must assume that there was a single species of common ancestor of winged insects possessing either wings or the appendages from which wings were evolved.

It is also generally agreed upon that the Thysanura is a primitively wingless group, as their general structure reveals a number of features that are more primitive than those of existing Pterygote insects.

If these premises are correct it follows that where structures or characters are found in both Thysanura and Pterygota, that are undoubtedly homologous, these structures or characters were present in the common ancestral Pterygote form, as also in the common ancestor of the Thysanura and Pterygota.

Thus, from what has been learned regarding the terminal segments and genitalia of the Orthopteroid insects, we should expect to find in the common Pterygote ancestor the following characters:

In both sexes:

(1). 10th sternum small, simple, distinct from paraprocts, without styli.

(2). A distinct supra-anal plate, bearing a segmented cerciform appendage.

(3). Well developed paraprocts, without additional appendages.

(4). Multi-articulate cerci.

In the male:

(5). Ninth sternum divided into sternite and styligerous coxites.

(6). Genitalia arising from the membrane between the sterna of segments 9 and 10, including a pair of parameres.

In the female:

(7). Eighth sternum with a median pair of appendages, the anterior gonapophyses.

(8). Ninth sternum represented mainly by the two elongate styligerous coxites, the lateral gonapophyses, and a median pair of appendages, the posterior gonapophyses.

(9). Genital apertures in the membrane between the sterna of segments 8 and 9.

There were probably two male genital apertures, each on a separate penis, as in the Ephemerida. The single penis of the Thysanura has probably been independently acquired, apparently by the union of the two primary penes, with no invagination to form a common ejaculatory duct. Otherwise we have to assume that the double or bipartite penis in the Ephemerida and Dermaptera as a secondary condition.

The double genital apertures of female Ephemerida are likewise to be considered as probably a primitive character, although their position between the 7th and 8th sterna is secondary. The occurrence of a single aperture in both the Thysanura and the majority of the Pterygota must be regarded as a parallelism, and not a surprising one, as a tendency towards a distal union of the genital ducts is very common in the Arthropoda.

The retention of this primitive character together with others, such as the median cerciform appendage, jointed coxites, the numerous moults, occurrence of a subimago stage, etc., stamp the Ephemerida as far removed from other orders and indicate that their line of descent had separated off before those of the other orders had become differentiated.

Next to the Ephemerida the Odonata are the most clearly circumscribed group, having no near allies among recent insects. The 9th sternum of the male preserves clear traces of the original division into sternite and coxites, and the lateral gonapophyses of the female are unique among Pterygote insects in retaining the styli in the adult stage. They also resemble the Thysanura (Machiloidea and Lepismoidea) somewhat in the form of these structures and their relation to the other two pairs of gonapophyses. In their venation and general structure of the body they show no near relationship to the other groups here considered and may be regarded as having probably separated off next in order after the Ephemerida.

In the remaining orders we may recognize two general trends of evolution. In the one the tarsi became 3-jointed (or remained thus), the ovipositor was reduced and subsequently in most cases wholly lost, the coxites of the male were fused with the 9th sternite, and the styli disappeared in both sexes.

One of the branches from this stock gave rise to the Plecoptera and probably from the same branch arose the Embiidina. From another branch the Dermaptera were evolved. The cerci were originally segmented in all of these groups, but lost this primitive character in the Dermaptera. The ovipositor was probably reduced in the common ancestor of all these orders and completely disappeared in all but a few of the Dermaptera.

The terminal abdominal structures, however, throw little light on the relationships of these groups and the views expressed here are based largely on the work of Crampton.

The other trend of evolution among Orthopteroid insects shows itself in the presence of 5-jointed tarsi, a well developed ovipositor, the retention of separate styligerous coxites in the male and the loss of the double penis. In most of the modern descendants of this branch, however, the coxites of the male have fused with the 9th sternite, or with one another, in many

the number of tarsal joints has been secondarily reduced, while in some the ovipositor has become vestigial or absent.

In this assemblage of groups there are two types of genitalia so distinct as to indicate with some probability two main lines of divergence. In one of these we have the true Orthoptera, in which the primitive bilateral symmetry of the penis has been retained, but the organ has acquired a peculiarly complex structure very distinct from that of any other group. In the earliest representatives of this line (Protorthoptera?) there was undoubtedly a well-developed ovipositor without styli; a subgenital plate was formed in the female from the 8th sternum and in the male from the fused coxites, which in all but the branch leading to the Acridoidea, united also with the 9th sternite. Styli were present in the males of primitive forms. The cerci were probably short and unsegmented or had few segments (as indicated by Tridactylus, in which the two-jointed cerci may be a secondary feature). The tarsi may have been 5-jointed in the earliest forms, as suggested by many Tettigoniidæ, but in all modern species the actual number of joints is 4 or less. The primitive plecopteroid form of body was apparently lost at an early stage, correlated with the development of saltatorial hind legs.

The second type of male genitalia is seen in the Phasmoidea, Grylloblattoidea, Blattoidea, Mantoidea and Zoraptera (?), and was doubtless present in the forbears of the Isoptera. This type of genitalia is asymmetrical and consists of the ejaculatory duct, sometimes borne upon a penis, between two unequally developed lobes or processes, right and left, which probably represent the parameres. The sagittal plane is usually so shifted that the right lobe overlies the left. Associated with this type of genitalia is a distinct tendency towards the reduction of the supra-anal plate.

These peculiarities are least marked in the Phasmoidea, which probably separated first. In this group many of the primitive Plecopteroid characters have been retained, particularly in the cervical sclerites, propleura, small and widely separated coxæ, and in the presence in such primitive forms as Timema, of well developed intersegmental sclerites in front of the meso- and metaterga (Crampton, '19). The cerci became short and lost their segmentation, while the male coxites fused

as in the Orthoptera and lost their styli. The development in the female of a large subgenital plate from the 8th sternum also recalls the Orthoptera. These last features together with the rather strongly Orthopteroid wing-venation make the position of the order doubtful. It is perhaps equally well placed at the base of the Orthopteran stem, in which case the resemblance of the penis to that of the other orders in which it is asymmetrical must be looked upon as a case of convergence.*

In the Grylloblattoidea the ovipositor is retained in its primitive exposed form, there being no distinct subgenital plate. The coxites in the male remain separate from the 9th sternite, and the supra-anal plate, though small, is distinct in the adult. The Plecopteroid form of body is retained, with many primitive features, e. g., in the cervical sclerites, the propleura, and separate latero-sternites of the meso- and metasterna. The legs, however, are Blattoid and the coxæ large and close together like all of the Blattoid groups.

In the Blattoidea, Mantoidea and Isoptera so many common features are present that we need have no hesitation in considering them as belonging to one common stock. The ovipositor is concealed by a large subgenital plate, the modified sternum of the 7th abdominal segment. It is reduced in the Blattoidea and is vestigial or absent in the Isoptera. The coxites of the male have fused with the ninth sternite, but the styli are retained. The penis, except in the Isoptera, in which it has disappeared, is remarkable for its extreme asymmetry of structure, which as in *Grylloblatta*, may be shared by neighboring parts. The cerci tend to shorten, being generally reduced in the Isoptera to two segments. The supra-anal plate is replaced by the 10th tergum. Among other peculiarities is the form of the cervical sclerites, the ventral pair of which meet in the middle line. The tarsi are primitively 5-jointed, even in the Isoptera, in which the number of segments is commonly reduced.

The exact relationship of the Isoptera to the other two orders is very uncertain. The form of the body and position of the head is more "plecopteroid" and hence apparently more

* The abdominal musculature, according to Miss Ford, shows a nearer relationship to the Blattoid-Mantoid type than to the Orthopteran type.

primitive than in these orders, but this may be due to adaptation to a life in passages or galleries, in which the flattened form of the Blattids would be a disadvantage. The thoracic sclerites are simpler and in some respects apparently more primitive than those of the Blattids, as shown by Crampton, but these more primitive features may have been present in extinct cockroaches. The similarity of the two pairs of wings is evidently secondary, due to reduction of the anal area of the hind wings. This is indicated by the distinctly expanded anal area of the hind wings in the primitive genus Mastotermes, in which the venation also approaches more closely the Blattid type. On the whole, however, it is perhaps best to consider the Isoptera as springing from the Protoblattoidea, a palaeozoic order from which probably all three orders of the Blattoid group were developed. As far as the terminal abdominal structures are concerned the Blattoidea and Mantoidea are more like one another than are the various families of Orthoptera.

The Zoraptera appear to have affinities with the Grylloblattoidea and the three orders just discussed. Like the former they are plecopteroid in the structure of the cervical sclerites, even more so, on account of the presence of a dorsal sclerite in this region (Crampton, '20). The thoracic sclerites show points of resemblance to *Grylloblatta* and the Isoptera, while the coxæ are large and much like those of Grylloblatta. The asymmetrical penis also apparently belongs to the type characteristic of the group of orders we have been discussing. On the other hand there is a loss in the male not only of the styli but of the 9th sternum itself (unless it be represented by the membranous lobe shown in Crampton's figure) (l. c., Pl. VII, Fig. 2), a structure otherwise so conspicuous in this assemblage of groups. The lack of modification of the 7th abdominal sternum as a subgenital plate places it nearer *Grylloblatta* than the other three orders, but Crampton finds important points of resemblance with the Isoptera. The reduction of the tarsal joints to two and the cerci to a short unsegmented structure, and the modification of the anal plates are peculiarities which set this order somewhat apart from the others, but I should place it tentatively as a branch arising near the point of divergence of the Grylloblattoidea from the Protoblattoidea.

This position is consistent with Crampton's views as to its relationships with the Plecoptera and Isoptera and probably also the Psocida.

These relationships are expressed in the accompanying table (Fig. 7).

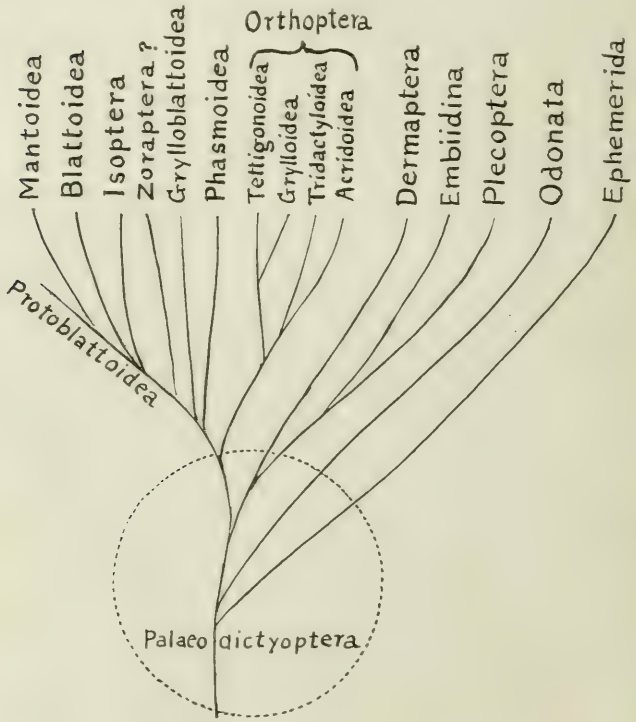

Fig. 7. Phylogeny of Orthopteroid Insects.

APPENDIX TO PART I.

There are a few matters discussed by Chopard ('20) in his excellent treatment of the female genitalia of the Orthoptera, on which my views do not quite coincide with his. The most important of these are the following:

Origin of the "pileolus" and subgenital plate in the Tettigonoidea and Grylloidea. Chopard contends that the subgenital plate in these groups develops, not from the 8th sternum (sternite) but from the membrane between the 8th and 9th sterna. His observations on *Pholidoptera femorata* Fieber agree closely with mine on *Ceuthophilus* and *Conocephalus* and his conclusions are reasonable, but it appears to me unnecessary to give up the view that the subgenital plate is formed from the 8th sternum. According to Chopard the 8th sternum is already, at the 2nd nymphal stage, reduced to two lateral pads, one at the base of each ventral valve. During subsequent growth these become shifted more and more laterad and finally form the small triangular plate, which is termed by Chopard the "pileolus" (valvifer). The subgenital plate appears at the third nymphal stage in the form of a pad, or fold, arising from the membrane, which separates the base of the ovipositor from the 7th sternum. This view seems to imply that the "genital pocket," under the subgenital plate, is an infolding of the membrane, but it appears to me to be formed rather by an infolding of the 8th sternum itself, which is quite flexible in the young nymph; so that, according to the latter view, the subgenital plate may be interpreted as an outgrowth from the basal part of the 8th sternum. The greater part of the sternal area is thus represented by the lining membrane of the genital cavity. This view is sustained by Miss Ford's findings in her study of the musculature of the parts in question, which are as yet unpublished. The two parts considered by Chopard to be the vestiges of the 8th sternum are the structures for which I have employed Crampton's term "basivalvula" and are, of course, quite properly assigned to this segment. But, although they do become shifted laterad, as Chopard states, they clearly do not become the pileolus or valvifer. This is derived from that part of the 9th sternal area which lies laterad of the bases of the dorsal valvulæ. Even in the adult the intersegmental groove can be

traced along the front margin of the valvifer, and the apodeme which runs along this boundary line is frequently continued along the front margin of the valvifer. Chopard's "pièce laterale" in the Blattoidea and Mantoidea is the same structure and is likewise ascribed by him to the 8th sternum. The "pièce laterale en baguette" is the valvifer together with the intersegmental apodeme which in the Blattids crosses a wide membranous area between the valvifer and the tergal margins.

Position of the genital aperture in the Blattoidea and Mantoidea. Chopard maintains that the genital aperture in these groups lies between the 7th and 8th sterna, instead of occupying its usual position between the 8th and 9th. This is a subject upon which I did not lay sufficient stress in Part I of this paper. The aperture in question has certainly experienced a forward shifting, as it lies distinctly cephalad of the bases of the ventral valves of the ovipositor, and is overhung by the "epigynum," which I agree with Chopard in considering as the homologue of the subgenital plate of the Orthoptera. But, as I consider this plate to belong to the 8th sternum rather than the membrane between the 8th and 9th sterna, I should describe the genital aperture as occupying the 8th sternal area, although the sternum itself has virtually disappeared as an individual sclerite. The position of the genital aperture in the Orthoptera and Grylloblattoidea is not really fundamentally different from this.

Ovipositor of the Isoptera. Since Part I of the present paper was published an interesting article by Crampton appeared entitled "The Terminal Abdominal Structures of the Primitive Australian Termite, *Mastotermes darwinensis* Froggatt (Crampton, '20). The important fact brought out is the presence in females of the solider caste in this species of three pairs of gonapophyses of distinctly primitive form, the lateral pair (dorsal valvulæ) terminating in well developed styli. As shown in Crampton's figure the resemblance to the immature Blattid or Mantid is unmistakable, much closer than to *Grylloblatta*, although all of these four types are much alike in essentials. The short, broad lateral gonapophyses, clearly forming part of the 9th sternum, and the reduced 8th sternum, overlapped by the large 7th sternum, are strongly Blattoid features.

The presence of these gonapophyses in Mastotermes is a clear proof of their having been present in the ancestral termites, and confirms my interpretation of the extremely rudimentary structures in Termopsis, which I took to represent a vestigial ovipositor.

ERRATA—PART I.

P. 286, 11th line from bottom; *R. forcipata* is an error for *R. forceps* Sauss. The species figured, however, is *R. carbonaria* Sauss.

P. 315, 13th line from bottom; for "*Ripipteryx forcipata* Sauss." read "*Ripipteryx carbonaria* Sauss."

P. 316. The explanation of Fig. 34, as given, applies to Fig. 35, that of Fig. 35 to Fig. 36, and so on to the end, the last figure being No. 75, instead of 76. The correct explanation of Fig. 34, which was omitted, is as follows:

34. Same; ventral view of dorsal and inner valvulæ.

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REFERENCE LETTERING.

(For additional lettering, see explanation of figures).

ar—Arch of endapophysis.
bc—basipodite of cercus.
c—cercus.
cf—caudal filament or telofilum.
ch—copulatory hook.
cl—clasper.
cx, cx 9—coxite, coxite of 9th segment.
cxx—coxale or united coxites.
cxl, cxr—left and right coxites.
dl—dorsal lobes of penis.
ej—ejaculatory duct.
end—endapophysis.
fps—floor of paramere sac.
gl p—glans of penis or penis lobe.
int s m—intersternal membrane.
int t m—intertergal membrane.
ll—left paramere lobe.
lst—lateral stylet.
m st—median stylet.
pa—paraproct.
pal—pallium.
pal pl—pallial plate.
pc—postcornua or processes of pseudosternite.
pe—penis.
pg—paragenital plate.
pm—paramere, or its main process; ectoparamere.
pmb—base of paramere, endoparamere.
pmo—opening into paramere.
pms—paramere sac.
pst—pseudosternite.
ra—ramus of pseudosternite.
rl—right paramere lobe.
s 7, s 8, etc.—sternum of 7th, of 8th segment, etc.
sa—supra-anal plate.
sp—spiracle.
sp gl—lateral glandular pouches.
spc—sperm conveyor.
sps—spermatophore sac.
st, st 7, etc.—sternite, sternite of segment 7, etc.
stl, stl 7, etc.—stylus, stylus of 7th segment, etc.
svl—subventral lobe.
t 7, t 8, etc.—tergum of 7th segment, of 8th segment, etc.
v—virga.
vl—ventral lobe of penis.
vs—dorso-median spines of spermatophore sac.

EXPLANATION OF PLATES.

Plate I.

1. *Machilis* sp. (Machiloidea). Ventral view of terminal segments.
2. *Blasturus nebulosus* Walk. (Ephemerida). Ventral view of terminal segments.
3. Same, ventral view of penis.
4. *Callibaetis ferrugineus* Walsh. (Ephemerida). Ventral view of terminal segments.
5. *Forficula auricularia* L. (Dermaptera). Lateral view of terminal segments.
6. Same, ventral view of penis.
7. *Anisolabis maritima* (Gene). (Dermaptera). Ventral view of end of abdomen.
8. Same, ventral view of penis.
9. *Oligotoma saundersii* Westw. (Embiidina). Dorsal view of end segments. r ap 10, l ap 10, right and left copulatory appendages of 10th tergum.
10. Same, ventral view of end segments. Lettering as in Fig. 9.

Plate II.

11. *Capnia vernalis* Newp. (Plecoptera). Dorsal view of end segments.
12. Same, ventral view of end segments.
13. Same, lateral view of end segments.
14. *Isogenus frontalis* Newm. (Plecoptera). Dorso-caudal view of end segments, the 10th and anal segments being somewhat upturned. sc, sac containing stylets, formed by invagination of the supra-anal plate. The 10th tergum is also divided into hemitergites by a median invagination, which forms a ventral apodeme.
15. Same: dorsal view of separated 10th and anal segments. The hemitergites of segment 10 are somewhat spread apart to expose the supra-anal plate. m ap, apodeme formed by invagination of 10th tergum.
16. Same, ventral view of isolated supra-anal plate. sc, sac containing the stylets and supported laterally by the paragenital plates.
17. Same, lateral view of isolated supra-anal plate, together with ventral apodeme (m ap), formed by median invagination of 10th tergum. sc as in Fig. 16; bb, basal bar connecting stylets with apodeme.
18. *Isoperla* sp. (Plecoptera). Ventral view of end segments. The copulatory hooks are processes of the paraprocts. Segments 8 to 10 are annular, the terga and sterna being fused.
19. *Perla tristis* Hag. (Plecoptera). Ventral view of end segments, the 9th sternum partly cut away to show the penis. Copulatory hooks as in Fig. 18. The 10th sternum is not separable from the intersternal membrane.
20. Same, ventral view of penis.
21. *Aeshna canadensis* Walk. (Odonata). Ventral view of terminal segments.

Plate III.

(Orthoptera—Tettigonoidea).

22. *Ceuthophilus lapidicola* Burm. Posterior view of penis with parameres retracted; fps, a temporary fold, formed by the retraction of the parameres and dividing the shallow spermatophore sac into an upper and lower part, the upper part corresponding to the paramere sac of most Tettigonoidea (Figs. 30 and 32), and the spermatophore sac in the Gryllidæ; pmo, opening into the invaginated parameres.

23. Same, posterior view of penis with parameres everted. The spermatophore sac is obliterated and the genital aperture concealed by the ventral lobe.
24. Same, lateral view of penis with parameres almost completely everted. Potash preparation.
25. Same, dorsal view of penis, with parameres retracted and inner parts exposed. Potash preparation. The parameres are unnaturally retracted owing to removal of enveloping muscles.
26. *Ceuthophilus aridus* Bruner? Posterior view of end of abdomen with penis very strongly retracted. The roof of the penis is drawn below the level of the ventral lobe, the walls thus forming a pair of lateral ridges. The pseudosternite is forcibly elevated to show the small arched passage (ar ej), which bridges over the ejaculatory duct in the retracted condition.
27. *Ceuthophilus maculatus* (Harr.). Posterior view of end of abdomen, the penis everted, but the parameres probably only partly so.
28. *Ceuthophilus lapidicola* (Burm.). Late nymphal stage. Dorsal view of penis with internal parts exposed. Potash preparation.

PLATE IV.

(Orthoptera—Tettigonoidea).

29. *Neduba carinata* Walk. Posterior view of end of abdomen. vs,* the valve-like plates on the under side of the fold (fps) that separates the spermatophore sac proper from the paramere sac.
30. Same, dorsal view of separated penis; potash preparation. The pseudosternite (pst) is represented only by a membranous fold (cut away on the right side). pmo, opening into paramere, occupied by muscles in the natural condition.
31. Same, lateral view of separated penis; potash preparation.
32. *Conocephalus brevipennis* (Scudd.). Posterior view of penis.
33. Same, dorsal view of penis.
34. *Conocephalus fasciatus* (DeGeer). Last stage of nymph; posterior view of end of abdomen. The parameres are represented only by a slight chitinization of the roof of the penis, just inside the wide genital aperture.
35. *Cyphoderris monstrosa* Uhl. Posterior view of end of abdomen. cps, a large, hook-like copulatory process, arising from the vertically placed sternum of segment 9.
36. Same, lateral view of the 9th sternum, showing the large copulatory process (cps).

PLATE V.

(Grylloidea and Tridactyloidea).

37. *Gryllus assimilis* (Fabr.). (Grylloidea). Dorsal view of separated penis, ventral lobes omitted. The integument is cut through just in front of the pseudosternite.
38. Same, ventral view of penis, the free parts of the ventral lobes cut off in order to show the spermatophore sac and structures underlying the pseudosternite.
39. Same, lateral view of separated penis; potash preparation.
40. Same, postero-ventral view of genitalia of last nymphal stage.
41. Same, ventral view of genitalia of last nymphal stage.
42. *Nemobius fasciatus* (DeGeer). (Grylloidea). Dorsal view of separated genitalia. The anterior, lighter part of the pseudosternite lies beneath the outer integument. The ventral lobes are represented as showing through from above.
43. Same, ventral view of genitalia.

*sv, in Figs. 30 and 31.

44. *Oecanthus nigricornis* Walk. Dorsal view of separated genitalia; potash preparation.
45. Same, posterior view of genitalia.
46. Same, lateral view of genitalia; potash preparation.
47. *Ripipteryx carbonaria* Sauss. (Tridactyloidea). Dorsal view of terminal segments. ch, copulatory hooks, apparently arising from the paraprocts.
48. Same, lateral view of terminal segments. Lettering as in Fig 47.
49. Same, dorsal view of penis; potash preparation. In front of the reflected integument (int) the organ lies beneath the outer surface.
50. Same, right lateral view of penis; potash preparation.

PLATE VI.

(Orthoptera—Acridoidea).

51. *Dissosteira carolina* L. Dorsal view of terminal segments.
52. Same, dorsal view of genitalia; potash preparation.
53. Same, ventral view of genitalia; potash preparation.
54. Same, lateral view of genitalia; potash preparation.
55. *Melanoplus bivittatus* (Say). Dorsal view of genitalia; parts in their natural position.
56. Same, dorsal view of genitalia with the pseudosternite omitted; potash preparation. The dorsal and ventral lobes are spread apart so as to show their relations to the parameres and to one another.
57. Same, ventral view of genitalia; potash preparation. The ventral lobes are spread apart to show the entire parameres. The ejaculatory duct is cut off at its junction with the spermatophore sac.
58. *Tettigidea lateralis parvipennis* (Harr.). Left lateral view of terminal segments. The pallial plates are elevated, exposing the proximal part of the rami.
59. Same, antero-dorsal view of genitalia. Only the anterior edges of the pallial plates are seen, these plates being elevated to expose the genital cavity.
60. *Acrydium granulatum* Kirby. Antero-dorso-lateral view of terminal segments. gc, opening into the genital cavity; pal h, pallial hooks.
61. *Melanoplus bivittatus* (Say). Median sagittal section through genitalia.

PLATE VII.

(Grylloblattoidea).

62. *Grylloblatta campodeiformis* E. Walk. Dorsal view of terminal segments.
63. Same, ventral view of terminal segments.
64. Same, posterior view of end of abdomen. cxp, process borne by right coxite, and forming with cl and lm a copulatory clasping apparatus; es, eversible sac, arising from left paramere lobe; at 10, arm of 10th tergum, with terminal sucker-like disc.
65. Same, ventro-posterior view.
66. Same, half-grown nymph. Ventral view of terminal segments.
67. Same, full-grown (?) nymph. Ventral view of terminal segments.
68. Same, full-grown nymph. Posterior view of end of abdomen.

PLATE VIII.

(Grylloblattoidea, Phasmoidea, Isoptera, Zoraptera).

69. *Grylloblatta campodeiformis* E. Walk. Right lateral view of terminal segments. cxp, spur-like process of right coxite; es, eversible sac arising from left paramere lobe.
70. Same, left lateral view of terminal segments.
71. *Anisomorpha buprestoides* (Stoll). (Phasmoidea). Ventral view of terminal segments. dpl, dorsal plate; vpl, ventral plate.
72. Same, dorsal view of penis.
73. Same, ventral view of penis.
74. *Diapheromera femorata* (Say). (Phasmoidea). Dorsal view of penis. ap, apodeme arising from base of cl; dpl, dorsal plate; pm (?) cornu, possibly representing the left paramere.
75. Same, ventral view of penis. Lettering as in Fig. 74.
76. *Termopsis angusticollis* Hagen (Isoptera). Ventral view of terminal segments.
77. Same, left lateral view of terminal segments.
78. *Zorotypus hubbardi* Caudell. (Zoraptera). Left lateral view of terminal segments. (After Crampton).
79. Same, dorsal view of genitalia. (After Crampton).

PLATE IX.

(Blattoidea).

80. *Blattella germanica* (L.). Posterior view of end of abdomen. The thin flap of the tenth tergum is elevated and the ninth sternum depressed to show the genitalia.
81. Same, dorsal view of genitalia and underlying parts, after removal of terga. The paraprocts are spread apart. The hooked left paramere is retracted into its sheath (sh). ap s 9, apophysis of 9th sternum.
82. Same, dorsal view of right paramere. The "clasper" (cl) probably serves here only for the attachment of muscles.
83. Same, ventral view of right paramere.
84. *Parcoblatta pensylvanica* (Burm.). Posterior view of end of abdomen, the 9th sternum cut away to show the genitalia. The left paramere is retracted, only the end of the hook being exposed. Each paraproct bears a copulatory hook, of which the right is large and heavily chitinized.
85. Same. dorsal view of right paramere. The "clasper" (cl) probably only serves for the attachment of muscles.
86. Same, ventral view of right paramere.
87. Same, dorsal view of left paramere, partly everted from its sheath.
88. Same, posterior view of abdomen of young nymph, showing the vestigial supra-anal plate.
89. *Periplaneta* sp., last stage of nymph. Ventral view of genitalia.
90. Same, ventral view of genitalia. with penis lobe (gl p) depressed.

PLATE X.

(Blattoidea).

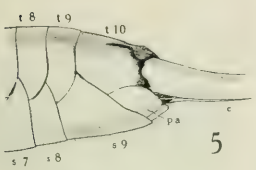
91. *Periplaneta fuliginosa* Brunn. Dorsal view of right paramere. dcl, dorsal valve of clasper; pml, shaft of paramere, terminating in the processes pm^1, pm^2, etc.
92. Same, ventral view of right paramere. vcl, ventral valve of clasper. For other lettering see Fig. 91.

93. Same, ventro-lateral view of right paramere, the two valves of the clasper, dorsal (dcl) and ventral (vcl) forced open.
94. Same, dorsal view of left paramere or paramere lobe. pm, shaft of paramere; ll^1, ll^2, etc., secondary processes from paramere lobe.
95. Same, lateral view of left paramere. Lettering as in Fig. 94.
96. *Periplaneta brunnea* Burm. Ventral view of right paramere. For lettering see Figs. 91 and 92.
97. Same, dorsal view of left paramere. Lettering as in Fig. 94.
98. *Periplaneta americana* L. Ventral view of right paramere. For lettering see Figs. 91 and 92.
99. Same, dorsal view of left paramere. Lettering as in Fig. 94.

PLATE XI.

(Blattoidea, Mantoidea).

100. *Periplaneta fuliginosa* Brunn. (Blattoidea). Dorso-posterior view of genitalia, the 9th sternum strongly depressed. pm, main shaft of left paramere; the secondary processes borne by ll lying to the right; pm^1, basal part of shaft of right paramere; pm^2, the principal terminal process.
101. *Blaberus atropos* Serv. (Blattoidea). Posterior view of end of abdomen, the 9th sternum, which is asymmetrical, somewhat depressed to show the genitalia. The 10th tergum is foreshortened. The right paramere, a long copulatory hook, is completely retracted within its sheath. The right paramere lobe extends far to the left in the form of a horizontal flap.
102. Same, left paramere.
102. Same, dorsal view of left paramere. df, dorsal flap.
103. Same, postero-dorsal view of left paramere, with the dorsal flap (df) reflected.
104. *Stagmomantis carolina* (L.) (Mantoidea). Posterior view of end of abdomen, the 9th sternum strongly depressed. lpm, the main process of the left paramere lobe, probably homologous with pm in Fig. 100; 11^1, 11^2, processes from left paramere lobe; df, dorsal flap of right paramere (cf. Figs. 100 and 101).
105. Same, dorsal view of genitalia in natural position. The clasper (cl) is represented as showing through, as in a cleared preparation. r pmb, base of right paramere. Other lettering as in Fig. 104.
106. Same, ventral view of genitalia. r pm, l pm, right and left paramere bases. Other lettering as in Fig. 104.
107. Same, ventral view of isolated right paramere.
108. Same, lateral view of left paramere. Lettering as in Fig. 104.
109. Newly hatched nymph of undetermined Japanese Mantid. Ventral view of terminal segments, showing well-marked supra-anal plate and processes of the 9th sternum, representing coxites and styli.



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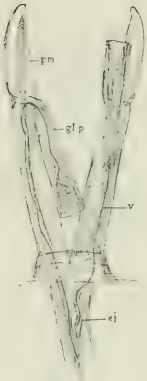

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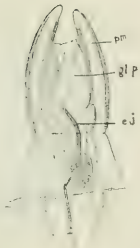

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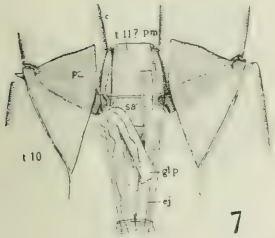

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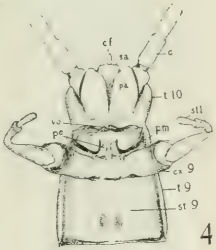

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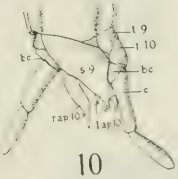

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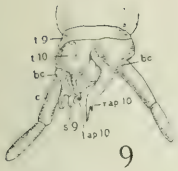

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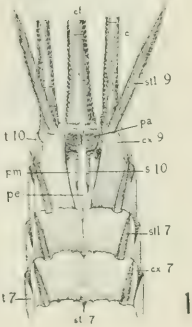

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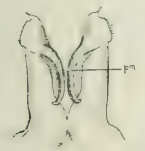

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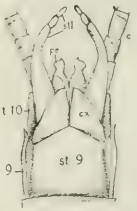

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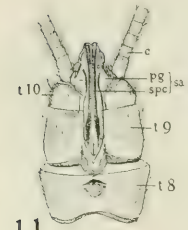

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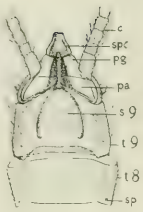

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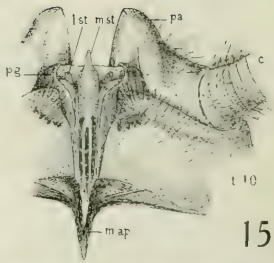

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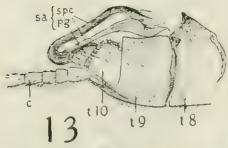

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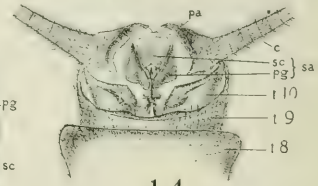

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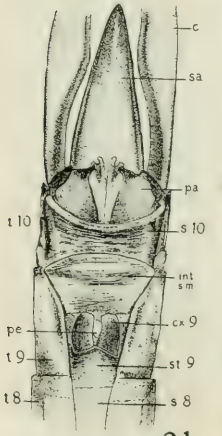

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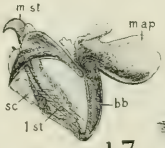

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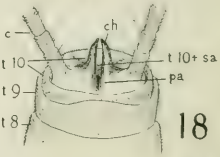

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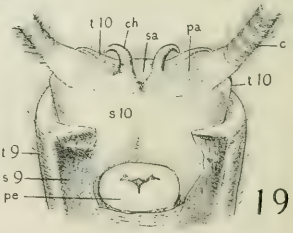

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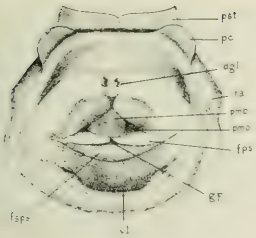

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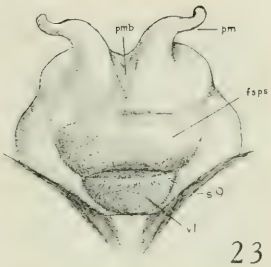

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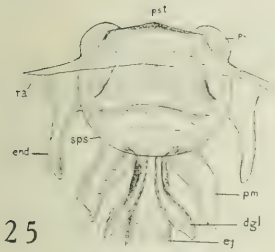

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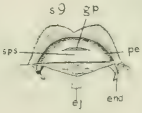

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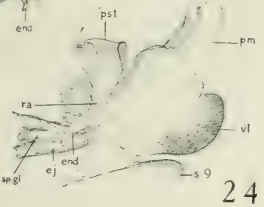

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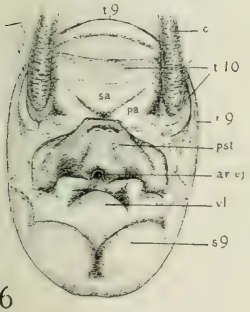

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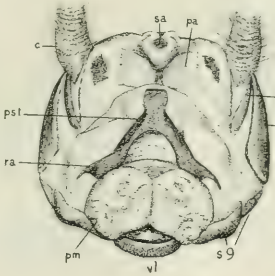

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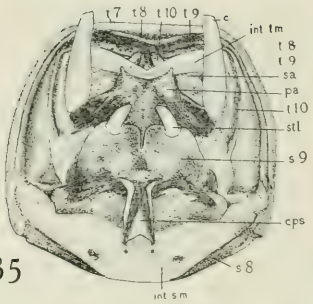

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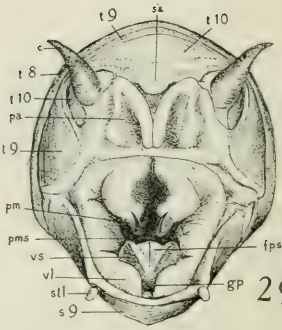

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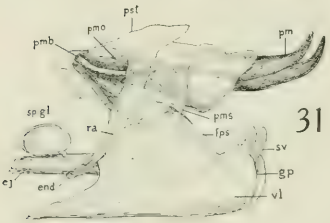

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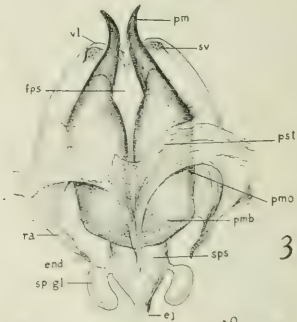

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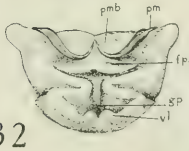

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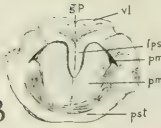

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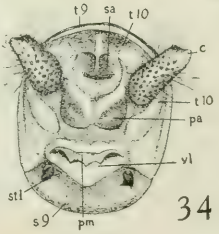

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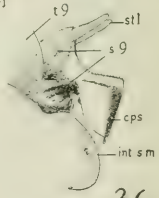

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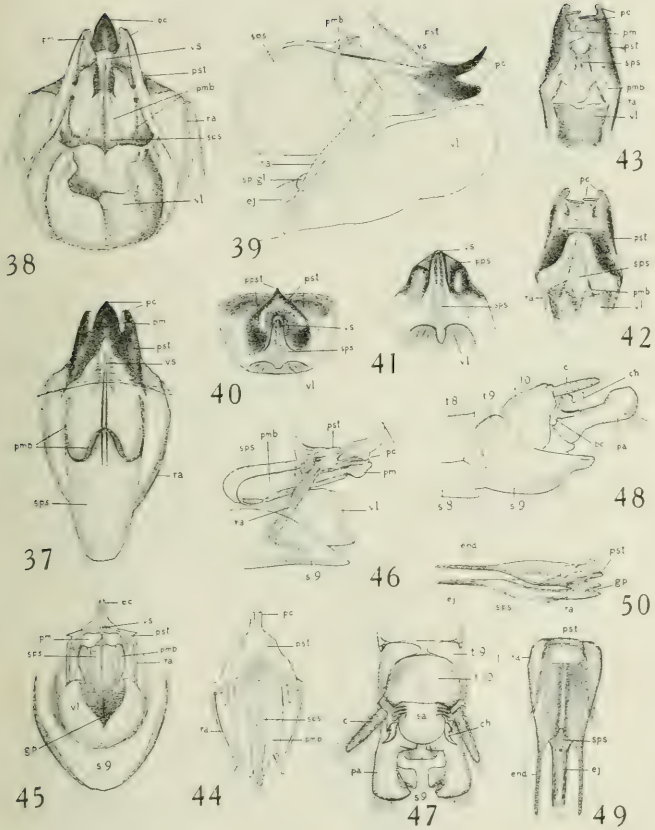
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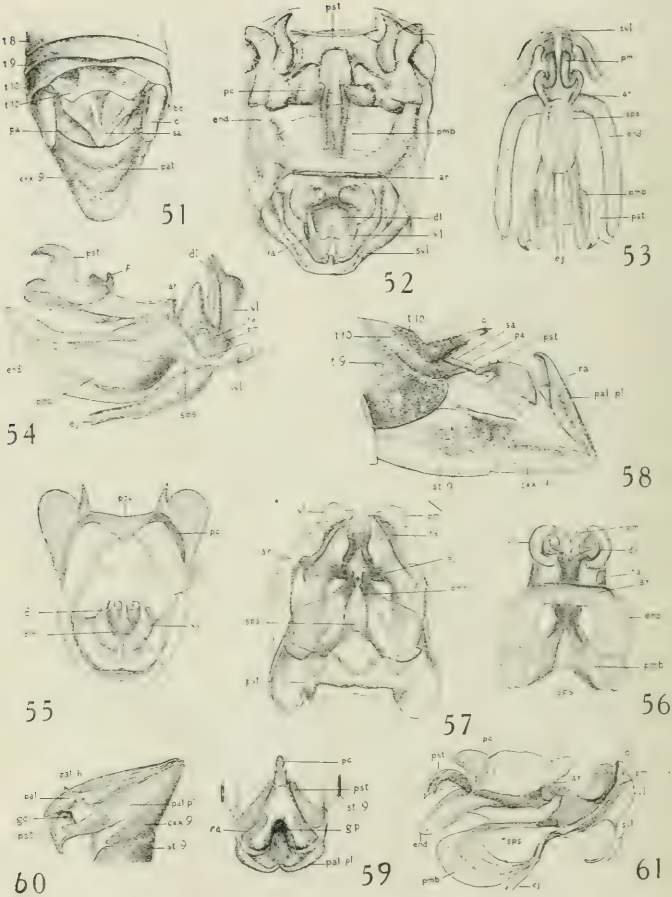

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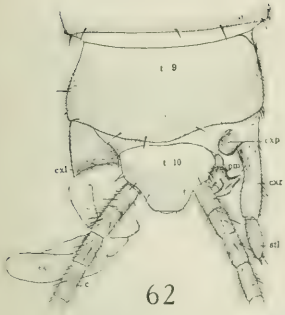
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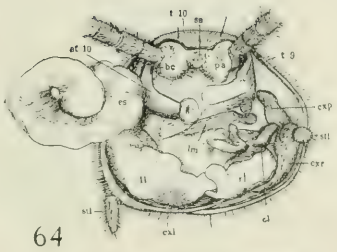
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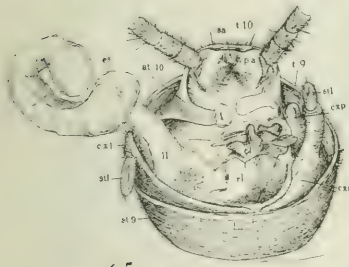
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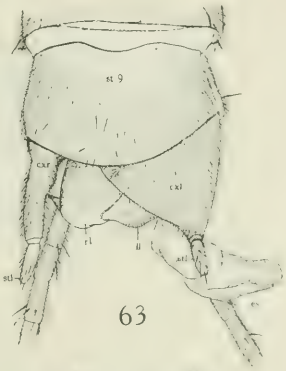
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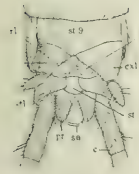
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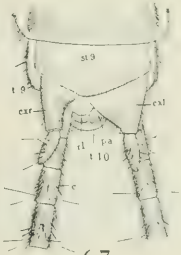
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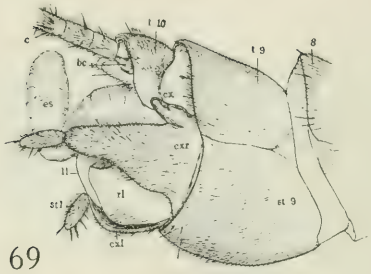

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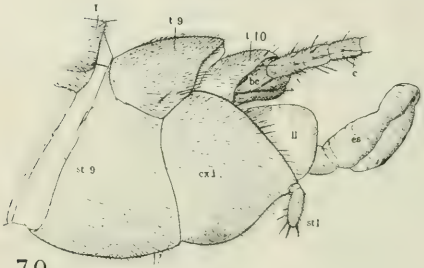

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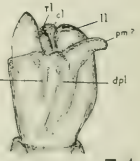

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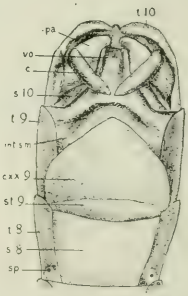

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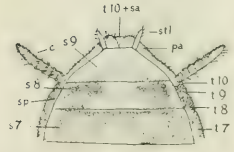

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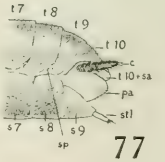

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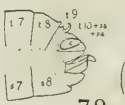

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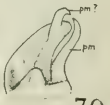

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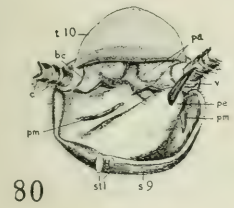

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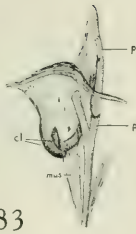

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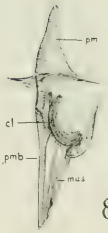

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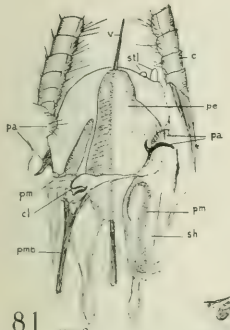

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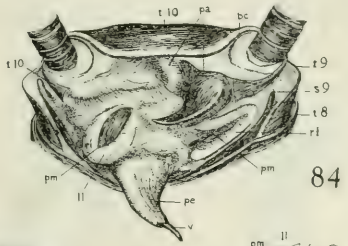

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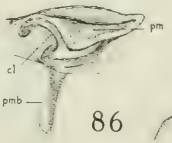

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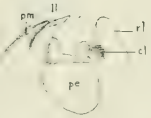

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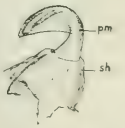

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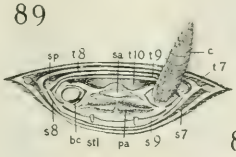

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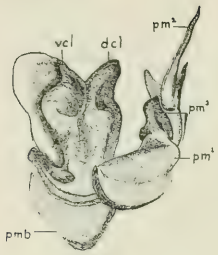

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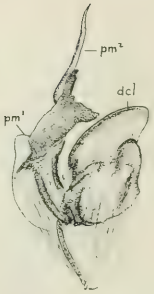

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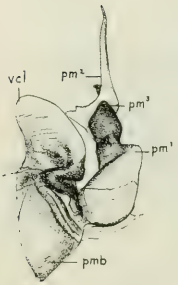

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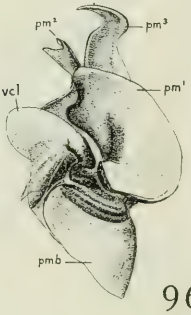

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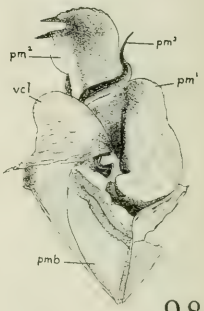

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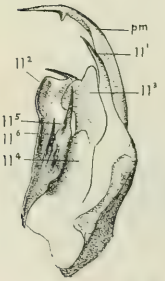

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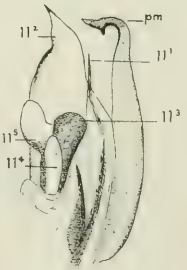

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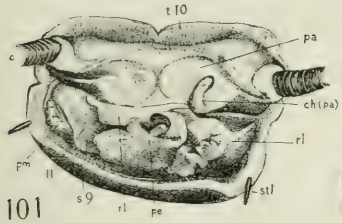

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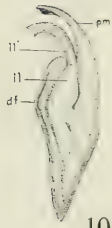

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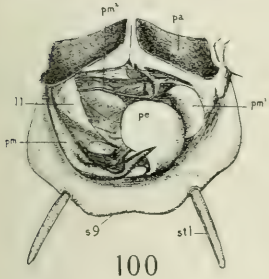

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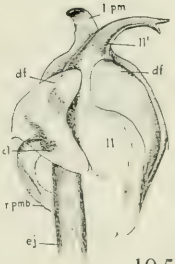

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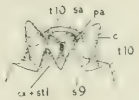

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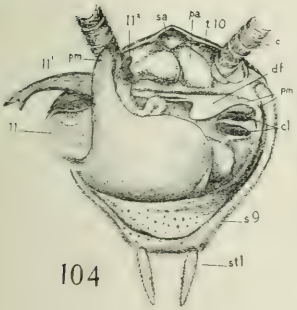

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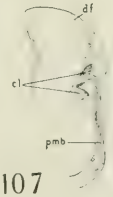

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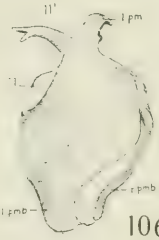

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E. M. Walker.

A REVIEW OF SOME GENERIC NAMES IN THE ORDER LEPIDOPTERA

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In the preparation of our Catalogue of North American Lepidoptera we have determined to investigate the history of all generic names now in use, and others as far as they concern us, in order to be certain that the use of the terms is correct according to the principles laid down in the "International Rules of Zoological Nomenclature." We use Smallwood's edition of these rules, and are indebted to Mr. F. H. Benjamin for information on some later opinions, notably that dealing with Lamarck's citations of 1801 which have been accepted by some writers as valid fixations. We are informed by Mr. Benjamin that these are repudiated in an opinion of the International Committee on Nomenclature. This action is strictly in harmony with the body of the rules as applied to Lamarck's work.

The one other set of rules which we have considered is the "Entomological Code" of Banks and Caudell. We favor these rules, for they are stated with enviable clearness and conciseness, but feel that the International Rules should be followed by all zoologists, from the very nature of their origin. The only point of extreme difference in the two is that the Code does not permit a species to be the type of two different genera, unless, of course, it be the orthotype of the second, established through oversight after becoming the type of the first. While this simplifies the fixation of a type in some cases, it frequently makes a decision more difficult.

In the relatively small part of the order now examined, we find so many radical changes that we feel it wise to present our conclusions thus far to the entomological fraternity, so that the sharp criticism which we frankly expect may have time to bear fruit in a more or less definite general opinion. Our own attitude to this subject is that, while intensely interesting research, the entire problem is so purely accessory to the true aim of science that it should be reduced to a firm basis as

speedily as possible. This basis is established for us by the International Rules, and we are heartily in favor of working out the standing of our genera according to these rules, accepting whatever radical changes they produce, and turning a deaf ear to the cries of those who would continue to make personal opinion their ultimate guide.

ASCIIDÆ.

Ascia Scopoli Logotype *Papilio monuste* Linn.

1777. Scopoli, Int. Hist. Nat. 434; *Crataegi, napi, sinapis, monuste, polybe.*
1872. Scudder, 4th Rept. Peab. Acad. 61, cites *monuste* as type.
1875. Id., Hist. Sk. 121-2, confirms this citation.
1918. Hampson, Nov. Zool. XXV, 385, cites *crataegi* as type.

Owing to Scudder's action in 1872 this genus must be regarded as valid, and will replace *Pieris* in our fauna. As a result of this the family name becomes *Asciidæ*. Hampson uses *cratægi* as type, following the first species principle, which is not permissible under the International Rules. He arrives, however, at the same conclusion regarding the family name, which he spells *Asciadæ*.

SATYRIDÆ.

Megisto Hbn. Logotype *Papilio eurytus* Fab.

1818. Huebner, Verz. bek. Schmett. 54; *Cymelia (euritus), argante, euridice (canthus, camerta), acmenis.*
1868. Butler, Cat. Satyr. B. M. 14, Cites *eurytus (euritus, cymelia)* as type.
1872. Scudder, 4th Rept. Peab. Acad. 27, follows Butler.
1875. Id., Hist. Sk. 213, says that this was incorrect because "*eurytus* is strictly congeneric with *penelope*, the type of *Cissia*," and cites *acmenis* as type.

Butler's citation of *eurytus* was valid and Scudder's later citation of *acmenis ultra vires*. As a result we must use *Megisto* to replace *Cissia*, type *penelope*.

Argus Scopoli. Logotype *Papilio eurydice* Joh.

1777. Scopoli, Int. Hist. Nat. 432; a heterogeneous group including *eurydice*.
1872. Scudder, 4th Rept. Peab. Acad. 27, cites *eurydice* as type.
1875. Id., Hist. Sk. 118, discards this genus because of its original heterogeneous nature. This may have been a desirable course, but it seems entirely indefensible, since the genus had already been given a valid type and definite generic usage in the modern sense.
1888. Id., Butt. New. Eng. I, 187, under *Satyrodes*, cites *Argus* Scudder (not Scopoli).

We see no way to avoid using this genus in place of Satyrodes.

Heliconius Linn. Logotype *Papilio psidii* Linn.

1758. Linneaus, Syst. Nat. Ed. X, 458. Many species, including *Danaidæ*, *Parnassiinæ* and *Heliconiinæ* (of authors).
1810. Latreille, Consid. Gen. 440, cites *polymnia* and *horta* as types. Neither of these species belongs to *Heliconius* Auct.

1872. Crotch, Cist. Ent. I, 60, cites *psidii* as type, giving Lamarck as authority. While Lamarck's work does not actually fix the type, Crotch's definitely cites "Type *H. psidii* Linn.," and we believe that his must be regarded as a valid fixation.
1875. Scudder, Hist. Sk. 185, cites *Antiochus* as type, but credits the genus to Latreille and says that Crotch was in error in referring the genus back to Linnaeus, Linnaeus' *Heliconii*, however, form as valid a genus as any other of his subdivisions of *Papilio*, and he does use the singular, *Heliconius*, in the page headings. Hence we regard this as truly a Linnean genus, and Scudder's action as *ultra vires*.
1913. Seitz, Macrolep. (2), V, 377, uses *Heliconius* Latr.

As a result of this history of *Heliconius*, we have concluded that it must be dropped from our lists, for *psidii* is a Danaid and no congeneric species is found in our fauna. The subfamily *Heliconiinæ* must be renamed and since Hampson has already applied the name *Eueidinæ* (which he spells, incorrectly, *Euidinæ*), we adopt that term. Since *Heliconius* does not take the place of *Danaus* we see no reason to change the family name *Danaidæ*.

Migonitis Hbn. Logotype *Papilio erato* Linn.
1816. Huebner, Verz. bek. Schmett, 12; *erato* and others.
1875. Scudder, Hist. Sk. 218, cites *erato* as type.

Migonitis takes the place of *Heliconius* Auct.

Dryas Hbn. Haplotype *Papilio paphia* Linn.
1806. Huebner; Tentamen. *Paphia* sole species and therefore type.

Argynnis Fab. Logotype *Papilio paphia* Linn.
1807. Fabricius, Ill. Mag. VI, 283, *paphia, cynara, cethosia, aglaija, liriope, morpheus, hermes*.
1810. Latreille, Consid. Gen. 440, cites *paphia* as type.
1816. Dalman, Vetensk. Akad. Handl. XXXVII, 57-66, cites *adippe* as type.
1830. Curtis, Brit. Ent. Lep. I, 290, cites *aglaia* as type.
1875. Scudder, Hist. Sk. 118; cites *aglaia* as type and says that Latreille cited *paphia* and *cinxia*, whereas the latter appears to be mentioned in synonymy. Other writers have followed Latreille and Curtis.

We regard *paphia* as the type of *Argynnis*, though there may be some slight doubt concerning Latreilles' citation of both *paphia* and *cinxia*. If it can be definitely shown that these were cited as two types, Dalman's fixation must prevail. All appear to be congeneric. The Tentamen genus, *Dryas*, must take the place of the more familiar name in either case, however, if we are to observe the generic limits adopted by most writers.

Lemonias Hbn. Haplotype *Papilio maturna* Linn.
1806. Huebner, Tentamen, *maturna* sole species and therefore type.

Melitaea Fab. Logotype *Papilio cinxia* Linn.
1807. Fabricius, Ill. Mag. VI, 284; *lucina, cinxia, cynthia, maturna*.
1816. Dalman, Vetensk. Akad. Handl. XXXVII, 57, cites *athalia* as type, but incorrectly, for it was not included by Fabricius.
1840. Westwood, Gen. Syn. 88, cites *cinxia* as type. This appears to be the first valid type fixation.

We have felt some doubt whether *Lemonias* of the Tentamen or *Lemonias* of the Sammiung was first published, but Huebner's statement in the preface to the Verzeichniss to the effect that the Tentamen was drawn up as a basis for the other work, leads us to the conclusion that the Tentamen has priority, hence *Lemonias* becomes a nymphalid genus and takes the place of *Melitæa*. This usage is not uncommon in the literature.

HAMADRYAS Hbn. Haplotype *Papilio io* Linn.
1806. Huebner, Tentamen. *Io* sole species and therefore type.

Io, *urticæ* and *antiopa* are generally regarded as congeneric, hence *Hamadryas* must be used for the group, supplanting both *Aglais* Dal. and *Euvanessa* Scud.

CYNTHIA Fab. Logotype *Papilio cardui* Linn.
1807. Fabricius, Ill. Mag. VI, 281; *cardui* and other species.
1840. Westwood, Gen. Syn. 87, cites *cardui* as type.
1872. Crotch, Cist. Ent. I, 66, also cites *cardui*, but the date of fixation which he gives is not in accordance with modern rules.
1875. Scudder, Hist. Sk. 152, says that *cardui* cannot be the type because "it is strictly congeneric with *atalanta*—type of *Vanessa*," a view which is obviously untenable. He cites *arsinoe* as type.

Vanessa Fab. Logotype *Papilio atalanta* Linn.
1807. Fabricius, Ill. Mag. VI, 281; *io*, *atalanta*, *urticæ*, *levana*.
1810. Latreille, Consid. Gen. 440, cites *atalanta* as type.
1840. Westwood, Gen. Syn. 87, cites *io* as type, incorrectly.

As a result of Scudder's peculiar reasoning, or through some strange oversight, *Cynthia* has had no place in our nomenclature. It immediately precedes *Vanessa* on the same page in Fabricius work, and the types as they were originally fixed are congeneric, so that we are forced to replace the more common term with it. *Pyrameis*, type *atalanta* also falls.

CALLICORE Hbn. Logotype *Papilio codomannus* Fab.
1818. Huebner, Verz. bek. Schmett, 41; *astarte*, *clymena*.
1820. Billberg, Enum. Ins. 78; *clymena*, haplotype of *Diaethria*, thus fixing *astarte* as type of *Callicore*.
1875. Scudder, Hist. Sk. 130, in spite of previous use of this genus for species allied to *clymena*, cites *codomannus* (*astarte*) as type, and notes also, on P. 135, that *Catagramma* falls before it.

We have sought some genus of which *codomannus* might have become the valid type before 1820 but without success. Such an action would constitute a valid fixation of *clymena* as type of *Callicore* under Opinion 6 of the International Rules, and permit its retention in the customary usage. As the matter stands, however, it will replace *Catagramma*, which is not represented in our fauna. *Diaethria* Billberg, type *Papilio clymena* Cram. replaces *Callicore*.

CELTIPHAGA *nom nov.* Type *Apatura celtis* Bdv. & Lec. New name for *Chlorippe* Auct.

Most writers agree on the generic distinctness of the North American species hitherto referred to *Chloripp*e or *Apatura* from the true European *Apatura*. Godman and Salvin (Biol. Cent. Am. Rhop. I, 312, 318) also indicate that they regard the North American species as distinct from those properly referable to *Apatura*, but use *Doxocopa* for the single allied species of Central America. *Chloripp*e is properly applied to a group of species which appear to be congeneric with *agathina*. Whatever application is to be made of these names, *Chloripp*e must fall before *Doxocopa*, for Scudder cites *agathina* as the type of *Chloripp*e in the Historical Sketch, and *polyxena* as the type of *Doxocopa*, but he had previously (Syst. Rev. 9) cited *agathina* as type of this genus, and this must stand. In the Bulletin of the Buffalo Society of Natural Science, Vol. II, p. 248, 1875, the same writer cites *laurentia* as the type of *Chloripp*e, but this is *ultra vires* in view of his former action. We have been unable to find earlier type fixations for either of the two genera, and it has proven equally impossible to find a described genus which will apply to *celtis* and its allies, so that a new name seems necessary.

CALEPHELIS G. & R. Orthotype *Papilio caeneus* Linn.

1869. Grote and Robinson, Trans. Am. Ent. Soc. II, 310; *caeneus* (as *caeneus*) designated type.

According to Opinion 14 of the International Rules, the type of this genus must be *cæneus* Linn. as specified by Grote and Robinson, and not *virginiensis*, which they erroneously placed as a synonym of *cæneus*, and which has been cited as the type by later writers. We are unable to find any other described genus which is applicable, and would suggest the anagram LEPHELISCA, type *Erycina virginiensis* Guer, to take the place of *Calephelis* Auct.

LYCAENA Fab. Logotype *Papilio phlaeas* Linn.

1807. Fabricius, Ill. Mag. VI, 285. Includes Lycaenids of all three subfamilies.
1815. Oken, Lehrb. I, 717, uses for blues and a few other species.
1824. Curtis, Brit. Ent. Lep. I, 12, cites *phlaeas* as type.
1832-3. Swainson, Zool. Ill. (2), III, 132, follows Curtis.
1840. Westwood, Gen. Syn. 88, also follows Curtis.
1872. Scudder, 4th Rept. Peab. Acad. 57, also cites *phlaeas*.
1875. Id., claims that the citation of *phlaeas* was *ultra vires* because of Oken's restriction, and cites *endymion* as type. Later writers have used it for the blues also.

It is unfortunate that the accustomed use of this genus must be so radically changed, but this is inevitable if we follow the International Rules, for Oken's action is not recognized as a valid restriction, and Curtis' specification of *phlæas* as type was legitimate. It is the earliest citation of a type which we have been able to find, and is abundantly substantiated by later writers.

The effect of this change on the names of the subfamilies must also be taken up. Since *Chrysophanus* is a synonym, the subfamily Chrysophaninæ of the "Check List" must fall, and logically becomes the LYCÆNINÆ. The blues, formerly the Lycaeninae, must have a new

name. In the absence of any rules on this point we prefer to take *Plebejus* Linn. as the stem for this name, forming the subfamily PLEBEJINÆ, rather than follow Van Duzee's rules and base the name upon the genus which replaces *Lycæna*. The family name remains, of course, LYCÆNIDÆ.

URBANUS Hbn. Haplotype *Papilio malvæ* Linn.

1806. Huebner, Teutamen, *malvæ* sole species and therefore type.

In view of the change in the application of *Hesperia* set forth under that genus, *Urbanus* takes the place of *Hesperia* Auct.

ERYNNIS Schrank. Logotype *Papilio tages* Linn.

1801. Schrank, Fauna Boica II, I, 157. *Comma, tages, malvæ* and others.
1872. Scudder, 4th Rept. Peab. Acad. 71, cites *tages* as type.
1875. Id., Hist. Sk. 167, claims that this was *ultra vires*, and that *comma* became type in 1832.

Unless a type was cited previous to 1872 this genus must replace *Thanaos*, and we have been unable to find such a citation.

The removal of *Hesperia* from this subfamily makes it necessary to establish a new name, which must be formed from one of the genera just discussed. According to Van Duzee's suggestions, it should become the subfamily URBANINÆ. *Erynnis*, the oldest included genus, would form the name *Erynninæ*. It seems to us that there is little choice in the matter, so we are adopting the former.

Thymele, hitherto applied by modern writers to a neotropical genus allied to *Telegonus*, will fall before *Erynnis*, as also will *Thanaos*. *Tages* was designated as the type of *Thymele* by Westwood (1840, Gen. Syn. 88) and Scudder's later actions (Hist. Sk. 282) were *ultra vires*.

HESPERIA Fab. Logotype *Papilio comma* Linn.

1793. Fabricius, Ent. Syst. III, (1), 258, corresponds to Linnaeus' *Papiliones plebeji*.
1798. Cuvier, Tabl. Elem. 592, cites only *malvæ* in this genus.
1810. Latreille, Consid. Gen. 440, cites *proteus, malvæ* and *steropes* as "types."
1816. Dalman, Vetensk. Akad. Handl. XXXVII, 200, cites *comma* as type.
1820–21. Swainson, Zool. Ill., (1), I, 28, cites *comma* as type.
1833. Curtis, Brit. Ent. Lep. II, 442, also cites *comma*.
1870. Butler, Ent. Mo. Mag. VII, 58, cites *exclamationis*, erroneously.
1872. Crotch, Cist. Ent. 1, 62, cites *malvæ* as type, giving Cuvier, 1798, as his authority.
1872. Scudder, 4th Rept. Peab. Acad. 73, cites *malvæ* as type.
1875. Id., Hist. Sk. 187, does same.

We have not been able to examine Cuvier's Tableau Elementaire, but in 1832 (An. Kingdom XV, 594, footnote) he refers to Fabricius' Ent. Syst. for "the other species," after citing *malvæ* as sole example of Hesperia. This is rather conclusive evidence that there was no intention to restrict in the mind of Cuvier, even though his action in 1798 were admissible as a restriction. Aside from this we find nothing on which to base the prevalent use of *malvæ* as type, and it seems that the genus properly applies to the species now placed in *Pamphila*. Westwood, in 1840, (Gen. Syn. 88) cited *comma* as the type of *Pamphila* so

that it is synonymous with *Hesperia*. This necessitates changing the name of the subfamily *Pamphilinæ* to HESPERIIÆ. As in the case of the *Lycænidæ*, we feel that it is both unnecessary and inadvisable to change the name of the family, as has been done by Hampson (Nov. Zool. XXV, 386).

SPHINGIDÆ.

PHLEGETHONTIUS Hbn. Logotype *Sphinx sexta* Joh.

1820. Huebner, Verz. bek. Schmett, 140, *cluentius*, *carolina* and others.
1892. Kirby, Cat. Lep. Het. I, 688, cites *sexta* (*carolina*) as type.
1903. Rothschild and Jordan, Rev. Sphing. I, 52, cite *cluentius* as type and place the name under *Cocytius*.

Kirby's appears to be the first type fixation, and will re-establish the use of this genus for the species now listed under Protoparce.

ATREIDES Holland, new name for *Atreus* Grt., type *Sphinx plebeja* Fab., preoccupied in *Arachnida*.

1903. Holland Moth Book 49, calls attention to the incorrect use of *Atreus* by Rothschild and Jordan and proposes the new name, which has since been overlooked.

HYLOICUS Hbn. Logotype *Sphinx pinastri*, Linn.

1820. Huebner, Verz. bek. Schmett. 138, *pinastri* and others.
1873. Grote, Bull. Buff. Soc. Nat. Sci. I. 27, cites *pinastri* as type.

Takes the place of *Sphinx*, which has been incorrectly used as explained under that genus.

PHRYXUS Hbn. Logotype *Sphinx caicus* Cram.

1820. Huebner, Verz. bek. Schmett, 137; *livornica* (*lineata*) and *caicus*.
1892. Kirby, Cat. Lep. Het. I, 697, cites *caicus* as type.
1903. Rothschild and Jordan, Rev. Sphing. II, 713, cite *lineata*, following the first species principle.

Grammodia R. & J. Orthotype *Sphinx caicus* Cram.

1903. Rothschild and Jordan, Rev. Sphing. I. 371; *caicus* designated type.

This matter needs no further explanation.

CALLIOMMA Wlk. Logotype *Sphinx parce* Fab.

1856. Walker, List. Lep. Ins. B. M. VIII, 108, *nomius*, *licastus* and others.
1892. Kirby, Cat. Lep. Het. 646, cites *licastus* as type. This species, according to R. & J., is synonymous with *parce* Fab.
1903. Rothschild and Jordan, Rev. Sphing. I, 387, cite *nomius* as type.

Rothschild and Jordan use *Hemeroplanes* Hbn. for *parce*, citing *pan* as type. Kirby in 1892, however, designated *triptolemus* as type of this genus, so that it replaces *Leucorhampha* R. & J., dropping out of our fauna, and is itself replaced by *Calliomma*.

HEMARIS Dalman. Orthotype *Sphinx fuciformis* Linn.

1816. Dalman Vet. Akad. Handl. XXXVII, 207, *fuciformis* designated type.

Haemorrhagia G. & R. Logotype *Sesia thysbe* Fab.

1865. Grote and Robinson, Proc. Ent. Soc. Phil. V, 149; *gracilis*, *ruficaudis*, *thysbe*, *fuscicaudis*.
1873. Grote, Bull. Buff. Soc. Nat. Sci. I, 18, cites *thysbe* as type.

We find it utterly impossible to agree with the reasoning of Rothschild and Jordan (Rev. Sphing. I, 438) regarding *Hemaris*. Opinion 10 of the International Rules deals with just such cases, and permits the use of *Hemaris* in place of *Hæmorrhagia*.

SPHINX Linn. Logotype *Sphinx euphorbiæ* Linn.

1758. Linnaeus. Syst. Nat. Ed. X, 489, includes all hawk-moths.
1810. Latreille, Consid. Gen. 440, cites *euphorbiæ* as type.
1820–21. Swainson, Zool. Ill. (1), II, 81, cites *convolvuli* as type.
1828. Curtis, Brit. Ent. Lep. I, 195, cites *ligustri* as type.
1873. Grote, Bull. Buff. Soc. Nat. Sci. I, 25, follows Curtis.
1892. Kirby, Cat. Lep. Het. I, 692, also designates *ligustri*.
1903. Rothschild and Jordan, Rev. Sphing. I, 313, cite *ocellata*.
1917. Barnes and McDunnough, Check List 24, apply to species now placed in *Hyloicus*, without any explanation.

Latreille's fixation, in spite of the fact that it does not agree with subsequent usage, must be regarded as the first valid type fixation. With *euphorbiæ* as type the genus takes the place of *Celerio*, type *Sphinx gallii* Roth.

SATURNIIDÆ.

SAMIA Hbn. Logotype *Phalaena cynthia* Dru.

1820. Huebner, Verz. bek. Schmett. 156, *cynthia, cecropia, promethea.*
1855. Walker, List. Lep. Ins. B. M. V, 1222, uses for *cecropia, promethea,* and others.
1865. Grote, Proc. Soc. Phil. V, 228, cites *cynthia* as type.
1874. Id; Proc. Am. Phil. Soc. XIV, 258, under *Philosamia*, mentions Walker's use of the genus and cites *cecropia* as type.
1886. Smith, Proc. U. S. N. M. IX, 416, uses for *cynthia* alone.
1892. Kirby, Cat. Lep. Het. I, 750, cites *cecropia* as type.

Philosamia Grt. Logotype *Phalaena cynthia* Dru.

1874. Grote, Proc. Am. Phil. Soc. XIV, 258, *cynthia* designated type.
1892. Kirby, Cat. Lep. Het. I, 748, cites *walkeri* as type.
1912. Packard, Mon. Bomb. Moths. N. A. III, 239.

Walker's action in 1855 was in no sense a restriction so far as the selection of a type is concerned, and Grote's first designation of *cynthia* is therefore valid and his later action in specifying *cecropia* as type *ultra vires*. In Packard's Monograph *Philosamia* is used for *cynthia* and allied species, with *Samia* quoted in synonymy. Under *Samia*, used for *cecropia* and allies, the references are by the editors, so it would seem that Packard recognized the use we make of the genus as correct.

PLATYSAMIA Grt. Logotype *Bombyx cecropia* Linn.

1865. Grote, Proc. Ent. Soc. Phil. V, 228; *cecropia, columbia, californica.*
1874. Id., Proc. Am. Ent. Phil. Soc. XIV, 258, under *Philosamia*, says that this genus should fall before *Samia*.
1912. Cockerell, in Packard's Mon. Bomb. Moths N. A. III, 211, follows Grote's action of 1874.

It seems that no type has ever been specified for *Platysamia*, so we select *cecropia*. The three species originally included are congeneric, so there can be no mistaken application of the genus, which takes the place of *Samia* as commonly used.

ACTIAS Leach. Logotype *Phalaena luna* Linn.

1815. Leach, Zool. Misc., II, 25; *luna* and *selene*.
1874. Grote, Proc. Am. Phil. Soc. XIV, 257, cites *luna* as type.
1892. Kirby, Cat. Lep. Het. I, 766, cites *selene* as type.
1912. Packard, Mon. Bomb. Moths N. A. III, 181, uses for *selene*.

Tropaea Hbn. Logotype *Echidna caudata selene* Hbn.

1820. Huebner, Verz. bek. Schmett. 152; *luna*, *selene*.
1864. Packard, Proc. Ent. Soc. Phil. III, 379, uses for *luna*, but cites no type.
1892. Kirby, Cat. Lep. Het. I. 765, separates from *Actias*, but cites no type.

Plectropteron Hutt. Haplotype *Echidna caudata selene* Hbn.

1864. Hutton, Ann. & Mag. Nat. Hist. XVII, 60; *dianæ* (syn. of *selene*) sole species and therefore type.

These three genera offer a nice problem in type fixation. When *selene* became type of *Plectropteron* in 1846, the types of one or both of the other two genera were automatically fixed as *luna*. A possible solution is that *luna* became the type of *Actias*, since that genus takes priority over *Tropæa*, and that either species could then be selected as type of *Tropæa*. Since Grote later cited *luna* as the type of *Actias*, everything favors this fixation. If it be thought desirable to separate *selene* and *luna* generically, the selection of a type for *Tropæa* becomes of some importance. We have been unable to find any type specified, so we designate *selene* in order that the earlier names may stand. Hampson, Rothschild and other writers regard *selene* and *luna* as congeneric, in which we follow them.

CERATOCAMPIDÆ.

EACLES Hbn. Logotype *Attacus imperialis* Dru.

1820. Huebner, Verz. bek. Schmett. 153; *imperatoria* and others.
1874. Grote, Proc. Am. Phil. Soc. XIV, 260, cites *imperialis* (*imperatoria*) as type.

We are unable to find any previous type fixation, and the name is not preoccupied, hence there appears to be no reason why it should not apply to the species now listed in *Basilona*. We are unable to find any designation of a type for the latter genus, and take this opportunity to suggest *cacicus*, which is congeneric with *imperialis*, as also is the remaining species, *ducalis*, according to Packard.

SYNTOMIDÆ.

PSEUDOMYA Hbn. Logotype *Glaucopis tipulina* Hbn.

1820. Huebner, Verz. bek. Schmett. 124; *melanthus*, *tipulina*, *temenus*, *eacus*.
1892. Kirby, Cat. Lep. Het. I. 138, cites *tipulina* as type.
1898. Hampson, Cat. Lep. Phal. B. M. I, 262, cites *melanthus* as type.

Owing to Kirby's designation of *tipulina*, this genus will replace *Saurita* in Hampson's Catalogue, and is not represented in our fauna. Its place is taken by

PSEUDOCHARIS Druce. Orthotype *P. naenia* Druce.

1884. Druce, Biol. Cent. Am., Lep. Het. I, 56, *P. naenia* designated type.

ARCTIIDÆ.

Nolinæ.

ROESELIA Hbn. Logotype *Tinea cucullatella* Linn.

1826. Huebner, Verz. bek. Schmett. 397; *togatulana, cucullatella* and others.
1874. Grote, Bull. Buff. Soc. Nat. Sci. II, 152, cites *cucullatella* as type.
1900. Hampson, Cat. Lep. Phal. B. M. II, 51, cites *togatulalis* as type.

We find no objection to Grote's fixation of *cucullatella* as type, and therefore sink this genus to *Nola*. The next available name for the species allied to *togatulalis* is *Sarbena* Wlk., Jn. Linn. Soc., Zool. VI, 137, 1862. We have not been able to consult the original description, but have found no type fixations to conflict with that of Hampson, who designates *S. lignifera* Wlk. and makes the name a synonym of *Roeselia*.

LITHOSIINÆ.

EUDESMIA Hbn. Haplotype *E. ruficollis* Hbn.

1824? Huebner. Samml. exot. Schmett. II, pl. 400; *ruficollis* sole species and therefore type.

This genus should be used for the North American species now listed under *Cisthene*.

CISTHENE Wlk. Logotype *C. subjecta* Wlk.

1854. Walker, List. Lep. Ins. B. M. II, 533; *trisigna, subjecta*.
1874. Grote, Bull. Buff. Soc. Nat. Sci. II, 151, cites *subjecta* as type.
1892. Kirby, Cat. Lep. Het. I, 288, follows Grote.
1900. Hampson, Cat. Lep. Phal. B. M. II, 243, cites *trisigna* as type.

There is nothing contrary to the International Rules in Grote's action in 1874, so we restore *Cisthene* to its former place, with *Illice* in synonymy.

HAEMATOMIS Hamps., 1900, Cat. Lep. Phal. B. M. II, 514.

This name was spelled *Haematomonis* in the Check List (p. 31), but neither in Hampson's text nor index does it appear in that form.

ARCTIINÆ

PHAEGOPTERA, H. S. Logotype *P. histrionica* H. S.

1853. Herrich-Schaeffer, Ausser. Schmett. 78, ff. 58-68; *histrionica* and other species.
1892. Kirby, Cat. Lep. Het. I, 212, cites *histrionica* as type.

Phegoptera H. S.

1853. Herrich-Schaeffer, op. cit. 16; no species mentioned.

Hampson (Cat. Lep. Phal. B. M. III, 117) discards *Phegoptera* H. S. as an undescribed genus and does not mention *Phægoptera*. The two names were doubtless intended to be the same, but the latter alone is valid. It takes the place of *Opharus* Wlk., type *procroides* (sole sp.).

PARASEMIA Hbn. Logotype *Bombyx festiva* Bock.

1822. Huebner, Verz. Bek. Schmett. 181, *plantaginis* and *lapponica* (*festiva*).
1828. Stephens, Ill. Brit. Ent., Haust. II, 72, used *plantaginis* as the sole species for his new genus *Nemeophila*, thus fixing the type of *Parasemia* as *festiva*.
1892. Kirby, Cat. Lep. Het. I, 250, cites *plantaginis* as type.
1901. Hampson, Cat. Lep. Phal. B. M. III, 458, cite *plantaginis* also.

This case is covered by Opinion 6 of the International Rules. With *festiva* as type *Parasemia* supersedes *Hyphoraia* Huebner, type *testudinaria* Four.

NEMEOPHILA Stephens. Haplotype *Bombyx plantaginis* Linn.

1828. Stephens, Ill. Brit. Ent. Haust. II, 72; *plantaginis* sole species. *Nemeophila* replaces *Parasemia* for reasons stated under that genus.

AGARISTIDÆ *vs.* PHALÆNOIDIDÆ.

Hampson's contention that *Phalænoides* should be the type genus of this family finds no support in the International Rules, which are disagreeably lacking on the point, and it conflicts directly with Van Duzee's recommendations. Since *Agarista* does not fall before *Phalænoides* we prefer to retain the older name, *Agaristidæ*.

PROCEEDINGS OF THE SIXTEENTH ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF AMERICA.

Toronto, Ontario, December 27 and 28, 1921.

The opening session of the Sixteenth Annual Meeting was called to order at 10:30 A. M., December 27, 1921, in Room 32 of the Engineering Building of the University of Toronto, by the President, Dr. J. M. Aldrich. The attendance was about 50, increasing to 120 during the session.

The following papers were presented:

A Study of the Wax-secreting Glands of *Pseudococcus citri*. ROBERT MATHESON, Cornell University.

The Segmental Unit of the Insectean Tracheal System. CLARENCE H. KENNEDY, Ohio State University.

The Wing Venation of the Coleoptera. WILLIAM T. M. FORBES, Cornell University.

On the Ovipositor of Certain Anthomyian Genera. H. C. HUCKETT, Cornell University.

Indexing Homopterous Literature. Z. P. METCALF, North Carolina State College.

The Reputed Vesicating Properties of the Granary Weevil. WM. A. RILEY and FLORENCE DEFIEL, University of Minnesota.

The Puss Caterpillar (*Megalopyge opercularis*) and the Effects of Its Stings on Man. F. C. BISHOPP, United States Bureau of Entomology.

A Case of Serious Injury by the Bite of the House Centipede. C. L. METCALF, University of Illinois.

Some Cases of Subcutaneous and Intestinal Myiasis. E. M. WALKER, University of Toronto.

President Aldrich appointed the following Committees:

Auditing Committee: S. J. HUNTER, C. H. TURNER, NORMAN CRIDDLE.

Committee on Resolutions: E. M. DUPORTE, H. C. HUCKETT, W. P. FLINT.

Nominating Committee: R. L. WEBSTER, H. B. HUNGERFORD, R. W. HARNED.

The President called attention to the Entomological Exhibit held in an adjoining room, composed as follows:

A Mantid with an Extra Leg-like Appendage. PHILIP P. CALVERT, University of Pennsylvania.

The Tracheal System of the *Lestes* (Odonata) Naiad. CLARENCE H. KENNEDY, Ohio State University.

The Wing-Venation of the Coleoptera. WILLIAM T. M. FORBES, Cornell University.

The Ox-Warbles and their Effects on Cattle. F. C. BISHOPP, United States Bureau of Entomology.

Adjournment.

SECOND SESSION.

A Joint Session with the Ecological Society of America was held in Room 32 of the Engineering Building on Tuesday, December 27, and was called to order at 2:00 P. M. under the Presidency of Dr. Stephen A. Forbes of the Ecological Society and Dr. J. M. Aldrich, of the Entomological Society. The attendance was from 120 to 150.

The following program was presented:

The Application of the Principles of Ecology to Practical Problems in Zoology and Entomology. V. E. SHELFORD, University of Illinois.

Hacker's Proposed New Method for Studying Distribution of Species. PHILIP P. CALVERT, University of Pennsylvania.

The Reciprocal Relations of Insects and Soil. JAMES W. MCCULLOCH, Kansas State Agricultural College.

Some Observations on the Influence of Soil Temperature on White Grub Activities. JAMES W. MCCULLOCH, Kansas State Agricultural College.

A Curious Relation Between a Midge and Mayfly. P. W. CLAASSEN, Cornell University.

Glandular Structure of the Abdominal Appendages of a Termite Guest. (*Spirachtha*). N. E. MCINDOO, U. S. Bureau of Entomology.

A Week-end with *Odynerus dorsalis*. C. H. TURNER, St. Louis, Missouri.

Are Insect Galls "Deformities" and "Abnormalities?" B. W. WELLS, North Carolina State College.

The Life History of *Nomophila noctuella* in Illinois. W. P. FLINT, Illinois State Natural History Survey.

Observations on the Life History, Habits and Work of the Sorghum Worm (*Celoma sorghiella* Riley). L. HASEMAN, University of Missouri.

Life History of *Crambus laqueatellus*. GEORGE G. AINSLIE, U. S. Bureau of Entomology.

New Mosquito Records and Notes on the Habits of Certain Species from Central New York. ROBERT MATHESON and R. C. SHANNON, Cornell University.

BUSINESS SESSION.

The third session of the meeting (for the transaction of business) was held in Room 10 of the Medical Building on the forenoon of December 28 with an attendance of about 55.

The Report of the Executive Committee was made by the Secretary as follows:

REPORT OF EXECUTIVE COMMITTEE.

The only matter that was referred to the Executive Committee in the interim between annual meetings was the selection of Dr. Seymour Hadwen of the United States Biological Survey to give the Annual Address.

The Executive Committee met at 10:00 P. M., December 27th, in Convocation Hall, with the following members present: J. M. Aldrich, Arthur Gibson, C. L. Metcalf, Herbert Osborn, E. M. Walker, W. A. Riley, O. A. Johannsen.

Dr. W. M. Wheeler and Dr. E. M. Walker were elected members of the Editorial Board to succeed themselves and Frederick C. Muir to succeed Mr. J. G. Sanders, these terms to expire in 1924.

As committeemen on the Thomas Say Foundation, Mr. Wm. T. Davis was re-elected and Mr. Arthur Gibson was elected to succeed Dr. C. Gordon Hewitt, these terms to expire in 1924.

The following were elected Fellows of the Society: Dr. S. J. Hunter, University of Kansas, Lawrence, Kansas; and Dr. J. M. Swaine, Department of Agriculture, Ottawa, Canada.

The following were elected members of the Society:

Wm. J. Baerg, Cornell University, Ithaca, New York.

Floyd J. Brinley, Box 69, Riverton, New Jersey.

Quinta Cattell, Garrison-on-Hudson, New York.

Stewart C. Chandler, 402 W. Walnut Street, Carbondale, Illinois.

Wallace Colman, 708 E. Seneca Street, Ithaca, New York.

Charles C. Compton, Box 12, Aurora, Illinois.

Angelo M. Costa-Lima, Rua do Ouvidor, No. 116, Rio de Janeiro, Brazil.

Raymond B. Cowles, 409 Dryden Road, Ithaca, New York.

Eugene M. Craighead, Bureau of Plant Industry, Harrisburg, Pa.

Clifford R. Cutright, Botany and Zoology Building, Ohio State University, Columbus, Ohio.

Norma Ford, 96 Dunn Ave., Toronto, Ontario, Canada.

Lloyd Victor France, University Farm, St. Paul, Minnesota.

Paul M. Gilmer, 21 Nourse Street, St. Paul, Minnesota.

Henry G. Good, Cornell University, Ithaca, New York.

Fay Erastus Guyton, Box 411, Alabama Polytechnic Institute, Auburn, Alabama.

Lawrence Lester Huber, Dept. of Zoology and Entomology, Ohio State University, Columbus, Ohio.

Harold C. Hallock, 504 South Aurora St., Ithaca, New York.

Albert Hartzell, Dept. of Zoology and Entomology, Iowa State College, Ames, Iowa.

Robert D. Harwood, Jacksonville, Illinois.

Sadie E. Keen, Drawer J, Forest Grove, Oregon.

Jerome McNeill, Box 55, Thonotosassa, Florida.

Edith W. Mank, 12 Reservoir Street, Lawrence, Mass.

Helen G. Mank, 12 Reservoir Street, Lawrence, Mass.

Arthur C. Mason, U. S. Dept. of Agr., Box 491, Orlando, Florida.

August E. Miller, Dept. of Zoology and Entomology, Ohio State University, Columbus, Ohio.

Theodore B. Mitchell, 221 W. Oregon Street, Raleigh, N. Carolina.

Elizabeth Marriott Moffatt, 335 W. Wesley Street, Wheaton, Ill.

Theunis Johannes Naude, 1620 Neil Ave., Columbus, Ohio.

Claud R. Neiswander, 17 W. Norwich Ave., Columbus, Ohio.

Ernest Nielsen, care of C. E. Olsen, Box 72, West Nyack, New York.

E. F. Phillips, Bureau of Entomology, Washington, D. C.

Johannes T. Potgieter, 1620 Neil Ave., Columbus, Ohio.

Theron Palmer Remy, Box 225, College Station, Texas.

R. R. Rowley, Louisiana, Missouri.

Robert D. Spencer, State Hospital, Ashland, Pa.

Orin A. Stevens, Agricultural College, North Dakota.

Georgia Sweet, Melbourne, Victoria, Australia.

Freeman R. Swift, Corcoran Manor, Mt. Vernon, N. Y.

Ryoichi Takahashi, Agricultural Experiment Station, Taihoku, Formosa, Japan.

A. C. Thomas, Bustleton, Pa.

Myron T. Townsend, 301 Nat. History Building, University of Illinois, Urbana, Illinois.

Francis M. Wadley, 126 S. Minneapolis Ave., Wichita, Kansas.

Morris N. Watt, St. John's Hill, Wanganui, New Zealand.

Walter H. Wellhouse, Dept. Zoology and Entomology, Iowa State College, Ames, Iowa.

Luther S. West, Department of Entomology, Cornell University, Ithaca, New York.

Grace Wiley, Chanute, Kansas.

Hans Zerny, Natural History Museum, Vienna I, Burgring 7, Austria.

Total new members, 47.

The Executive Committee directed the Secretary to credit the current account finally with the interest collected from permanent funds during 1920 and 1921, an amount totaling $34.77, which has been carried tentatively in the current fund but credited also to the permanent fund. The permanent fund is therefore debited this amount from the total given in the treasurer's report below.

At the request of the Managing Editor of the Annals, Dr. C. H. Kennedy was appointed Assistant Managing Editor.

The report of the Secretary was presented as follows:

REPORT OF THE SECRETARY.

At the Chicago meeting of the Society a new Secretary-Treasurer was elected, necessitating the removal of the office and accounts from Washington to Columbus. This Secretary-Treasurer subsequently moved from Columbus to Urbana, again necessitating a change of address, the transfer of accounts, etc. The Secretary begs the indulgence of members for any inconvenience or annoyance that may have arisen from this *incertis sedis* of their official and trusts he may be able to manage the affairs entrusted to him in a much more efficient manner another year.

That the Society is in a healthy condition is evidenced in several ways. The number of titles on the program for the present session is more than twice the average number of papers presented for the past ten years. There are this year fifty titles including the annual address. The largest previous number the Secretary could find listed was thirty titles for the year 1913.

The membership including the newly elected members is 606. The corresponding figures for the past ten years are:

1911—391	1916—611
1912—410	1917—606
1913—439	1918—594
1914—551	1919—601
1915—578	1920—567

Financially it may be said that the total receipts for the year are in excess of those of any year in our history. Even after subtracting the large balance remaining from last year, the income during the year is within a few dollars of the largest amount ever received by the treasury in a single year (1917). The large balance of 1920 was due to two causes: first, the unusual number of issues of the ANNALS that were not paid for when the books were closed; and, secondly, the unusual number of members (281) who had paid in advance for the following year, both factors operating to reduce our balance this year. Due to the greater cost of printing, engraving, clerical help, etc., the expenses of the Society have been very high. Five issues of the ANNALS were paid for during the year, this bill alone amounting to $1,854.31. We still owe printing and engraving bills totalling $80.25, and for the entire fourteenth volume of the ANNALS. Estimating the cost of this 1921 volume at approximately the same as that for 1920 it will be seen that the balance in the current fund is about $350 short of our liabilities. In this connection it is well to keep in mind that our present balance includes about $450 of dues already paid for 1922 and subsequent years. The amount that may be expected from the dues of members during the coming year *for the coming year*, hardly exceeds $750. Of course, the Society has the permanent fund ($840.00) which would more than meet our liabilities. The Secretary does not wish to imply that we are in an unusual financial condition, but wishes the members to be informed that we are practically running behind a year, to cover which liability we have the permanent fund.

In spite of the evidences of health and prosperity of the Society the Secretary does not believe that we are living up to our full opportunity for service to Entomology in America. The membership is not what it should be by at least two or

three hundred members. Between annual meetings the only realization most of us have of any connection with the Entomological Society of America is the quarterly receipt of the ANNALS and an occasional statement of annual dues from the Secretary. The ANNALS is a credit to our Society and the annual program is always a splendid one. But surely there must be other ways in which an organization of approximately 600 persons, all vitally interested in one profession, should, and can, make itself felt during the year.

As a step in preparation for any larger service that the Society may deem it expedient to undertake, the Secretary has taken the initiative in preparing blank, index, information cards, which were mailed to all members with the preliminary announcement of this meeting. The annual statement of dues appears on one side; on the reverse the secretary asked for the following information: (1) full name and correct address; (2) official title, firm or other institution with which the member is connected; (3) the subject in which the member has published papers; (4) projects on which the member has work in progress; (5) taxonomic groups in which the member is interested and in which he is willing to make determinations; (6) and, finally, the degrees held by the member. There is also space provided for a record of the date of recommendation to membership, date of election as a member, as a fellow, and as an honorary fellow, and for a record of memberships terminated by death, by resignation or failure to pay the annual dues.

These cards should serve several purposes. They will serve as the official mailing list of the Secretary's office. The very roving nature of most Entomologists makes it impracticable to keep the members revised address on the same sheet with his financial statement; since the latter must be permanently filed and in a few years becomes so checkered with alterations and revisions of the address as to be unreadable. With the card system a new card may be filed with each change of address and the old one discarded.

If the members will fill out the cards faithfully they will serve as a splendid basis for selection of persons for symposia, public addresses, etc. And if the Society desires to make use of the Secretary's office in such a way, they would furnish a basis for helping amateurs who desire identification in various groups, for bringing together specialists working on similar problems and as an indication of members who might be available to undertake a particular type of work.

Unhappily in spite of the admonition "See the other side" that appears at the bottom of the card, many members have apparently noticed only the statement of their account and have failed to see the information blank on the reverse side of the card. Others have for various reasons probably been reluctant to fill in the card. The Secretary has no desire to press the matter but is firmly convinced in his own mind that his office will be able to serve the Society better if the information asked for appears beneath your name and address. A supply of these cards is available if members who have not sent them in, care to fill them out.

Some of the avowed objects of the Society, as expressed in the constitution and at other times, are: to promote the Science of Entomology in all its branches; to keep amateurs in touch with professional entomologists and with a central body; to build up and foster local societies; and to give the study of entomology that standing which its importance in relation to all forms of human activity warrants and demands.

Let us ask ourselves seriously whether as a society we are living up to the high ideals avowed at the foundation of our organization. The Secretary would like to see some of the splendid enthusiasm and active zeal evinced during the convocation week pervade the membership of our organization during the other fifty-one weeks of the year so that the Society may make itself felt as a power for the advancement of Entomology as a profession, and will welcome suggestions from any member of ways in which he may serve to this end.

At the Baltimore meeting of the Society in 1918 a motion was passed that each annual program should have one session devoted to a symposium on some general entomological topic. The Executive Committee has not provided a symposium this year, for two reasons. Because of the loss of Monday from our usual convocation week and because of the demand for two joint sessions it appeared that the time for the reading of papers was likely to be curtailed. Especially after it was found advisable to schedule the public address during one of the day-time sessions, it was evident that no time was available for a symposium. Again the officers did not know what to suggest for a symposium or whom to ask to take this part of the program.

What do the members desire shall be done about a symposium? If a symposium is to be held (and the Secretary is heartily in favor of the idea) what subjects will the members like to hear discussed? The index cards of members should be of great aid in the arrangements for such a symposium because they will indicate the major interests of the members. If you vote to continue the symposium (and I hope you will) please let me beg of you not to refuse to take part in the discussion if you are asked to do so. The Secretary believes that the subject for the symposium should be selected annually one year in advance by vote of the members at the annual meeting from subjects nominated through the Secretary or Executive Committee.

The Executive Committee has learned with sorrow of the death of our Honorary Fellow, Professor Charles Henry Fernald, on February 22, 1921, and of the following members: Edward G. Love in 1919, and Dr. William A. Nason, date unknown. Total—3.

The following members have resigned and their membership is hereby terminated: John Wendell Bailey, Myron H. Swenk, B. P. Young, Philip A. Munz, Daniel M. Brumfiel. Total—5.

Twenty-six members whose dues are unpaid for more than the alloted two years and who have been notified of the rule are retained for the present until they have had one more opportunity to remain in good standing. Such delinquent members cost the Society practically nothing since the ANNALS is not sent to them. Total losses in membership—8.

Forty-seven members and two fellows were elected by the Executive Committee on December 27, 1921.

The actual membership reported December 21, 1920 (See Annals, Vol. XIV. p. 41) was	567
New members 1921	47
Loss of Members 1921	8
Net Gain 1921	— 39
Actual Present Membership	606

On December 24th, when the records for 1921 were closed the membership of the Society was in the following condition with respect to the payment of dues:

Members and Fellows paid for 1924	1
Members and Fellows paid for 1923	3
Members and Fellows paid for 1922	222
Members and Fellows paid for 1921	219
Members and Fellows not paid for 1921	52
Members and Fellows not paid for 1920 and 1921	18
Members and Fellows not paid for 1919, 1920 and 1921	26
New Members	47
Life Members	13
Honorary Fellows	5
Total Membership	606

One life membership was received during the year from Mr. W. M. Giffard.

Respectfully submitted,

C. L. METCALF, *Secretary.*

The report of the Treasurer was next presented:

TREASURER'S REPORT.

(December 24, 1921)

CURRENT FUNDS.

Receipts.

Balance, December 21, 1920 (See Annals, Vol. XIV, p. 41)	$1,681.64
From Annual Dues of Members	890.53
From Managing Editor of the Annals	787.86
One Life Membership	50.00
Interest	29.91
Exchange	.24
Check refused by bank, to balance	6.00
	$3,446.18

Expenditures.

Annals for December, 1919	$ 345.75
Annals for March, 1920	406.00
Annals for June, 1920	413.50
Annals for September, 1920	298.50
Annals for December, 1920	327.75
Postage, Envelopes, etc., for Annals	62.81
Engraving for Annals	221.86
Stamps and Stamped Envelopes	24.79
Clerical and Stenographic Assistance	34.10
Printing	115.88
Office Supplies	11.97
Express	6.09
Exchange	1.78
Telegram	.78
Safety Deposit Box, one-half year	1.50
Check refused by bank, to balance	6.00
Cash on deposit, First National Bank, Champaign, Ill., December 24, 1921	1,167.12
	$3,446.18

LIABILITIES.

The Society owes the publishers of the ANNALS for the four issues of 1921. Also for engravings for December, 1921, ANNALS, $56.25. Also for printing the program, $24.00.

CONDITION OF PERMANENT FUNDS.

On hand last report (Annals, Vol. XIV, p. 41)	$795.09
Appreciation of nine War Savings Stamps	1.08
One life Membership, W. M. Giffard, carried in current account	50.00
From Interest on bonds, in current account	29.91
	$876.08
Less interest accrued during 1920 and 1921, now vested in the current fund	34.77
Actual present balance	$841.31

SECURITIES.

The securities held remain exactly as recorded in the Treasurer's report for last year (See ANNALS, Vol. XIV, p. 41) except that Fourth Liberty Loan Temporary Bonds, Nos. 490,434, 4,714,709 and 6,951,394 have been converted to Nos. H. 05,321,828; C. 04,921,513; and D. 04,921,514. These securities are held in safety deposit box of the First National Bank, Champaign, Illinois.

By direction of the Executive Committee the Life Membership fee of W. M. Giffard ($50.00) and other such fees as received will be invested in bonds.

Respectfully submitted,

C. L. METCALF, *Treasurer.*

On motion the reports of the Secretary-Treasurer were accepted and the financial parts thereof referred to the Auditing Committee.

On motion, the Society selected by *viva voce* vote, the following subject for the symposium at the 1922, Boston meeting:

"The Adaptations of Insects to Special Environments."

The following report was next presented:

REPORT OF MANAGING EDITOR.

Our publication for the year 1921 has apparently suffered no more from the prevailing difficulty in regard to printing than some of those of our sister Societies. In some respects we have, I think, gained ground and can report a fair prospect for the coming year. The income of the office has amounted to $863.92, which is a larger amount than has been received in any previous year, but it should be noted that several items have been collected which have come over from last year, and that we can hardly expect as large an amount for the coming year. It may be mentioned, however, that a considerable item, $211.85, represents sale of back volumes, and with resumption of scientific activities throughout the world, I think we can count on the sale of an increased number of back volumes which will help out in future publication. It may be stated also that back numbers and subscriptions have been entered from such widely separated localities as Japan, India, Australia, New Zealand, Ceylon, and Germany, which apparently marks

a recognition of the importance of our journal. There are still many institutions in foreign lands which must ultimately find it desirable to have our publication in their libraries.

The receipts and expenditures may be summarized as follows:

Receipts.

Subscriptions	$289.50	
Sale of back numbers	211.85	
Sale of reprints	166.69	
Contributions for engraving	195.88	
		$863.92

Disbursements.

Stamps, postal deposits and express	$ 29.10	
Stenographic and clerical assistance	46.96	
Balance paid to Treasurer	787.86	
		$863.92

For the coming year we have a number of excellent papers in hand, and apparently our only difficulty in the matter of material lies in the lack of funds with which to publish all the papers that are available. As in previous years, we have received generous contributions from authors toward the expense of engraving. Otherwise, a number of these papers would have had to be refused, or their printing much delayed.

I wish to recommend the appointment of Dr. C. H. Kennedy as assistant managing editor, his name to appear on the front page of cover, in connection with the Editorial Board. Dr. Kennedy has kindly offered to assist in the details of handling the journal and with such assistance I believe it will be possible to continue the general management of the ANNALS, if this is desired by the Society.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

On motion, this report was accepted and referred to the Committee on Auditing.

The next item of business was the following report:

REPORT OF COMMITTEE ON NATIONAL MUSEUM.

Your Committee begs leave to report that during the past year there has seemed to be no particular opening for activities in addition to the measures which were inaugurated last year. The conditions with reference to the collections of insects have not been changed and it is desirable that every effort should be made to secure additional space suitable for the development of the collections, and to provide for additional curatorial service as rapidly as possible. The collections are increasing in quantity and value, and there should be every possible encouragement to entomologists throughout the country to deposit material that may be of service in their extension. Especially is it desirable that type material should be represented in this museum as extensively as possible.

The museum has, during the past year, utilized the services of certain specialists in the rearrangement and the study of certain groups, and this policy would seem well worth continuation. There certainly should be a more general interest throughout the country in the growth of the national collections, and there should

be a national pride in making them as extensive and useful as possible. It is very much to be hoped that in the near future it may be possible to secure adequate room for expansion, and statements concerning this need may very properly be made by individuals to any official who may be in a position to assist in this direction.

Respectfully submitted,

HERBERT OSBORN, *Chairman*,
WM. BARNES,
WM. M. WHEELER,
JAS. G. NEEDHAM,
C. W. JOHNSON.

On motion, the report was accepted and filed.

The following report was read and referred to the Auditing Committee:

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

Receipts for 1921.

Balance on Hand, January 1st, 1921		$287.41
One Subscriber, $3.50	$ 3.50	
Five Subscribers, $3.00	15.00	
		18.50
Interest on $200.00 (to September 15)		8.50
Total Receipts, 1921		$314.41

Expenditures for 1921.

July 11th, Binding 50 volumes (Vol. 1)—Lafayette Printing Company	$ 25.00
Express on above to Washington, D. C.	2.92
Postage on six copies	.76
Total Expenditures, 1921	$ 28.68
Cash on hand to balance	285.73
Total	$314.41
Balance on hand, January 1, 1922	285.73

There are outstanding obligations to the original subscribers of $260.00, leaving a net balance of $25.73 to the credit of Volume I if the original grant of the Society of $50.00 is neglected, or a deficit of $23.39 if it is considered.

Respectfully submitted,

E. D. BALL, *Treasurer*.

The Society then heard the following report:

REPORT OF THE AUDITING COMMITTEE.

Your Auditing Committee, after examination of the accounts submitted, begs leave to report:

1. That the accounts of the Managing Editor of the ANNALS from December 21, 1920, to December 24, 1921, have been audited and found correct.

2. That accounts of Secretary-Treasurer of the Entomological Society from December 21, 1920, to December 24, 1921, have been audited and found correct, with the exception of errors in computations to the amount of $1.50 in favor of the Society.

3. The report of the Treasurer of the Thomas Say Foundation has been received and is recommended to be placed on file.

4. Your Committee, in the interests of the officers of the Society and for the information of future Auditing Committees recommends that the Reports of the Auditing Committee from year to year be made a part of the permanent records of the Society.

Respectfully submitted,

S. J. Hunter,
Norman Criddle.

On motion, this report was accepted.

The Committee on Nomenclature presented no formal report but the following statement from one of its members was read by the President:

THE PUBLICATION OF INADMISSIBLE SPECIFIC NAMES.

It has been customary to allow very great latitude in the matter of specific names, but obviously there must be some limits beyond which names proposed are to be rejected as not in conformity with the rules. We would call attention to one objectionable practise, which we think should not be permitted. In 1906 Kohl published an excellent work on the Hymenoptera of Sokotra in which he published two species as *Eucera W. F. Kirbyi* and *Megachile W. F. Kirbyi*. During the present year, Strand has published a species *Andrena W. A. Schulzi* from Crete. Frieso, in citing Kohl's Megachile, wrote it *M. Kirbyi*. These names may be considered to present a certain analogy with those of *Coccinella 22-punctata* L., *C. 18-guttata* L. etc , but these latter can be latinized, and are so treated in Leng's catalogue. An attempt to latinize in full the above-cited names of Kohl and Strand would produce appellations which we should hesitate to print. No doubt Frieso was correct in writing *M. Kirbyi*, simply. The question arises, however, as to the proper authority of the name. If *M. W. F. Kirbyi* is to be rejected as contrary to the rules, it has no better standing than a polynomial and in that case dates, from the standpoint of nomenclature, from Frieso's publication, and he stands as the author.

In this country, in 1894, Dyar published a description of a sawfly as *Nematus hudsonii magnus*, not intending to indicate a subspecies. Marlatt, in 1896, called the species *Pteronus hudsonii* Dyar. Dyar's name, as it stood, was clearly a polynomial. We venture to suggest that the above criticised names should be rejected as contrary to the rules and rejected in toto.

We would also call attention to the apparently increasing frequency of badly constructed names, which cannot be rejected, but remain to offend subsequent generations of those who have any appreciation of latin or greek usage, or even of elegance in language. Would it serve a useful purpose to compile annually and present at the meeting of the Society a list of the worst of these, as a warning for the future?

(Signed) T. D. A. Cockerell.

The Committee on Resolutions reported as follows:

The Committee on Resolutions has the honor to report as follows:

(1) We desire to call attention to the faithful and efficient services of our Executive Committee, to the courtesies extended to us by the University of Toronto and the Royal Canadian Institute and to the excellent arrangements made by the Local Committee of the Association and to express our sincere thanks for their services.

(2) WHEREAS, The Science of Entomology has suffered the loss of one of its pioneer workers and this Society one of its most valued members and Honorary Fellows in the recent death of Prof. C. H. Fernald; therefore

Be it Resolved, That we take this occasion to express our deep grief over his loss; and be it further

Resolved, That we extend our sympathies to his family.

(Signed) E. MELVILLE DU PORTE,
H. C. HUCKETT,
W. P. FLINT.

The Nominating Committee reported as follows:

REPORT OF NOMINATING COMMITTEE.

Your Committee on Nominations has to report as follows:

For President—ARTHUR GIBSON.
For First Vice-President—W. A. RILEY.
For Second Vice-President—R. A. COOLEY.
For Secretary-Treasurer—C. L. METCALF.
For Members of the Executive Committee—J. M. ALDRICH, WM. T. DAVIS, E. M. WALKER, O. A. JOHANNSEN.

(Signed) R. W. HARNED,
H. B. HUNGERFORD,
R. L. WEBSTER.

On motion the report was accepted and the Secretary instructed to cast the unanimous ballot of the Society for these officers; which, being done, they were declared elected.

The Secretary presented the following resolutions which were adopted by a conference called by the Division of Biology and Agriculture of the National Research Council held in the King Edward Hotel on the afternoon of December 27th:

Resolved, (1) That it is the sense of this conference that an inter-society conference should be raised to study and report upon the feasibility of federation of the biological societies and to develop plans for the said federation.

Resolved, (2) That for the purpose of effecting such an organization, each society, and Sections F. and G. of the American Association for the Advancement of Science, be requested to designate its President and Secretary as members of an intersociety council which shall be authorized (*a*) to deal with all matters of common interest such as the correlation of programs, studying problems of pub-

lication, the reorganization of bibliographies, etc., that are consistent with the existing regulations of constituent societies; and (b) to draw up proposals for a Constitution and By-laws of a federation of the societies in question, and to present them for action at the next annual meeting.

Although no formal action was taken, it was understood that the conference raised by the adhering societies should be empowered to invite other organizations to join it later.

On motion the Society approved these resolutions and designated its President and Secretary to represent it in this Council.

It was moved by W. A. Riley that the matter of adjustment of the $50.00 loaned to the Thomas Say Foundation be referred to the Executive Committee with power to act; but with the expression of opinion on the part of the Society that the same should be given to the Thomas Say Foundation. The motion carried and the matter was so referred.

It was moved by J. Chester Bradley that the Executive Committee be requested to extend an invitation to leading Entomologists of Central and South America to become members in order to make the Society more fully representative of the Western Hemisphere.

The motion carried and the President, the Secretary and Doctor Bradley were designated a committee to extend these invitations.

The following Amendment to the Constitution was proposed and is hereby recorded for consideration at the next annual meeting:

ARTICLE V, SECTION 4. ELECTION OF HONORARY FELLOWS.—All nominations for Honorary Fellows shall be made in the manner prescribed for the nomination of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Election shall be by mail ballot of the Fellows of the Society, a two-thirds vote of all the Fellows being required for election.

To be amended to read: Honorary Fellows may be nominated by unanimous vote of the members of the Executive Committee present at an annual meeting. The nominee shall be voted on by the members by ballot and must receive four-fifths of all ballots cast to be elected.

Not more than one Honorary Fellow may be elected in three successive annual meetings.

ARTICLE VI. MEETINGS.—An Annual Meeting shall be held in conjunction with the annual meeting of the American Association for the Advancement of Science and at such time and place as the officers may elect.

To be amended to read: An Annual Meeting shall be held in affiliation with the American Association for the Advancement of Science or at such time and place as the Executive Committee may select.

There being no further business, the session adjourned.

FOURTH SESSION.

The Society was called to order at 2:00 P. M., December 28th, in Room 10 of the Medical Building. President Aldrich introduced Dr. Seymour Hadwen, of the United States Biological Survey, who presented the Annual Address on the Subject, "Northern Oestridæ."

Dr. Aldrich then introduced Dr. C. J. S. Bethune, an Honorary Fellow of the Society and long-time Editor of the Canadian Entomologist, who was very warmly greeted by the audience.

FIFTH SESSION.

The final session of the 1921 meetings was a joint session with the Entomological Society of Ontario, at which Mr. Arthur Gibson, President of the Entomological Society of Ontario and President-elect of the Entomological Society of America presided. The Session met at 3:00 P. M., December 28th, in Room 10 of the Medical Building, and the following papers were presented:

Algonquin Days. F. J. A. Morris, Peterborough, Ontario.

Ecdysis in *Tmetocera ocellana*. S. W. Frost, Arendtsville, Pa.

Cocoon Spinning by Species of *Bucculatrix*. O. A. Johannsen, Cornell University.

The Ventral Prothoracic Gland of the Red-humped Apple Caterpillar (*Schizura concinna*). J. D. Detwiler, Western University.

Are There Two Species of the Oyster-shell Scale? Grace H. Griswold, Cornell University.

The Phylogeny of the Gall Mites and a New Classification of the Suborder Prostigmata of the Order Acarina. H. E. Ewing, United States National Museum.

An Extreme Case of Delayed Fall Emergence of Hessian Fly (*Phytophaga destructor*). W. H. Larrimer, United States Bureau of Entomology.

Importance of Insects in the Food of the Brook Trout. W. A. Clemens, University of Toronto.

The Effect of Vitamines on the Growth of *Ephestia kuehniella* in Wheat Flour. Charles H. Richardson, U. S. Bureau of Entomology.

Adjournment.

ANNALS

OF

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ON THE SOUTH AMERICAN SPECIES OF THE DIPTEROUS GENUS CHIROMYZA WIED.

By Professor M. Bezzi,
Turin, Italy.

In the recently published Revision of the Chiromyzini by Mr. G. H. Hardy* Australian forms only have been dealt with. In the present paper the writer will take into consideration South American forms only.

Agreeing with Verrall (Brit. Flies V, p. 44) the Chiromyzini are accepted here as a tribe of the family Stratiomyiidæ, chiefly on account of the form and position of the præfurca; but they have many important characters in common with the Rhagionidæ.

The main character of the tribe is that of the atrophied mouth parts, which must be in correlation with some peculiar habits of the adult flies. In addition may be recorded the sunken face and the greatly developed and apparently bisected front coxæ. The third antennal joint is more or less distinctly annulated; the last abdominal segments of the female are ovipositor-like; the tibiæ are not spurred. The wings have the ambient vein complete, even if sometimes very thin; a short præfurca; only 4 posterior cells, all open; the anal cell closed and stalked, but long.

Because of the normally developed mouth parts the genus *Allognosta* must be placed in the *Beridini*.

A peculiar feature of the Chiromyzini is the great variability in venation of the wings. Mr. Hardy points out that in

*Proceedings of the Linn. Soc. of N. S. W. XLV, 1920, p. 532-542, pl. XXIX-XXX.

Australian forms even the upper branch of the cubital fork may be variable, being present in some specimens of one species and wanting in others. I have never found this to be the case with South American forms, which all have an unforked cubital vein, except in *Hylorus*. I have observed the following anomalies:

(*a*) The hind cross-vein may be more or less obliterated, in part or as a whole, the discoidal cell being thus partly or entirely open.
(*b*) The third vein issuing from the discoidal cell may be quite wanting or represented by a short stump.
(*c*) The ambient vein may be sometimes rather indistinct, chiefly in female specimens.

It is evident that this variation by reduction refers chiefly if not exclusively to the veins of the hind half of the wings. It may be interpreted as a condition of the true Stratiomyiid flies, in which the veins of the fore half only are thickened and crowded together near the costa, and as a tendency toward degeneration of wing, a fact which has reached its climax in the Australian genus *Borcoides* with subapterous females.

The South American genera of the tribe may be distinguished as follows:

1. (2) Third longitudinal vein forked; eyes bare and united in the male; third antennal joint with numerous annulations.....*Hylorus* Phil.
2. (1) Third longitudinal vein simple; third antennal joint with less than 8 annulations.
3. (6) Eyes of male united, quite bare or with few and scattered hairs; third antennal joint more or less distinctly annulated or even simple.
4. (5) First antennal joint much longer than the second, being as long as the third .....*Inopus* Walk.
5. (4) First antennal joint as long as the second and much shorter than the third; metapleura with short hairs; wings with microscopical pubescence and with the first longitudinal vein clothed with short hairs.....*Chiromyza* Wied.
6. (3) Eyes of male broadly separated, and clothed with abundant and short hairs; third antennal joint with deep annulation, and much longer than the first; metapleura with long hairs; wings with long pubescence and with the first longitudinal vein clothed with long hairs.....*Barbiellinia*, n. genus

I. **Hylorus** Philippi.

The unique South American form with forked third longitudinal vein, only known by the type species *Krausei* Phil. from Chile. Placed in *Chiromyza* by Hardy; not seen by the writer.

II. **Inopus** Walker.

The unique South American form with elongated first antennal joint, only known by the type species *despectus* Walker from South America. Placed by Mr. Hardy with a query in synonomy with the Australian *Metoponia rubriceps* Macq.; not seen.

III. **Chiromyza** Wiedemann.

The genus *Xenomorpha* Macquart, with the type *leptiformis* Macq. from Rio Janeiro, is evidently the same; likewise the genus *Nonacris* Walker.* with the type *transequa* Walk. from South America; and even the genus *Lagarus* Philippi with the type *paulseni* Phil. from Chile, and *Lagarinus* Enderlein with the type *paradoxus* End. from Chile, as pointed out by Mr. Hardy.

It may be noted that in the original figure of the type species by Wiedemann the second longitudinal vein of the wings was omitted, perhaps accidentally. This vein is well shown in the figure of *Xenomorpha* by Macquart.

The South American forms before me can be distinguished as follows:

1. (8) Anal cell long, its terminal stalk being much shorter than the preceding part of the postical vein; halteres and coxæ of a pale yellowish color.
2. (7) The fourth longitudinal vein is forked before the hind crossvein, which is always complete; the second posterior cell is therefore sessile and rather obtuse at base; the third vein issuing from the discoidal cell frequently present in the shape of a short stump; scutellum never greenish.
3. (4) Back of thorax with four longitudinal dark stripes; pleuræ with several blackish spots ..... *vittata* Wied.
4. (3) Thorax with three longitudinal stripes only, or not evenly striped.
5. (6) The 3 dark stripes on thorax are broad and partly confluent, the back appearing thus in great part infuscated ..... *fuscana*, Wied
6. (5) The above named stripes less developed and often obliterated, the back appearing for the most part reddish yellow ..... *ochracea* Wied.
7. (2) The fourth vein forks beyond the hind cross-vein, which is often obliterated in its upper portion, or quite wanting; the second posterior cell is therefore acute at base and mostly provided with a short stalk; the rudiment of the third branch of media is never present; sides of thorax and of scutellum greenish ..... *viridis* n. var.
8. (1) Anal cell rather short, its stalk being about as long as the preceding portion of the postical vein; the whole antennæ, the halteres and the coxæ quite black ..... *nigra* n. sp.

1. Chiromyza vittata Wied. (**leptiformis** Macq.)

As shown in the original figures by Wiedemann and by Macquart, the main character of the present form is that of the divided middle dark stripe of the back of mesonotum, which has therefore 4 longitudinal stripes. I have in my collection 3 female specimens from S. Sebastiao, seashore of the State of S. Paulo, Brazil, collected by the Count *A. A. Barbiellini*. They agree in having the discoidal cell broad and obtuse outwardly, the second posterior cell with broad sessile base, the anal cell with short terminal stalk. One specimen only shows the short basal rudiment of M 3. The scutellum of the female has a shining black depression on each side at base; the same depression in the male is reddish or only a little darkened.

*It must be noted that in the original description for "Fourth posterior areolet closed before the border", the anal cell is meant.

2. **Chiromyza vittata fuscana** Wied.

Numerous specimens of both sexes, some in copula, from Puerta Bertoni, Alto Parania, Paraguay, June, 1919, collected by Mr. C. Schrottky. One male specimen from S. Sebastiao, Brazil, by *A. A. Barbiellini.*

These specimens agree in having the middle dark stripe of thorax undivided, and usually prolonged behind to the scutellum; the back of mesonotum is broadly infuscated; the dark spots of the pleuræ are less developed; the scutellar depressions as in the preceding.

The venation is as in *vittata;* the rudiment of M 3 is present in 11 specimens of 12. There are frequently abnormal cross-veins in the base of the second posterior cell, forming 1–4 small supernumerary cells; they are present in all the female specimens, but are not symmetrically placed, being often present on one wing only.

3. **Chiromyza vittata ochracea** Wied.

(? *transequa* Walk.)

This is the palest of all the forms, with unspotted pleuræ and bright orange abdomen.

One male specimen from S. Paulo, Brazil, March, 1906 (R. von Ihering). Agreeing in venation with the preceding forms; there is no rudiment of M 3.

4. **Chiromyza vittata viridis** n. var.

Two males from S. Paulo, Brazil (*A. A. Barbiellini*). They seem to agree with *ochracea* Schiner in being more slender than the preceding forms.

Male, length of body, 8–9 mm.; of wing, 8–9 mm.

Eyes closely approximated, but a very small stripe of the frons is visible between them. Third antennal joint twice as long as the two first joints together, black, pilose, distinctly annulated.

Thorax reddish on the back, with three less marked dark longitudinal stripes; pleuræ pale yellowish, unspotted; the sides of the back posteriorly and the border of the scutellum are distinctly greenish. Halteres pale yellow as in all the preceding forms. Abdomen entirely orange, more pale on the venter. Coxæ and legs entirely pale yellowish, with last tarsal joint blackened; trochanters greenish. Wings yellowish, hyaline. One of the two specimens has the discoidal cell complete; in the other only a stump of the hind cross vein is present inferiorly, the cell being broadly open. Both specimens have the second posterior cell acute at base and there provided with a short stalk, which forms a common basal stem for M_1 and M_2; the discoidal cell is acute outwardly; there is no rudiment of M_3; the terminal stalk of the anal cell is short as usual. The present species shows that the condition of *Lagarinus* is a casual one; but Enderlein's species has the third antennal joint not annulated.

5. **Chiromyza nigra** n. spec.

Type ♂, a single specimen in the writer's collection from Ecuador, received many years ago from Dr. J. Escher-Kundig, Zurich, Switzerland.

This may be a melanic mountain form, but it is here described as specifically distinct, chiefly on account of the peculiar shape of the anal cell, which recalls the condition of this same cell in the Beridinæ.

♂ Length of body 11 mm., of wing 10 mm.

Head entirely black, but the occiput and the face densely covered with a dark gray dust. Ocellar tubercle deep black. Eyes bare, intimately united, no distinct line being visible between them. Antennæ entirely black; the 2 basal joints are of about equal length; the third joint is only a little longer than the two first joints together; it is pilose, but I cannot perceive trace of its annulation because of its bad preservation. Mouth parts rudimentary as usual.

Thorax blackish-brown on the back, more reddish on the sides, with a short darkish pubescence; pleuræ dark brownish, more pale on the sternopleura; hairs of meso- and metopleura very short. Scutellum blackish, with more pale border; lateral depressions black. Halteres with yellowish stalk, but with a black knob.

Abdomen dull black, with shining black genitalia, which have the upper lamella deeply emarginate and yellowish at end. Venter yellowish grey. Coxæ shining black, with the sutures reddish; femora yellowish, with the apical part blackish-brown; tibiæ and tarsi almost entirely blackened, only the base of tibiæ and of prætarsi being more pale; claws black, with reddish base; the 4 posterior tibiæ are thickened and a little curved as usual.

Wings greyish hyaline, with a faint yellowish tint on costal cell. Discoidal cell open, only the lower part of the hind cross vein being present; no rudiment of M_3. Second posterior cell acute at base. The two branches of M and the distal portion of upper branch of Cu are very faint, almost spurious, perhaps due to immaturity of specimen. The stalk of the anal cell is much longer than in any of the preceding forms of *vittata*, being about as long as the preceding part of the postical vein; surface of wing is microscopically pubescent as usual.

IV. **Barbiellinia** new genus.

Closely allied with *Chiromyza*, but at once distinguished by the long haired and broadly separated eyes of the male; moreover the hairs of the body, legs and wings are much more developed than in the allied forms. According to Mr. Hardy, Australian species of *Chiromyza* have either contiguous or separated eyes in the males; but the present case is the first known among Brazilian forms, and is here assumed as being of generic value on account of the unusual hairiness of the eyes.

Head rounded, rather small size, more narrow than the thorax. Occiput triangularly excavated above, with no prominent borders. The three ocelli are of rather large size, placed in an equilateral triangle on

an inconspicuous plate. Eyes rounded, with equal areolets, clothed with numerous, but not dense, long hairs. Frons with parallel sides, only a little constricted towards its middle, not at all prominent in profile, about a half of the breadth of one eye. Antennæ inserted below; the second joint being a little longer than the first; third joint as long as the two first joints together, divided into three parts by two complete and deep annulations; it is entirely clothed with rather long hairs, like the basal joints. Face receding, sunken in the middle as in the Rhagionidæ. Mouth parts rudimentary; proboscis atrophied, palpi very small. Thorax greatly developed, almost puffed up and convex above; metapleura with long, erect hairs. Scutellum elongated, rounded behind, flat above, with well developed basal depressions on the sides, destitute of longer hairs at hind border. Halteres large, with oval knob; squamulæ rudimentary. Abdomen flattened, composed of 7 segments, the last of which is only one-half as long as the preceding one; genitalia small, but open. Legs long, intermediate pair shortest. Front coxæ greatly developed and apparently bisected, the plate above them being very large; middle and hind tibiæ distinctly curved and thickened; claws and pulvilli proportionately small. Pubescence of legs and hairs of coxæ longer than in *Chiromyza*. Wings distinctly pubescent on the whole surface; first and third longitudinal veins clothed with long hairs above. Præfurca short, originating over the base of the discoidal cell. Second longitudinal vein short; third vein single, ending before the tip of the wing; costa thickened to a short space beyond the tip of third vein, but prolonged as a thin ambient vein along the whole hind border of the wing. Discoidal cell complete, about as long as broad, obtuse at its distal end; second posterior cell sessile at base, the M forking before the hind cross vein; the rudiment of M_3 is wanting. Stalk of the anal cell short, much shorter than the preceding part of the postical vein. Alula rudimentary. Hind border of the wing with rather long ciliation.

Named in honor of the Count A. A. Barbiellini, who during the long years of his residence in S. Paulo has greatly contributed to the progress of entomological studies in Brazil, by the publication of the Journal "O Entomologista Brasileiro" 1908–1910, and now by the general Review "Chacaras e Quintaes." The writer is indebted to him for large collections of Brazilian Diptera, the exposition of which will appear in the future.

Type: the following new species.

Barbiellinia hirta n. sp.

Type ♂ a single specimen in the writer's collection from Terme do Lindoya (1000 m.), Serra Negra, Eita do do S. Paulo, Brazil, March, 1918. (*A. A. Barbiellini*).

♂ Length of body 8 mm.; of wing 8 mm.

Head entirely yellowish, the occiput whitish, dusted; ocellar plate black; occipital border with a narrow white line and with erect black hairs. Frons with a narrow, less distinct, dark transverse band on the middle, whole length clothed with erect black hairs. Antennæ entirely yellowish, black haired. Hairs of the eyes black. Face with black hairs on the sides; palpi reddish. Thorax on the back yellowish-brown, with rather long dark pubescence; the middle of the dark longitudinal stripes is abbreviated behind, divided along the middle by a pale line, but the lateral ones are not distinct. Pleuræ pale yellowish, unspotted, with rather long hairs on the mesopleura, and with longer ones on the metapleura. Scutellum like the thorax, with short dark pubescence. Halteres pale yellowish, dirty on the knob. Mesonotum pale yellowish. Abdomen yellowish above, rather shining, with blackish pubescence; all the segments are narrowly black on the sides; venter pale yellowish; genitalia quite reddish, even on the upper lamella and lateral appendages. Coxæ and legs entirely pale yellowish, the last tarsal segments only being blackened; coxæ clothed with rather long black hairs, even the black pubescence of the remainder of the legs being longer than usual. All the femora are equally thin; front tibiæ thin, much more slender than the others; claws proportionally short; the three pulvilli dirty yellowish. Wings grayish hyaline, with dark yellowish veins, the basal portion of the fourth longitudinal vein being whitish.

ADDITIONAL NOTE.

Having received a paratype of *Boreoides subulatus*, through the courtesy of Mr. G. H. Hardy, and comparing it with the types of *Boreoides tasmaniensis* I have found:

(*a*) That the differences in the annulation of the third antennal joint and in the position of the hind coxæ are not consistent, these organs being not differently shaped or located in both the species.

(*b*) On the contrary the differences in the form of the scutellum, in the length of the wing-rudiments and in the coloration of thorax, are of great importance.

I find, moreover, that the legs of *tasmaniensis* are thinner and more slender than in *subulatus*, which is chiefly evident in the tarsi, which are not at all incrassated in the former. Even the color of the legs is lighter in *tasmaniensis*, the tibiæ and tarsi being entirely yellowish, while in *subulatus* they are in greatest part black. The two species are without doubt distinct; and Mr. Hardy informs me that even in Australia there are several different species of *Boreoides* not yet described.

ADDITIONAL NOTE (2).

In the meantime a paper by Dr. Günther Enderlein, Berlin, has appeared (Ueber die phyletisch älteren Stratiomyiidensubfamilien, in Mitteil. Zoolog. Mus. Berlin, X, 1921, pp. 153–214), in which a new classification of the Chiromyzini is proposed, with the descriptions of many new genera and species.

The South American species with contiguous eyes of the male are subdivided between the genera *Xenomorpha* Macquart, *Mesomyza* Enderlein and *Nonacris* Walker; while those with the separated and hairy eyes of the male are united in the genus *Chiromyza* Wiedemann. But this proceeding is evidently contrary to Wiedemann's statement, which says in the original diagnosis of the genus: " * * * *oculi maribus contigui:* * * * Augen beim Männchen zusammenstossend * * *" I am therefore of the opinion that the nomenclature used by me is more correct. The type species *vittata* Wiedemann was described only from the female sex, and thus there are no male types of it; Enderlein moreover, has not seen the female type. The genus *Inopus* is placed in synonymy with *Xenomorpha;* the genera *Lagarus* and *Lagarinus* are not mentioned at all.

CONTRIBUTIONS TO A KNOWLEDGE OF THE CRAMBINAE. II.

Crambus laqueatellus Clemens.

By Geo. G. Ainslie,
U. S. Bureau of Entomology.

Crambus laqueatellus is one of the largest and most beautifully marked species in this genus and is easily distinguished from all other North American forms by the two parallel silver stripes running almost the full length of the fore wing. (Fig. II, 6).

SYSTEMATIC HISTORY.

Crambus laqueatellus was first described by Clemens in 1860. Walker redescribed it in 1863 from specimens from "North America" as *C. semifusellus*, a name reduced to synonomy in 1891 by Smith. Aside from its inclusion in various lists and the few references to it as an economic species its literature is meager. Fernald (1896) and Holland (1903) both figure the moth in colors. Nothing has ever been written about any stages other than the adult, except Felt's (1894) description of the egg and first stage larva. In other respects also his notes are hitherto the most extensive of any relating to this species.

DISTRIBUTION.

It is a North American species and occurs throughout a section of the United States extending from Maine to Texas and from Louisiana and Tennessee on the south to Colorado and southern Minnesota on the north. The writer has seen specimens from nearly every state within this area. The Texas record is based on Zeller (1872) who received specimens, presumably from Bosque County, collected by Boll. Fyles (1896) records it from Montreal and Quebec, Zeller (1863), Lintner (1874) and Felt (1894) list it from New York State, and Fernald (1896) from Maine and Louisiana. As indicated by Fyles' records, the species extends somewhat into Canada, but it does not appear in Allen's (1918) list of Nova Scotian

Crambinæ. The shaded portion of the accompanying map (Fig. I) indicates at a glance the territory from which *laqueatellus* has been reported but more extensive collections will likely somewhat extend these limits.

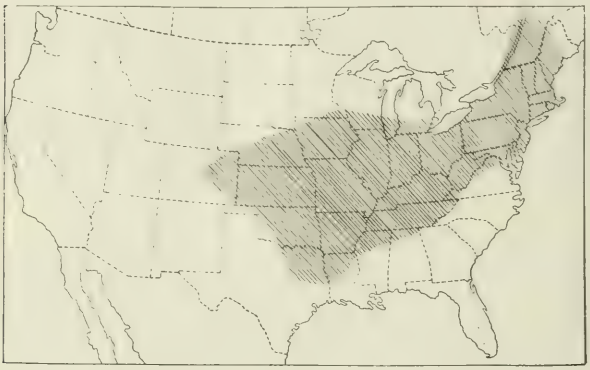

FIG. I.

SEASONAL HISTORY.

Crambus laqueatellus has one distinct generation annually. In Tennessee, where the appearance of the moths has been closely watched for several years, the period during which they have been found in the field extends from April 24 to May 31. Farther north they appear correspondingly later. Felt (1894) states that this is the earliest species to appear in New York State and that at Ithaca it has a compact breeding season of about five weeks. His trap light record for 1889 shows that at Ithaca specimens were taken from May 26 to June 17. According to Webster (1896) moths were abundant in northern Ohio in 1881 from May 29 to June 17. At Columbus, Ohio, Hine (1897) records the moths as present the latter part of April and through May. In Smith's (1900) New Jersey list the species is recorded for May, June and August. August is included on the basis of a single moth taken on the 31st. This record and one by Gillette (1898) mentioning the capture

of a specimen at light at Denver, Colo., on August 16, seem to indicate that there is a slight tendency toward a second generation. This is corroborated by the results of our rearing experiments, reported in more detail later, where moths matured in September from eggs laid the previous May. In general, however, it may be assumed that there is but a single annual generation, the period during which the moths are present in any given locality covering about five weeks. The following table gives the dates within which the moths have been recorded in the respective states.

Illinois—May 14–May 28.
Iowa—June 6–June 16.
Kentucky—May 23–June 21.
Maryland—May 8–May 28.
Michigan—June 6–June 14.
Minnesota—June 6.
New Hampshire—June 2.
New Jersey—May 18–June 24.
New York—May 20–June 24.
Ohio—June 9.
Pennsylvania—June 14–June 30.
Tennessee—April 24–May 31.
Wisconsin—June 15.
District of Columbia—May 20.

This list is very incomplete, but will serve as a starting point for further observations.

The larvæ have never been taken in the field and nothing is known of their seasonal habits. Judging from others of this genus it may be predicted that the larvæ feed and grow during the late spring and summer, reach their growth by the end of the summer season and then remain quiescent in their cocoons during the winter, pupating ten days or two weeks before their emergence in the spring. Whether they feed at all in the spring or complete their growth in the fall is a fact that will have to be ascertained by further studies.

ECONOMIC HISTORY.

Unless further observations bring to light something entirely new in the economy of this species, it must be listed as of little or no economic importance. It has once been charged with injury but it seems certain that it was a case of mistaken identity or bad companions. F. M. Webster (1896) found the moths abundant in association with those of *Crambus trisectus* and *C. mutabilis* a short time after crambid larvæ had devastated fields of grass and small grain in northern Ohio in 1896. While *laqueatellus* larvæ, if present in numbers, might somewhat intensify the damage in such a case, it is very much more probable that the injury should be laid to the other two species,

both of which have repeatedly proved themselves capable of becoming pests of considerable importance. No adults were reared directly from the larvæ which caused the Ohio damage. Runner (1914) lists this species as of economic importance, but apparently bases his statement on the foregoing record and furnishes no additional evidence. Felt (1906) also blackens its character on the same flimsy basis, but until new evidence can be produced the verdict must be "not guilty."

HABITS OF THE MOTHS.

In Tennessee the moths have been found only on lands which have been devoted to grass for some years, such as parks, permanent pastures and meadows. They occur on rolling, well-drained, and sometimes rather damp land, either open or with scattering large trees, but never on high or dry knolls. They do not appear to be generally distributed over a district, but seem closely confined to certain small areas varying in size from a few yards to two or three acres. During the early part of their season no moths occur outside these areas, but toward the close of their period of flight they become somewhat more diffused. Observations show that these infested areas remain the same from year to year. For some time no explanation could be offered for this fact but when it was found that the larvæ, especially in the early stages, can subsist only on certain mosses, it appears that the presence of these essential food plants is the factor determining both the abundance and exact distribution of the species.

The moths are easily flushed at any time of day, fly in a rather direct line for four to ten yards and alight abruptly, always head up, sometimes on a broad-leaved plant, but preferably on a grass stem. When blue grass is present they often choose its more or less pendulous heads and when so resting are very inconspicuous. Occasionally moths which have been flushed several times will feign death and often when struck down with a net they remain motionless until touched.

In our collections the males greatly predominate, especially at the first appearance of the moths. Apparently the males emerge somewhat earlier than the females and the following

record of moths taken at Nashville in 1916 by Mr. W. B. Cartwright bears this out:

Date Taken	Total Moths	Male	Female
May 5	10	10	...
May 6	38	32	6
May 8	43	30	13

Of the 38 specimens taken in the field in 1914, 22 were males; of the 118 taken in 1915, 101 were males, and of 94 taken in 1919, 75 were males. Of the total taken in the three years, 79% were males. Felt's (1894) record shows that in 1889 at Ithaca, N. Y., 55 moths were captured in a lantern trap, 26 of them males and 28 females, this being the only one of all the species which he worked where the females captured at light exceeded the males. In our work no trap lights have been operated near where these moths were known to occur. None were taken at light at Nashville, and but one, a male, at Knoxville. We have been unable to verify Felt's statement that the females fly later in the day than the males.

The adults of both sexes are vigorous and live longer in confinement than those of most species. Eighty-four males collected on various dates lived on the average 4.7 days confined in dry 2-dram vials; 21 females under the same conditions averaged 5.8 days. In the open, under normal conditions, the moths of both sexes probably live much longer than this. The sexes are more nearly equal in their vitality than is usual in this group, for in confinement the males of other species usually die very much sooner than the females. One male lived 11 days, which is longer than any female survived.

The great vitality of these moths is also displayed by the fecundity of the females. Felt states that the species is prolific and we have found this to be true, in fact, this is the most prolific species in this genus of which we have any knowledge. His record of "over two hundred" eggs was far surpassed. One moth laid 868 eggs, the largest number obtained from any individual of any species of this genus so far. Others laid 832, and 720, and eight laid over 500 each. The average for

25 moths under observation was 378, an average of 65 eggs per day for the life of the average female. Our records show that the largest number of eggs was deposited usually the first or second night after capture with a gradual decrease in number nightly until the death of the moth. The largest number laid by one moth in one night was 455, but records of 250 were several times obtained. All these moths were confined in dry vials and undoubtedly died somewhat sooner than they would have done under natural conditions, but from results obtained in more extensive experiments with other species it is concluded that the total number of eggs produced would not have materially increased with lengthened life.

The moths follow the usual habit of the genus in dropping their eggs promiscuously while in flight, but it seems that they are not so careful to await nightfall before beginning operations as are many of the other species. Females captured late in the afternoon sometimes dropped several eggs within a few minutes of their capture.

The larvæ.—In the first two years of work with this species we were entirely unsuccessful in rearing the larvæ. Great numbers of active, newly-hatched larvæ were placed in the small tin boxes used for rearing other species and supplied with fresh leaves of bluegrass, red and white clover, alfalfa, soy bean, cow pea, wheat, rye, corn, timothy, orchard grass, *Muhlenbergia diffusa*, *Plantaga lanceolata* and *Rumex crispus*, all of which they consistently refused to touch. Numbers of larvæ were transferred to potted plants of corn, rye, oats and bluegrass, but later no trace of their having fed could be found. The flora of the various tracts frequented by the moths was minutely studied in an effort to find some plant common to them all. In several such places the stand was apparently pure bluegrass. No empty cocoons or pupal shells were found by digging about plants where the moths were active. Numerous crambid larvæ collected from various places were reared, but none developed into moths of this species.

In the spring of 1916, however, acting on a clue gained from another species, some of the larvæ were put into a box containing among other things, a bit of moss. It was seen almost at once that the larvæ were attracted to the moss. They fed on it to some extent and one or two of the larvæ prepared

to molt to the second instar. None succeeded, however, and all finally died.

The next year the test was repeated, using moss of several different species. The larvæ fed to a slight extent on several of them, but throve and finally matured on only one, *Thuidium delicatulum* (L.) Mitt. It is very likely that other species are equally as acceptable as this one. After the first instar leaves of bluegrass, corn, cow peas and crabgrass were offered them frequently and as they grew older some of the larvæ fed to a greater or less extent but without showing any marked preference. They continued at the same time to feed on the moss and some of them reached maturity without other food. It was plainly evident that moss is absolutely essential to the young larvæ, as we never succeeded in getting them beyond the first instar without it. In the later instars their appetites are a little more elastic, but even then they do not appear to thrive as well on a diet limited to grasses as when they have a little moss for an appetizer.

As stated above, nothing is known of the behavior of the larvæ in the field for they have never been found under natural conditions. After it was found that they would feed and thrive on moss a number were reared from egg to adult in individual tin boxes. Instar records of some were kept but because of the small number for which the data are complete it is not possible to draw reliable conclusions. It is not easy to get accurate instar records of this species because each larva makes for itself a silken tube or retreat running through the moss mass. To search out and examine the larvæ daily to determine their condition results in the death of most and the abnormal development of the rest. Suffice it to say for the present that larvæ obtained from eggs laid May 17, developed into moths, part of which emerged in the rearing boxes between September 21 and 26. Others were apparently full grown and some in the pupa stage when exposure to an unusually severe frost on November 28, killed them all. The fact that there was such a variation in the period of development in this material showed that the results could only suggest and not prove the usual progress of events. It is evident that it is a very rare occurrence for moths of this species to appear in the fall. In several years collecting we have not known

such a case and the only recorded instances are those reported above from New Jersey and Colorado.

The egg.—The eggs when first laid are clear ivory-white. They hatch in 9 to 12 days, depending on the temperature. In one lot of eggs closely observed during the 12 days required for incubation, it was noted that after one day they had become flesh-colored, in two a pale salmon, which, during the third and fourth days slowly deepened to a rich salmon-red and then remained constant until the eleventh day. On the seventh day two small dark eye spots become faintly visible toward one end of the egg, by the eighth day they had become more apparent as small black points within the egg and remained thus until the egg darkened just before hatching. On the eleventh day the head and cervical plate were apparent, the former as a dark area nearly at the end of the egg and the latter as a transverse band close behind it. The dark color of these parts gave a purplish tinge to the whole mass of eggs. On the twelfth day the young larva emerged, effecting escape through an irregularly cut hole at one side of the larger end of the egg. The hole is just at the position on the egg occupied by the head of the larva before hatching, its edge not quite reaching the pole. In this species, as in several others, the egg shell consumed by the larva in effecting its escape from the egg changed to a bright red or orange in the intestinal tract, passed through as a solid plug and was voided as a brightly colored particle just in advance of the first excrement. The empty egg shell is pearly white with an irridescent lustre.

Infertile eggs do not change color and soon shrivel. Some eggs color slightly and then shrivel, indicating that they lack the vitality to develop even though they seem to be fertile. As a rule nearly all eggs hatch, only the last few deposited before the death of the moth being weak or infertile. This leads to the conclusion that the female moths mate but once and from observations on other species this probably takes place shortly after emergence from the pupa.

The pupa.—Nothing definite can be said about the cocoon or pupa. The few that were formed in the breeding boxes were enclosed in cocoons of silk and debris with nothing to differentiate them from those of other species.

DESCRIPTIONS.

The egg. Ivory-white, elongate oval, bluntly rounded on both ends, one of which is only slightly the larger, with about 16 longitudinal ribs merging at each end into an irregularly tuberculate polar area, these ribs and the intervals between them crossed by other less prominent ridges of which there are about 18 in the length of the egg. Measurements (10 eggs measured):

	Maximum	Minimum	Average
Length	.4413 mm.	.4060 mm.	.4130 mm.
Width	.3001 mm.	.2648 mm.	.2718 mm.

The larva. Instar I. (Newly hatched). Length 1.15 mm. Head width .1589 mm. Head deep fuscous to black, cervical plate fuscous, body pale orange, the color heightened by the red color of the particle of ingested egg-shell, paler caudad. Head and body with numerous pale slender hairs, those on body arising from small dusky pinacula.

II. Length 1.40, head width .2294 mm. Head black, cervical plate deep fuscous, body reddish brown with a greenish tinge.

III. Length 2.80, head width .3353 mm. Head dark yellow, semi-transparent, unmarked, shining, ocellar area black; cervical plate fuscous, shining, darker than the head; body pale green prominently marked with transverse segmental bands of reddish brown overcolor giving the entire insect a dingy brownish color.

IV. Length 3.5, head width .4235 mm. No marked change.

V. Length 5.9, head width .5118 mm. Head clear dingy yellow, unmarked, ocellar area and narrow lateral margin black; cervical plate transparent, dusky greenish-brown with two or three dusky spots laterally; body reddish brown, pinacula fairly distinct especially on the thorax, somewhat darker than skin and rugose but not sharply defined, moderate in size. Setæ pale and shining.

VI. Length 7.0, head width .7415 mm. Head clear amber-yellow, mouth parts brown, ocellar area and marginal line black; cervical plate glassy, transparent and colorless except for the greenish color from food, a dusky spot toward either end; pinacula prominent, rugulose and chocolate-brown, rather large; skin finely granular, glistening, covered especially caudad with reddish-brown or maroon overcolor through which are small groups of small clear vacuoles along the lateral margin. At a glance the larva appears dark reddish-brown with a clear yellow head.

VII. Length 10.0, head width .9794 mm. Head clear yellow with a row of small dusky points across the face, ocellar area marginal spot and line and mouth parts black; cervical plate transparent, greenish-yellow; body heavily covered with reddish-brown overcolor in which are rows of small clear vacuoles along the dorsolateral margin; skin dull, pinacula feebly shining and rugulose, poorly defined and indicated only by the character of the surface, body paler caudad.

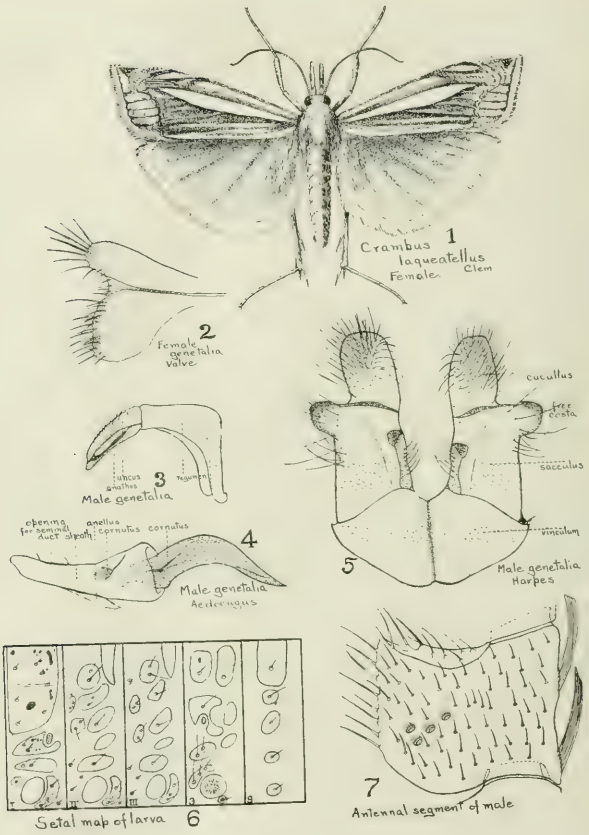
Crambus laqueatellus Clem
Female
1
Female genetalia Valve
2
Male genetalia
3
Male genetalia Acrocercops
4
cucullus
costa
sacculus
vinculum
Male genetalia Harpes
5
Setal map of larva
6
Antennal segment of male
7

FIG. II.

VIII. Length 14.0, head width 1.2126 mm. Head clear pale yellow; cervical plate transparent with dusky cephalic margin; skin of thorax pale yellow, of abdomen deeply covered with purplish-brown overcolor against which the chocolate-brown pinacula are distinguishable only by the texture of their surface.

IX. Length 15.0, head width 1.4929 mm. Head yellow with a slight brownish tinge and a very faint brownish pattern, clypeus whitish, rest of mouth parts dark brown; ocellar area and marginal spot black; cervical plate clear greenish-yellow with an oval fuscous spot near each end; body color dusky green, darker caudad with the dense dark purple overcolor through which on the caudal two-thirds of the body there are conspicuous rows of large clear vacuoles along the lateral and segmental lines; skin granular, pinacula large, dark purple, shining and feebly rugose; caudal plate dusky with dark points. For relative size and arrangement of the pinacula see (Fig. II, 6.(

The pupa. Length 9.0 mm., width 2.8 mm. Dusky yellow, of the usual pyralid shape. Spiracles small but sharply elevated. Cremaster broad, flattened, from above subquadrate, somewhat narrowed caudad with a minute pale seta at each outward angle, the tip narrowed and abruptly depressed, almost tubercle-like, bearing at its extremity a pair of larger dark setæ; lateral grooves shallower and narrower than in most species, only moderately curved; beneath excavated.

The adult. The following is Clemens' (1860) original description slightly modified by Fernald (1896). (Fig. II, 1.)

"Expanse of wings 23 mm. Head luteous; thorax and palpi fuscous, the latter whitish beneath. Fore wings ochreous, with two silvery-white streaks separated by a fuscous streak; the outer silvery streak margined on costa with fuscous; the inner one, which extends beyond the apical third, edged on the fold with fuscous. Beneath the fold the wing is pale yellowish with fuscous streaks along the submedian veins. Apex of the wing tinted with ochreous yellow, the veins streaked with silvery white; on the costa near the tip an oblique silvery streak, margined on both sides with fuscous. The subterminal silvery-white line much angulated, bending in below the apex, leaving a large whitish marginal patch streaked with dark parallel lines which end in dots before the terminal line. Fringes lustrous ochreous. Hind wings pale fuscous; fringes white."

The Tennessee specimens agree well with this description but are somewhat larger, averaging 27 mm. in alar expanse. The "whitish marginal patch" is more pale fuscous than white and the "pale fuscous" hind wings are whitish along the margins especially toward the apex.

Genitalia. Female. (Fig. II, 2). Anal plate wider than long, somewhat constricted at base, margins serrate with tubercles terminating in long stout spines; the upper third sharply rounded and separated from the rest by a deep rounded notch, lower lobe shorter than the upper, evenly rounded above, slightly angled at lower corner. *Male.* Tegumen (Pl. XII, Fig. 3) with both body and limbs rather narrow and about equal in length the latter slightly narrowed mesad, and rounded

distad. Uncus setigerous, stout, narrowing acutely distad and tipped with a short sharp curved tooth; gnathos naked, slender, exceeding the uncus, at tip widening and the margins upturned forming a pocket into which the tip of uncus fits when closed. Harpes (Fig. II, 5) broad at base, the costa of the harpes proper free but greatly reduced to chitinized angular lobe extending at right angles to the base of the cucullus which is a broad rounded, lightly chitinized process, hairy within and separated from the sacculus by a narrow chitinized carina. Sacculus broad and almost rectangular, slightly concave, sparingly setigerous on both margins with a portion of the inner margin thickened and inturned and terminating in a small rounded lobe. Vinculum a broad subtriangular, weakly chitinized area supporting the sacculi. Aedoeagus (Fig. II, 4) subconical, smaller and rounded at the base, flaring somewhat at the open end, very feebly chitinized, bearing inside about midway a small acute chitinous spine with a broad flat base, and just within the open end and projecting far beyond a huge, heavily chitinized curved, flattened spine longitudinally carinate at the base and covered with minute acute points inclined toward the tip, this spine or cornutus equalling in length the aedoeagus proper. The anellus is a mere membrane attached to the aedoeagus ventrad.

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*Because of the trivial nature of so many of the references it has been decided unwise to continue the plan outlined in the first paper of this series (Ann. Ent. Soc. Am. 11:51, 1918) and only literature referred to in the text is included in this bibliography.

A REVIEW OF THE DESERT LEAFHOPPERS OF THE ORGERINI (RHYNCHOTA FULGORIDAE).

By E. D. Ball and Albert Hartzell.

Stal[1] in 1859, figured and described *Orgerius rhyparus* from material collected at San Francisco and for many years the relation of this species to the other members of the group remained an unsettled question. About ten years ago it chanced to be the good fortune of the senior writer while collecting Homoptera in California to rediscover Stal's species and secure sufficient material to throw some light on the interpretation of the characters and classification of this aberrant and interesting tribe of Fulgoridæ. Collections were made covering Oregon, Idaho, Utah, Nevada, California and Lower California, Mexico.

The adults of the Orgerini are wingless with brachypterous elytra and resemble the nymphs of winged species. They present a grotesque and unusual appearance in that they assume an upright position in walking on their long, slender legs; their short, stout bodies and their long, pointed cephalic processes together with a peculiar strut in locomotion give the insects a unique place among Nature's odd creatures. The rostrum is remarkably long, in some of the more upright species, exceeding the abdomen and instead of carrying it inclined forward as most leafhoppers do in feeding these insects feed with the rostrum running down the abdomen and extending beyond into the plant tissue. These odd adaptations seem to fit the insects to the hot, dry inhospitable desert regions of the Southwest and apparently is an arrangement to lift the body from the burning heat of the sands. Among the host plants recorded for the various species are some of the more common xerophytic vegetation such as Mormon tea, sage brush, tree Yucca and chaparall.

In 1909, the senior[2] writer published an account of some of the material he collected from this region proposing the genera *Timodema* and *Orgamara* with a number of new species. In 1913, Oshanin[3] published a synopsis of the tribe *Orgerini* of the

[1] Freg. Eugen. Resa. Ins., p. 274, 1859.
[2] Ball, E. D., Proc. Bio. Soc. Wash., Vol. 12, pp. 197-204, Dec., 1909.
[3] Oshanin, B. F., Insecta Hemiptera, Vol. 3, part 1, pp. 1-113, 1913.

Russian fauna. This was followed in the same year by a resume[4] in German with the keys translated in Latin. It appears from the keys and descriptions that he has misinterpreted the character of the genus *Orgerius* as he describes it as wanting a callosity behind the eye while he erects the genus *Nymphorgerius* for species with short angular vertices and the eyes bearing posterior callosities. Stal's figure of *Orgerius* shows distinct callosities behind the eyes and our material also exhibits this character. Unfortunately, Oshanin had no American material for comparison and it is very unlikely that the genus *Orgerius* is represented in Europe. As some of the European genera appear to be closely related to our American genera we have attempted to state the differences here.

The genus *Sphenocratus* Horv. superficially resembles *Deserta* but differs from the known American genera in lacking ocelli. *Nymphorgerius* Oshanin resembles the true *Orgerius* but has the antennæ placed in a large pit with the margins elevated into a carina. Unless we misinterpret this character none of the known species in North America possess this peculiarity. *Haumavarga* Oshanin differs from all known American genera of this tribe in lacking a median carina on both vertex and pronotum. It bears no superficial resemblance to any of our species as the vertex is much broader and the angles very much rounded. *Repetekia* Oshanin has the anterior femora and tibia flattened as in *Timodema* Ball but has the median carina of the front divided by an obtuse fracture. *Timodema* in addition has the middle femora and tibia foliaceous. *Ototettix* Oshanin resembles *Timonidia* but has a distinctly different front resembling that of *Ticidia* Uhl. but may be separated from the latter genus by its broad head which is upturned at an angle of about 45°, while *Ticidia* and *Timonidia* have the head normal; also the species of *Ototettix* are not banded as are the species of *Ticidia* and *Timodema*. *Tigrahauda* Oshanin resembles *Acinaca* in the shape of the cephalic process but differs in having the oblique carina running parallel to the ventral margin of the cepahlic process while in *Acinaca* the oblique carina curves abruptly upwards and ends on the dorsum. It also differs from *Acinaca* in having the vertex furrowed and wanting a median carina.

[4] Oshanin, B. F., Rev. Rus. Ent. Vol. 13, No. 1, pp. 135-147, 1913.

KEY TO THE N. A. GENERA OF ORGERINI.

A. Callosity behind eye; vertex elongate or angulate.
  B. Vertex elongate, with more than one-half its length beyond the eyes.
    C. Cephalic process truncate at the extremity. Five-angled.
      D. Cephalic process gradually tapering as seen from both top and side. Apex small.....*Orgamara* Ball.
      DD. Cephalic process parallel margined; apex as seen from the side slightly enlarged; projecting at an angle with vertex.....*Yucanda* nov. gen.
    CC. Cephalic process as seen from side, beak-like, the apex obliquely rounding from above, the lower angle slightly produced.....*Deserta* nov. gen.
  BB. Vertex angulate, narrowing from the eyes, less than twice the length of the eye.....*Orgerius* Stal.
AA. No callosity behind eye; head rounding or if elongate, broad, if seen from the side.
    E. Vertex angulate, produced in front of the eyes at least one-third its length.
      F. Head twice the length of the eye as seen from the side, widening toward the truncate apex.....*Acinaca* nov. gen.
      FF. Eyes contigious to pronotum; head distinctly less than twice the length of the eyes; as seen from the side, distinctly narrowing and roundingly truncate.....*Aridia* nov. gen.
    EE. Vertex broad and short, scarcely longer than its basal width. The lateral carina of the front closely margins the eye clear to its juncture with the lateral margin of the vertex.
      G. Fore and middle tibia broadly foliaceous.....*Timodema* Ball.
      GG. Tibia normal.
        H. Lateral carinæ of the frontal tablet uniting some distance below the apex of the head.....*Ticidia* Uhl.
        HH. Lateral carinæ of the frontal tablet narrowing but not uniting before joining the vertex.....*Timonidia* nov. gen.

Orgamara Ball.

Resembling *Orgerius* Stal but with the vertex produced into a long stylate process, similar to that found in *Scolops*, but stouter.

Cephalic process long, tapering, nearly twice the length of the eye, truncate apically, but slightly inclined to the plane of the vertex. Front straight in profile, tricarinate, the lateral carinæ narrowing near the apex but not uniting with the median. The carina from the lower corner of the eye running obliquely to the upper margin of the snout at or beyond the middle; below this carina, the front is pustulate. A transverse carina sets off the posterior third of the vertex; median carina of the vertex extending onto the cephalic process a slight distance. Eye separated from the pronotum by an elongate callosity. Pronotum with a central raised tablet, tricarinate, the lateral extensions sloping strongly downward and backward, pustulate. Elytra covering the second segment of the abdomen, irregularly reticulate; a row of pustules near the posterior border of each segment. Legs long, slender, terete; hind tibia with 5–6 weak spines. Rostrum about equalling the abdomen.

Type of the genus *O. acuta* Ball.

This genus as now restricted, with *acuta* Ball as type, includes two species known only from Southern California and Lower California, Mexico. The slender tapering cephalic process will at once separate them from other groups.

Key to the Species of Orgamara.

A. Cephalic process long and slender, nearly twice as long as the eye; the anterior tablet of the vertex longer than wide.....*acuta* Ball
AA. Cephalic process broader and shorter, extending beyond the eye, but little more than its length; anterior tablet of vertex rectangular..*reducta* Ball

Orgamara acuta Ball.

(Plate XII, Figs. 12, 14, 16.)

Orgamara acuta Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 198, Dec., 1909.

A short-winged, dark fuscous species with an extremely long and slender cephalic process. Length 5–6 mm.

Cephalic process long and slender more than twice as long as the eye. The oblique carina meeting the margin of the cephalic process about one-third the distance from the apex. Anterior tablet of the vertex slightly longer than wide. The front narrow, elongate, over one-half its length beyond the median line of the eyes.

Color—Brownish fuscous, pronotum much lighter than scutellum. Irregular reticulations on the elytra and about four irregular stripes on the abdomen, lighter. Whole insect with a coppery reflection along the median line. Face uniformly brown.

This species is strikingly distinct from all others in the group and may be recognized by its long, slender, pointed cephalic process. Specimens are at hand from the region of San Diego, California, and adjacent portions of Mexico. Solitary individuals have been taken from the middle of June until early August. They occur in open spaces in the chaparall, two of them were beaten from *Arctostaphylos* but this may have been accidental.

Orgamara reducta Ball.

Orgamara reducta Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 198, Dec., 1909.

Resembling O. acuta, slightly smaller, paler, with a shorter cephalic process. Length 4 mm.

Cephalic process broad, less than one and one-half times the length of the eye. Oblique carina meeting the dorsum at the middle. Front broader and shorter than in *acuta*, the median line of the eye bisecting its length.

Color—Pale gray, mottled with fuscous. The carinæ on the vertex, the central plate of the pronotum, most of the elytra reticulations and four interrupted stripes on the abdomen creamy white. Front pale, slightly sprinkled with fuscous.

The stouter, lighter appearance and the shorter cephalic process will at once separate this species from *acuta*. Specimens are at hand from the Salton Sink region of California, taken late in June.

Yucanda nov. gen.

Cephalic process long, more than three times the length of the eye, parallel margined as seen from the side, curving upwards at an angle slightly less than 45°, widening toward the truncate tip, where it is five-angled. Front of equal width throughout, tricarinate, the lateral carinæ widening and the median carina elevated toward the apex of the cephalic process. Oblique carina extending two-thirds the length of the cephalic process, pustulate below. Pronotum narrow, pustulate, median tablet not differentiated. Eye separated from scutellum by an elongate callosity. Anterior tablet of scutellum raised, tricarinate, lateral projections pustulate. Elytra abbreviated, irregularly reticulate. Abdomen long, oval, obese. Rostrum definitely exceeds the abdomen. Legs long, slender; hind tibia with 4–5 weak spines.

This genus is readily distinguished from Orgamara by its curved and apically truncate cephalic process.

Type of genus *Orgamara albida* Ball.

Yucanda albida Ball.

(Plate XII, Figs. 2, 7.)

Orgamara albida Ball. Proc. Biol. Soc. Wash., Vol. XXII, p. 200, Dec., 1909.

A large globose creamy yellow species with a long curved cephalic process. Length 6–7 mm.

Structure of the genus, pale creamy yellow, the eyes, lateral carinæ, the antennæ, fore and middle tibia and the tip of the rostrum brownish.

This strikingly distinct species in both color and structure lives, both nymph and adult, upon the tree Yucca (*Yucca baccata*) of the Mojava desert region. These insects hide between the bases of the sword-like leaves where they are practically inaccessible except to vigorous beating with a heavy club. Adults were abundant together with a few large larvæ June 15 indicating that a brood was just maturing, while on another visit July 30 but one or two old adults could be found.

Deserta nov. gen.

Intermediate between *Yucanda* and *Orgamara* but with the apex of the cephalic process beaked.

Cephalic process moderately long, very nearly parallel margined to just before the apex where it rounds over to the acute and slightly pro-

duced lower angle which is curved down like the beak of a raptorial bird, the extremity triangular. Front broad and nearly parallel, the lateral carinæ widening toward the apex. Median carina of vertex extending the full length of the cephalic process. Central tablet of pronotum distinct. A definite oval or slightly oblique callosity behind the eye, separating it from the pronotum. The elytra brachypterous, irregularly reticulate. Legs simple; hind tibia with 7 strong spines.

Type of the genus *Orgamara bipunctata* Ball.

This group is distributed from southern Idaho to Mexico between the Wasatch and Sierra Nevada Mountains and extending across the latter range in Southern California. All the species of this group have been taken from sage brush regions and most of them have been beaten directly from species of *Artemesia*.

Key to the Species of Deserta.

A. Part of the front above the center of the eyes twice as long as that below.
B. Cephalic process as seen from above extending beyond eye less than twice the length of the eye. Lower angle of anal tube of male more than one and one-half times the dorsal length of the tube, broadly expanded and curved down to meet the long, narrow plates. *obscura* Ball
BB. Cephalic process more than twice as long as the eye. Lower angle of anal tube of male narrower and less produced. . . . . *bipunctata* Ball
AA. Part of the front above the center of the eyes equalling that below. *obesa* Ball

Deserta obscura Ball.

(Plate XII, Figs. 4, 11.)

Orgamara obscura Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 200, Dec., 1909.

Resembling *bipunctata*, darker with a shorter cephalic process. Length, females, 6 mm.; males, 5 mm. Ashy gray with a curved and slightly hooked process.

Cephalic process shorter and stouter than in *bipunctata*. Front with the median tablet expanded before the apex, rounding above. Part above the center of the eyes one-half longer than that below. Color—white, finely sprinkled with dark points, giving the insect an ashy gray appearance. Front greenish, the clypeus rusty orange.

Genitalia.—Lower half of anal tube in the male extended over one and one-half times the median length of the tube, broadly expanded and curved down to meet the margins of the long, narrow plates. Surface of the lower half furrowed and covered with coarse hairs.

This species has been taken on sage brush (*Artemesia tridentata*) at Nampa, Idaho, Wells, Nevada, Marysvale and Chadburn's, Utah, and Doyle and Chilcoot, California. Collections have been made all around this area, without finding the

species; it therefore appears to be confined to the State of Nevada and a narrow fringe of the adjoining states and only on the higher levels where sage brush grows. Nymphs and adults were found during July at the lower levels, adults were nearly all out by July 20 but in the mountains nymphs were still present up to early August, while adults were taken up until the last of the month.

Deserta bipunctata Ball.

Orgamara bipunctata Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 199, Dec., 1909.

Resembling *obscura* but with a longer, slimmer, less inclined cephalic process about twice the length of the eye and lighter in color. Length, female, 6 mm.; male 5 mm.

Front with the central raised tablet distinctly narrowing before the eyes, then parallel margined to the clypeus. The part of the front above the center of the eyes almost double that below. Elytra shorter than in *obesa*, slightly abbreviated, truncate. Color—Variable, but usually a dull fuscous, finely irrorate with fuscous brown.

Examples are at hand from St. George, Utah, and Ravenna, California, probably on *A. tridentata*.

Deserta obesa Ball.

Orgamara obesa Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 199, Dec., 1909.

Resembling *bipunctata* but smaller with a shorter, blunter cephalic process upturned at a sharper angle, slightly less than 45°. Length, female, 6 mm.; male, 5 mm.

Cephalic process slightly more than once the length of the eye. Elytra short, the inner angles broadly rounding. Front parallel margined, part above eyes but little larger than that below.

Color—Pale straw, with a dirty orange cast. Nervures of the elytra with the cells smoky, the nervures of a pale straw color.

This species has been taken at American Fork and Parowan, Utah, from sage brush in July and August.

Orgerius Stal.

Resembling *Deserta*, but with a broader, shorter, distinctly triangular cephalic process.

Cephalic process short, broad at the base, tapering to an angular or slightly conical point, not truncate. The lateral carinæ of the front rounding into the median carina at the apex of the cephalic process. Oblique carina curving upwards from the eye, pustulate below; median carina extending to the apex. Eye separated from the pronotum by a diamond-shaped callosity. The anterior margin of the lateral tablets

of pronotum transverse instead of inclined posteriorly as in *Deserta*. Carinæ of scutellum sharply defined. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Rostrum equalling the abdomen. Anterior femora expanded three times the width of the tibia; post tibia flattened, inclined to be serrate, the serrations crowned with 6–8 black spines.

This genus was described by Stal for *O. rhyparus* from San Francisco. Oshanin, 1913, in a review of the group evidently misinterpreted the character of the genus as he describes *Orgerius* as wanting a callosity behind the eye, while he erects a new genus, *Nymphorgerius*, for species with short, angular vertices and the eyes bearing posterior callosities. He mentions a carina between the antenna and the eye, which is lacking or but feebly developed in our species and it is probable that the true *Orgerius* does not occur in Europe.

Key to the Species of Orgerius.

A. Size variable. Vertex narrow, one-half longer than its width; the hind tibia distinctly flattened basally, the heavy spines appearing as serrations. *O. rhyparus* Stal.

AA. Small, pale, vertex wider, less than one-half longer than its basal width. Posterior tibia not modified.....*O. minor* Ball

Orgerius rhyparus Stal.

Orgerius rhyparus Stal. Freg. Eugen. Resa. Ins., p. 274, 1859.

A large, obese, globose species with a long, acutely angular vertex extending one-half its length beyond the eye. Vertex long, parallel margined or widening near the base, then acutely angular, the apex slightly rounding, the lateral carinæ strongly foliaceous. Face in profile slightly dished, forming with the vertex an acute angle. Median tablet narrow, parallel margined, about equalling the width of the eye.

This species appears to be extremely variable in size and color and is best characterized under its varieties. It was described by Stal from specimens from San Francisco and has been found to extend from Oregon to Mexico, west of the Sierra Nevada range. The larvæ appear in May and June, the adults in June and July. They are found in bare places in dry, exposed situations.

Key to Varieties.

A. Large, obese forms, partly rufous or testaceous.
B. Species entirely rufo-testaceous.....*var. rhyparus* Stal.
BB. Rufous with elytra black.....*clitellus* n. var.
AA. Without reddish shade.
C. Uniformly fuscous, size variable.
D. Large, obese, females, 5 mm. or longer.....*concordus* n. var.
DD. Small, females 4 mm. or less.....*pajaronius* n. var.
CC. Uniformly pale or fuscous and pale, small.....*ventosus* n. var.

Variety **rhyparus** Stal.
(Plate XII, Fig. 15).

This variety is characterized by its rather uniform testaceous color and appears to be one of the rarer forms. It has been found in the foothills around the Sacramento and San Jauquin valleys and extending over the range towards the Salton Sink as far as Cabazon.

Variety **clitellus** n. var.

Resembling var. *rhyparus*, large, obese forms with a testaceous color sharply set off by the shining black elytra.

Described from three examples from Santa Margarita, Chico and Colfax, California. This variety was found with the preceding and appears to be a still rarer adaptation to these dry, hot situations.

Variety **concordus** n. var.

Large, obese form with the females averaging from 5–6 mm., uniform dull fuscous above, with a slightly pearl-gray sheen.

Described from two pairs from Cabazon, California, and Ti Juana, Mexico. This is the common variety in southern California extending from Visalia and Cabazon south and west to Ti Juana, Mexico.

Variety **pajaronius** n. var.

Small, rather slender, female not over 4 mm. in length, resembling *concordus* above but much smaller and with the face much more frequently transversely banded with light.

Described from two pairs from Salinas and Watsonville, California. This variety occurs on the Coast Range from the Salinas Valley north to San Francisco and a pair were taken on the eastern slope of the Sierra Nevadas near Le Grande, Oregon.

Variety **ventosus** n. var.

Resembling *pajaronius* in size and form, dimorphic in color, the female mottled fuscous and white, the central tablets of the pronotum and scutellum almost creamy, the face trifasciate with light. Male clear yellowish-white with a few fuscous spots on the lateral carinæ of the vertex.

Described from three pairs from Mojava, California, taken July 30. This peculiar form appears to be strictly confined to the sparse vegetation of that windy and inhospitable desert region. Most of the specimens were beaten from a low, spiny white shrub.

Orgerius minor Ball.

(Plate XII, Figs. 1, 6, 9.)

Orgerius minor Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling *rhyparus* but smaller, paler, with a shorter, broader vertex, two-thirds as wide as long, the foliaceous margins rounding into the blunt apex. Posterior tibia normal. Length 4.5 mm.

This species occurs in the desert region of southwestern Colorado and southern Utah, where it is found on the ground usually associated with some of the smaller salt bushes (*Atriplex* spp.).

Acinaca nov. gen.

Resembling *Yucanda* in structure, but with a very much smaller, shorter and more compressed cephalic process.

Cephalic process moderately long, strongly compressed, narrowing toward the apex; as seen from the side, flat and widens rapidly to a slightly rounding truncate apex, curving upwards, strongly inclined, much wider at apex than at base. The vertex is narrow, less than the width of the eye. The lateral carina of the face cuts the dorsum at one-third the distance to the apex. Median carina faint or wanting. Central tablet of front narrow, almost linear, tricarinate. No callosity behind eye, eye and pronotum widely separated. Pronotum very small, narrow, pustulate, the lateral extensions only represented by a narrow collar, a median but no lateral carinæ, without a raised central tablet. Scutellum very small, with a single carina. Elytra brachypterous irregularly reticulate. Pustules on abdominal segments large, prominent and extending only half way to the median line. Rostrum equalling the abdomen in length.

Type of the genus *Acinaca lurida* sp. nov.

This genus may be distinguished from any other of the group by its simiter-shaped cephalic process.

Acinaca lurida sp. nov.

(Plate XII, Figs. 8, 10.)

A small, globose, highly ornamented green and brown species with a compressed cephalic process. Length, females, 3 mm.; males, 2.5 mm.

Cephalic process slightly longer than the eye, roundingly truncate; its tip about five times as deep as wide. Vertex a narrow, slightly widening strip between the large round eyes. Dorsum of cephalic process long, triangular, equalling the vertex, inclined upwards at an angle of 45°. Front elongate, widening below the eyes which are slightly above the middle. Frontal tablet very narrow, almost linear, strongly

inflated just above the eyes. Pronotum scarcely more than half as long as the diameter of eye, sloping irregularly backwards to a mere collar. Scutellum very small without a defined tablet.

Color—Bright testaceous with the head and pronotum a bright green. A belt covering most of the elytra deepening anteriorly and encircling the insect below just back of antennæ, dark shining brown to black. The lateral carinæ, median carina of the front and the margins of the truncate cephalic process black-lined. Fore and middle tibia lineate with light.

Described from three pairs from Mojava, California, taken July 30, 1912. Other examples are at hand from Ravenna, California. This striking and easily recognized species was taken only on one of the chaparall bushes, *Eriogonum fasciculatum*, of the deserts and dry mountain slopes to which its color almost perfectly adapts it.

Aridia nov. gen.

Resembling *Acinaca*, but with a shorter, broader, more rounding cephalic process.

Cephalic process broad and short, rounding at the apex, slightly inclined upwards. Vertex broad, as wide as the eye, the median carina fades out before reaching the apex. Front narrow, with very sharply defined carinæ; median carina of the front uniting with the lateral carina in a five-sided figure. Frontal tablet linear, inflated just below the eyes. No callosity behind the eyes, the eye and pronotum contiguous. Pronotum short, with median carina, without a central tablet, pustulate. Scutellum with central tablet, with three sharply defined carinæ. Elytra brachypterous. Strongly reticulate. Abdomen ovate. Abdominal segments with a row of pustules along posterior margin two-thirds of the distance to the median line. Legs linear, not expanded.

Type of the genus *Orgerius compressus* Ball.

Key to the Species of Aridia.

A. Cephalic process upturned at an angle of about 45°. Rostrum about equalling the abdomen.....*A compressa* Ball
AA. Cephalic process flat or upturned but very slightly. Rostrum decidedly longer than abdomen.....*A. erecta* Ball

Aridia compressa Ball.

Orgerius compressus Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling *erecta*, but with a longer, narrower more upturned cephalic process. Length 4 mm.

Cephalic process upturned at an angle of about 45°, slightly less than the length of the eye, acutely angular with apex truncate. Front narrower than in *erecta*, sharply carinated. Line through center of eyes cutting slightly above the middle. Vertex long, angulate with faint

median carina, lateral carina more sharply defined. The lateral carinæ of the front rounding in and uniting with the median at the rather broad truncate apex, not joining the median carina of the vertex. Rostrum about equalling the abdomen. Grayish brown, abdomen smoky with a few irregular lines.

Examples are at hand from Helper and Marysvale, Utah, taken in July and August from sage brush (*Artemesia tridentata*) growing on the sunny slopes of the Wasatch Mountains at elevations of 7,000 to 8,000 feet.

Aridia erecta Ball.

(Plate XII, Fig. 3.)

Orgerius erectus Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 202, Dec., 1909.

Resembling *Orgerius minor*, but smaller and with a rounding cephalic process very slightly upturned. Length, 4 mm.

Cephalic process short, extending beyond the eye less than its length, rounded at the apex with a truncate tip. Front sharply carinated, narrow, the width about one and one-half times the short diameter of the eye, lateral carinæ uniting with the median carina just before the truncate apex of head, median carina of the vertex not uniting with the median carina of the front. Vertex small, triangular, apex of the head as seen from side bluntly rounded, almost truncate, not curved upward as in *compressa*. Rostrum decidedly longer than abdomen. Pale smoky lined with brown; elytra dirty straw; abdominal segments smoky with irregular dark markings.

Examples are at hand from Reno, Nevada, Doyle, Chilcoot and Kelso, California, indicating a distribution for a long distance along the slopes of the Sierra Nevada Mountains. The larvæ were abundant in early June. Very few adults at low levels while they were about equally divided on the highest levels late in July. They were found on the ground in open places.

Timodema Ball.

Intermediate between *Aridia* and *Ticida* but with the anterior femur greatly expanded, foliaceous.

Cephalic process short, broad at the base, rounding at the apex, vertex tricarinate, shorter than eye, not extending to the apex of the head, with acutely angulate anterior margin, the median carina of the front uniting with the median carina of the vertex. Front broad, five carinate, median tablet tricarinate. Median carina of the front and cephalic process coalescing. Clypeus broad, distinctly tricarinate. No callosity between the eye and pronotum. Pronotum short without raised tablet, pustulate to the median carina. The central tablet of the

scutellum not pustulate, tricarinate. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Abdominal segments with distinct median carina. Fourth, 5th and 6th segments with a row of pustules along the posterior margin for a part of their length. Rostrum equalling the abdomen. Fore and middle femora and tibia greatly expanded, foliaceous, carinated; basal part of tibia leaf-like, tapering. Hind tibia with four spines.

Timodema miracula Ball.

(Plate XII, Fig. 17.)

Timodema miracula Ball. Proc. Bio. Soc. Wash., Vol. XXII, p. 201, Dec., 1909.

Resembling *Ticidia cingulata* Uhl. but with the anterior and middle legs foliaceous, slightly larger, broad and darker, pitchy brown or black with two white spots on the elytra. Length 3.5–4 mm.

Cephalic process appearing only as a rounding margin to the vertex, extending less than its width beyond the eye. Vertex shorter than eye, with indistinct median carina, anterior third angulate. The line uniting the frontal tablet with vertex equalling only one-half the length of the vertex. Front short and broad, not extending beyond the eyes. Fore and middle femora broadly foliaceous on both margins longitudinally carinated. Tibia broadly foliaceous at the base, rapidly narrowing to the rather attenuate apex.

Color—Dark brown or black with a transverse line on the scutellum, the posterior margin of the elytra and the tips of the fore and middle tibia milky white, and a transverse band on the fore and middle tibia reddish. A transverse band of white across the base of the clypeus.

Examples of this curious species have been found at Ravenna, Ontario, Pasadena and Tia Juana, California, and in Lower California, Mexico. They occur only on the slopes of the mountain sides and have been found under the dense green-brush (*Adenostoma fasciculatum*) so common in the chaparall of these slopes. The adults appear late in June on the lower slopes while the larvæ will be common above. A month later the adults will be appearing near the tops of the ridges. Even the youngest stages of the larvæ have the foliaceous legs and present a ludicrous appearance, somewhat resembling a crab as they strut about.

Ticidia Uhler.

Ticidia Uhl., Trans. Md. Acad. Sc. I, p. 143, 1891.
Loxophora Van Duzee, Proc. Acad. Nat. Sci., Phila., LIX, pp. 469, 472, 1908.

Resembling *Timodema* Ball but smaller, with the fore and middle tibia normal, linear, not foliaceous.

Cephalic process short, broad at the base, with a round apex, vertex short, as long as the eye, margins carinate. Front five carinate, with median tablet tricarinate, the lateral carinæ roundingly uniting before the apex of the vertex. Clypeus broad, tricarinate. The eye set into the curve of the pronotum, without callosity. Pronotum short, transverse, without median tablet, entirely pustulate. Central tablet of the scutellum broad, without pustules. Elytra brachypterous, irregularly reticulate. Abdomen obese, oval. Abdominal segments with a row of pustules on the outer margin of the posterior two-thirds. Rostrum distinctly exceeding abdomen. Anterior and middle tibia linear, not foliaceous; hind tibia with 6–7 spines.

Type of the genus *Ticidia cingulata* Uhl.

Ticidia cingulata Uhl.

Ticidia cingulata Uhl., Trans. Md. Acad. Sc., I, p. 144, 1891.
Loxophora transversa Van Duzee, Proc. Acad. Nat. Sci., Phila., LIX, p. 473, 1908.

Resembling *Timodema miracula* but smaller and with the fore and middle tibia normal. A small oval species transversely banded with gray and white. Length, 3.5 mm.

Cephalic process short, extending only slightly in front of the curve of the eyes. Front broad, distinctly wider than the eye. The single carina above the frontal tablet nearly as long as the vertex. Vertex wider than long, not extending beyond the eyes, obtusely triangular, posterior third with a strongly carinated margin, median carina obscure or wanting. Legs normal, anterior and middle tibia not foliaceous.

Color—Ashy gray, transversely banded with fuscous and white as follows: A narrow light band across the scutellum, a broader one across the apical half of the elytra and a third across the apex of abdomen. There is a pitchy black band across the face just below the eyes, bordered below by an ivory white one.

This species is evidently widely distributed over the desert region of south Utah as it has been taken at various places from Moab to St. George, Utah. It also occurs in a number of situations in south California from Cabozon to Ravenna. In all cases it has been found strictly around open spaces in the desert regions. The only plant which occurs in all these locations is the bush atriplex (*A. Canescens*) and it has usually been found closely associated with this plant. Adults have been captured from June 10 in hot situations to August 10 in cooler ones.

Timonidia nov. gen.

Resembling *Ticidia*, but smaller with a larger and more sharply angled vertex and still wider front.

Cephalic process almost wanting. The apex of the vertex slightly exceeding the eyes. Vertex triangular clear to the base, median carina weak. Front broader than in *Timodema*, frontal tablet broad, scarcely elevated, parallel margined to just before the apex where the lateral carinæ round in and unite with the vertex. Clypeus broader than in *Timodema*. No callosity between the eye and pronotum. Pronotum short, without raised tablet, pustulate throughout. Central tablet of scutellum broadening posteriorly without pustules. Elytra brachypterous, irregularly reticulate. Abdomen oval, abruptly terminating posteriorly, almost truncate. Abdominal segments pustulate as in *Ticidia*. Fore and middle tibia and femora linear, not foliaceous or expanded. Hind tibia with 2 4 weak spines. Rostrum equalling the abdomen.

Type of the genus *Timonidia solitaria* sp. nov.

Timonidia solitaria sp. nov.

(Plate XII, Figs. 5, 13.)

A small, globose, creamy yellow species. Length, female, 3.5 mm.; male, 3 mm.

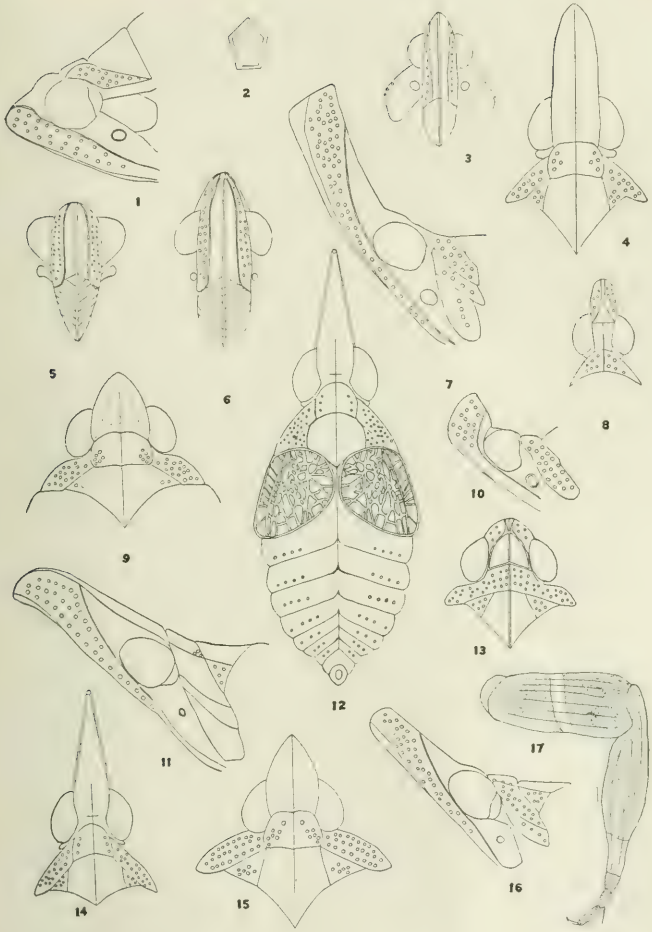
Structure of the genus, vertex short, about equal to the eyes. Roughly equilaterally triangular with the apex extending to the apex of the head where it joins the lateral carinæ of the front. Front broader than the width of the eye. Pale creamy yellow with a tawny tinge, eyes light brown.

Described from three examples from Mojava, California, taken July 30, on *Eriogonum fasciculatum* along with *Acinaca lurida*. This species superficially resembles *Orgerius rhyparus* var. *ventosus* but is quite distinct structurally. It is not well adapted to this plant in color and it is possible that this occurrence was accidental.

EXPLANATION OF PLATE XII.

The Figures of this plate were made with camera lucida by the junior author.

Fig. 1. *Orgerius minor* Ball, lateral view of head.
Fig. 2. *Yucanda albida* Ball, end of cephalic process.
Fig. 3. *Aridia erecta* Ball, front.
Fig. 4. *Deserta obscura* Ball, head, pronotum and scutellum.
Fig. 5. *Timonidia solitaria* sp. nov. front.
Fig. 6. *Orgerius minor* Ball, front.
Fig. 7. *Yucanda albida* Ball, lateral view of head.
Fig. 8. *Acinaca lurida* sp. nov., head, pronotum and scutellum.
Fig. 9. *Orgerius minor* Ball, head, pronotum and scutellum.
Fig. 10. *Acinaca lurida* sp. nov., lateral view of head.
Fig. 11. *Deserta obscura* Ball, lateral view of head.
Fig. 12. *Orgamara acuta* Ball, dorsal view without legs.
Fig. 13. *Timonidia solitaria* sp. nov., head, pronotum and scutellum.
Fig. 14. *Orgamara acuta* Ball, head, pronotum and scutellum.
Fig. 15. *Orgerius rhyparus* var. *rhyparus* Stal., head, pronotum and scutellum.
Fig. 16. *Orgamara acuta* Ball, lateral view of head.
Fig. 17. *Timodema miraculata* Ball, 1st leg.



Ball and Hartzell.

STUDIES OF THE LIFE HISTORY OF NOMOPHILA NOCTUELLA.

W. P. Flint.

This insect, one of the common and widely distributed species of the world, is of considerable economic importance, but for some reason seems to have received but little attention from American entomologists.

In 1919 the insect became so abundant as to seriously damage several newly seeded fields of sweet clover on the Experiment Station farm at the University of Illinois. Nearly every year injury by this insect is reported from some localities in Illinois.

In 1872 A. S. Packard (Ann. Lyc. Nat. Hist., N. Y., X, pp. 258-260) gave a brief account of the insect. E. P. Felt (Can. Ent., V. 25, No. 5, pp. 129-135; 1893) gives a full description of the different stages of the insect, together with observations on its feeding habits and the number of generations occurring in New York. Judging from collections made in trap cages, he estimated that three generations of the insects occurred annually in the vicinity of Ithaca, N. Y.

So far as the writer is able to learn, no detailed observations of this insect have been carried through, even for one season. For this reason an attempt was made to ascertain the facts regarding its life history in central Illinois.

Nearly full grown larvæ were taken from the field June 6, 1919, and confined in breeding cages in an outdoor screened insectary, where conditions were practically the same as in the field. The larvæ were placed in large tower cages with plants of red and sweet clover.

The insect was carried through three generations during the remainder of 1919, adults appearing first on June 19, again July 28, and September 11. Larvæ hatching from eggs laid by the adults appearing on the latest date were from one-fourth to nearly full grown on October 30, when freezing weather prevented any more feeding for the season. Adults were noted in the field the following spring on March 21, during a period of unusually high temperatures. This period of warm

weather, however, was followed by almost a month of abnormally low temperatures, with several snow storms and many nights when the temperature was several degrees below freezing. In cages, the first adults were taken on April 21, and again on June 19, August 3 and October 4. Larvæ from the last named adults went into hibernation the latter part of October, many of them being full grown at this time.

Judging by the observations made during the seasons of 1919 and 1920, four generations of the insect occur each year, being divided as follows:

Hibernating larvæ.
First brood pupæ.
First brood adults.

First generation consisting of—
First brood eggs.
First brood larvæ.
Second brood pupæ.
Second brood adults.

Second generation consisting of—
Second brood eggs.
Second brood larvæ.
Third brood pupæ.
Third brood adults.

Third generation consisting of—
Third brood eggs.
Third brood larvæ.
Fourth brood pupæ.
Fourth brood adults.

Fourth generation consisting of—
Fourth brood eggs.
Fourth brood larvæ.

The average period from adult to adult for each generation was fifty days. Females were observed to lay over 100 eggs. The average egg period was six days; average larval period thirty days; average pupal period ten days.

So far as our observations go, they pass the winter in the larval stage in heavy silken cases just at, or below, the surface of the ground, and protected by the overhanging leaves of plants, bits of which are incorporated in the cases.

Larvæ, as noted by Dr. Felt, feed mainly on legumes. The observations here recorded show that they seem to prefer red clover (*Trifolium pratense*), sweet clover (*Meliotus alba*), and alfalfa (*Medicago sativa*). They have, however, been found in a few cases feeding on blue grass (*Poa pratensis*), purslane (*Portulaca oleracea*), corn (*Zea mays*), wild mustard (*Brassica arvensis*), cinquefoil (*Potentilla canadensis*), white

clover (*Trifolium repens*), foxtail (*Setaria glauca*), and in one instance, soybeans (*Glycine histida*). In this case the beans had been planted on clover sod, plowed up rather late in the spring, and many of the insect inhabitants of the field previously feeding on the clover had turned their attention to the soybeans.

They feed in much the same manner as Crambid larvæ, making a shallow burrow in the ground, loosely lined with silk, and a silken tube extending a short distance from this burrow. The first instar larvæ feed mainly on the under sides of the leaves, especially where such leaves come in contact with the ground. They work as skeletonizers, leaving the coarser parts of the leaves. After the third instar, the larvæ work on both the upper and under sides, and usually consume the entire leaf, unless the veins are large and very woody. Frequently the stalk of small plants, and the stems of the leaves, are cut off close to the ground, and the leaf or plant dragged to the burrow of the insect, being pulled partly within the burrow, and then nearly all consumed. The larvæ also frequently web the leaves lightly together when feeding upon them.

The insect has been observed and reported as injuring red clover, sweet clover, and alfalfa in numerous instances during the past three seasons. In several cases, crops have been seriously damaged.

A small percentage of the larvæ have been found to be parasitized.

Complete control was obtained in fields of young sweet clover by thoroughly spraying the plants with a solution of arsenate of lead, used at the rate of two pounds to fifty gallons of water.

NEW MOSQUITO RECORDS AND NOTES ON THE HABITS OF CERTAIN SPECIES FROM CENTRAL NEW YORK.

Robert Matheson and R. C. Shannon.

Culicella (Culex) **dyari** Coq.

According to Howard, Dyar and Knab (1915) this is a rare species, only single specimens being taken. Barber in 1910 collected at Wilmington, Mass., at arc lights, 107 males and 2 females (Dyar, Ins. Ins. Mens. 7:30, 1919). There is recorded but a single known specimen from New York. Dyar collected a single larva from Tupper Lake from which the adult issued on August 16, 1905.

During the past summer the writers found what appears to be a natural habitat of this species. Within the last two years there has been set aside a wild preserve of about eighty-three (83) acres, consisting of sphagnum bogs, marl ponds, wooded swamps and hills. There is a single deep pool known as Mud Pond and several small streams, while at one side flows a rather large creek. This is located near McLean, distant about eleven miles from Ithaca. This area lies above 1100 ft. contour line and the highest point within the area is 100 ft. Early last spring there was erected near Mud Pond a small open shelter for the purpose of protection during storms and to enable students to remain over night. On the first trip to this area (June 25, 1921) the writers found a large number (35) of what appeared to be a very striking, large, brown species of mosquito. These were all collected on the sides, underneath and within the shelter, both males and females being taken in about equal numbers. After a little study we decided the species belonged neither in *Culex* nor *Aedes*, but probably was a *Culiseta*. However no such species could be found described in *Culiseta*, so that our interest was aroused.

During the summer this species was under constant observation. Large numbers of the adults were seen in this shelter throughout June and July, the last large collection being made on July 18, (31 specimens). On September 4, no specimens

could be found. Although search was made throughout the summer in this area, not a single individual was obtained in any other location. Even sweeping failed to bring any to light although other species were obtained in abundance.

As only perfect specimens were obtained we thought the larvæ ought to be easily located in some of the nearby pools, bogs or streams. All these places were searched in vain, though numerous larvæ of other species were found. Dyar believes this species lays its eggs singly during the summer and they hatch the following spring with the melting of the snows. He states the larvæ mature early and there is but a single annual generation. All his records for collection are for May, except one taken at Tupper Lake, N. Y., on August 16, 1905, and Barber's collection in Massachusetts, in July, 1910. The interesting fact that only perfect specimens were found in our collecting would indicate either late maturing larvæ or a possible second generation. Gravid females were not found in the collection made on June 25, the first being obtained on July 9, and again on the 11th and 18th.

The adults are sluggish, resting quietly and easily captured by placing a small killing tube over them. The most interesting observation is their non-biting habit, at least as far as man is concerned. Several days and nights were spent in the shelter during both sunny and cloudy weather, but never once did this species offer to bite, though it was the predominant form there. Contrary to Barber's experience, they were not attracted to light, only two specimens being collected at the gasoline lantern used during the summer. About 150 specimens were collected, but this does not in any way represent the numbers present in and about the shelter.

Our doubt as to the identity of the species was kindly settled by Dr. H. G. Dyar, who exclaimed on being shown the specimens, "That is my namesake, *Culex dyari*!" He has now placed it in the genus *Culicella*, a genus intermediate between *Culex* and *Aedes*.

At the last moment, while examining larvæ collected on April 28, 1921, at Freeville, N. Y., for student use, we found a single specimen of *C. dyari*. This location is about two miles from what is described above as a natural habitat of this species. Furthermore, a single reared specimen of which we have the

last larval skin, pupal skin and adult, was also found in student material collected in swampy, grassy pools at Ringwood, N. Y., on May 10, 1921. This location is about six miles from the McLean habitat.

Aedes canadensis Theob.

This is one of the most common species of mosquitoes about Ithaca. It is generally believed that there is but a single generation each season, the overwintering eggs hatching at irregular intervals during the summer. Their normal habitat is woodland pools of a temporary character. The following observations would tend to show that there are more than one annual generation.

In our attempts to secure the larvæ of what proved to be *Culicella dyari*, we made two artificial pools on July 1st, in the sphagnum bogs at McLean. These pools were about 18 inches square and the water was from 10 to 15 feet deep. These bogs were dry on the surface when the openings were made. About 10 days later we found in these pools young larvæ which were remarkable on account of their blackish color. On July 18, nearly mature larvæ were found. These proved to be *A. canadensis*, not the unknown mosquito (*Culicella dyari*) as we had hoped. This would appear a new habitat for this species. The dark color of the larvæ was no doubt due to the decaying sphagnum which was eaten for food. The appearance of the species in these freshly made pools would seem to indicate that eggs were undoubtedly laid during mid-summer and hatched the same season.

The genus **Aedes**. Group **stimulans**.

Dyar (1920) has divided the genus *Aedes* into a number of groups, one of which is the *stimulans* group. During the past spring we made observations on three closely related species of *Aedes*—*A. stimulans* Walker, *A. excrucians* Walker (*abfitchii* F. & Y.) and *A. fitchii* F. and Y., all belonging to the *stimulans* group. Furthermore, Dyar considers each one of these to represent typically the three series into which he divides the *stimulans* group and around each are placed the known North American species according to their relationships.

While collecting larvæ on April 19, in the Renwick flats, at the head of Cayuga Lake, a single larva of *A. stimulans*

and two of *A. excrucians* were taken in a deep pool on open ground. The pool had a mud bottom covered with leaves. On April 21, Mr. Sibley brought in from Ringwood a great number of mature larvæ and pupæ. This material consisted of two species, *stimulans* and *excrucians* (*abfitchii*). A large number of isolations were made, but they proved difficult to rear under artificial conditions. However, seventeen adults were secured, the last larval and pupal skin being saved. These were all mounted and 5 proved to be *excrucians* and 12 *stimulans*. Of these we had 4 males of *excrucians* and 6 males of *stimulans*. Not a single *fitchii* larva was found in this collection. Mr. Sibley reported that these larvæ and pupæ were present in immense numbers.

On May 10, the writers visited Ringwood and located the pool described by Mr. Sibley. It was the last of three pools situated in the woods in a line back from the roadway at an elevation of about 1300 feet. The first pool was covered over by a dense mat of duckweed and in this no mosquito larvæ were found. The second pool which is of considerable size and depth, is evidently a pothole and is isolated from the other two. Practically no aquatic vegetation was present and the bottom and margins had a dense covering of decaying leaves and mud. Immense numbers of pupæ and relatively few larvæ were present along the edge and about floating tree trunks in the pool. None were found in the open water where it was deeper than three feet. The presence of such vast numbers was all the more surprising, as Mr. Sibley found none in it on April 21st. A greater surprise awaited us when we learned that this vast number of larvæ and pupæ in pool number two consisted of but a single species—a pure culture of *A. fitchii*.

Pool number three, which is similar but smaller than number two, did not contain at this time a single larva. It was in this pool that Mr. Sibley, eighteen days earlier, found such immense numbers of *A. stimulans* and *A. excrucians*.

These observations are of interest in showing an instance of two species, *A. stimulans* and *A. excrucians*, inhabiting but a single pool, even though a second pool of similar character is only a short distance away. Then a third very closely allied species, *A. fitchii*, occupies the second pool, to the exclusion of the one occupied by the first two species. Another point

of interest is the complete emergence of *A. stimulans* and *excrucians* at least two to three weeks earlier than *A. fitchii*, i. e., the pupal period of the former species was at its height about April 21, while the latter was on May 10.

These three species proved vicious biters and were the most troublesome, where they occurred, during the early spring months and lasting well into July.

Mansonia perturbans Walker.

Mansonia perturbans is a mosquito of wide distribution. However there are only two published records from New York State—Rochester and Ithaca. The recorded material Ithaca was collected by Comstock in 1891. The writers have found only a single specimen in the Cornell collection bearing an Ithaca label, but no date. During the past summer this species has not been taken around Ithaca. On a trip made to North Fairhaven on July 3-5, this species was met with in large numbers. North Fairhaven lies on the shores of Lake Ontario and is surrounded by large swampy areas, providing ideal conditions for the development of this species.

This species maintained its reputation of being a vicious biter. It would bite freely in the woodlands during the day. In the evening they became extremely annoying in and around the house. Their attacks continued after dark, even after all lights were extinguished. One of the writers was compelled to change his sleeping place after 10:30 P. M. to a more protected room. This activity of the mosquito would indicate that this species is not entirely crepuscular in feeding habits as stated by Howard, Dyar and Knab. They also have a mean habit of attacking low down, crawling up inside one's trouser legs. It might be added that these experiences occurred at an isolated farm house about two miles from the village.

Swarming of the males was observed just at dusk, the individuals being barely discernible. The swarm was seen at the edge of a cattail pond, the height being from three to five feet. The swarm contained about thirty individuals, of which eight were captured.

Anopheles quadrimaculatus Say.

This species has always been supposed to be a common one about Ithaca, breeding in large numbers in the marshy areas

at the head of Cayuga Lake. Early in the season we attempted to secure specimens for class use, but all collections made and adults reared proved to be *A. punctipennis* Say. This induced the writers to make a rather intensive survey of a considerable area bordering the city park located at the head of the Lake. A student spent a good part of his time locating pools, making collections and rearing adults. The writers also made extensive collections of larvæ and adult mosquitoes found in this area. What was our surprise to find that in all this material there was not a single individual of this species. The only specimens obtained during the season were collected in two private houses located on the heights about a mile distant from these marshes. In one house two females were obtained on August 15, and in November we collected two more in another private house.

Ithaca used to be considered a malarial city and numerous cases of this disease occurred every summer. In talking with the health officer, Dr. Crum, he informed us that not a single case was reported this past season and scarcely any for a number of years previously. One case came to our knowledge last summer and that person arrived in the city suffering from the disease. This is an interesting coincidence between the apparent disappearance of the chief malarial carrier of this region and the disease.

Anopheles punctipennis Say.

This is undoubtedly the dominant anopheline in the Ithaca region. It has been taken in large numbers wherever the writers collected. It proved one of the troublesome biters all season and the larvæ were collected in all sorts of locations. In the marshes the larvæ occurred in large numbers in a great variety of pools. Roadside puddles of a very temporary character often contained a much larger percentage of this species than any other. In puddles formed by local showers in wagon ruts this species was generally present, showing the great abundance of the species. Many rearings were made and in all cases only adults of this species were secured.

On the hills surrounding Ithaca it was very abundant and we were always sure to find them when collecting. If the human reservoir of malaria continued in Ithaca after the gradual disappearance of *A. quadrimaculatus* it is certain that *A. punctipennis* must be a poor host for the development of the malarial organisms in this region.

Anopheles walkeri Theobald.

This anopheline is widely distributed in Eastern North America, but is rarely taken or seen in collections. There are no records of it having ever been taken in New York State. On July 3, 1921, five specimens, while in the act of feeding, were collected at North Fair Haven. A single specimen was taken on August 5, at Duck Lake, while in the act of biting.

Wyeomyia smithii Coq.

Wyeomyia smithii Coq. is well known to be an obligate inhabitant of the pitcher plant (*Sarracenia purpurea*) and practically all that is necessary to get the mosquito is to find the plant.

Pitcher plants are well known to occur in New York State, but to date there have been no records published of the occurrence of the mosquito in our boundaries.

The sphagnum bogs of McLean, N. Y., contain numbers of pitcher plants and during June and July, when these plants were examined, many of the larvæ of this unique mosquito were found in them. Only plants containing an abundance of fluid, as yet uncontaminated by decaying insects, were inhabited.

The swamp lying close to Duck Lake, N. Y., is an excellent region for pitcher plants, where they flourish in great abundance. The larvæ of *Wyeomyia smithii* occur in great numbers, and during the middle of August, when this region was visited, large numbers of the larvæ could be obtained from the plants. The adults were also observed, flying amongst the low vegetation.

Successful rearings were easily obtained by isolating the larvæ in vials and using the fluid from the plants as the rearing medium.

ECDYSIS IN TMETOCERA OCELLANA SCHIFF.

S. W. Frost,
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An examination of the literature on the Bud-moth, (*Tmetocera ocellana* Schiff.) reveals little concerning the moulting of such a common pest. In fact there has been very little investigation of the moulting of any of the Lepidoptera and especially of the measurement of the moulted head capsules. In response to the need of detailed study on this phase of the life history, the writer has assembled the following notes.

A brief summary of the development of the subject may be of value. Several writers have previously called attention to the moulting habit of the Bud-moth, but there still remains an opportunity for considerable investigation along this line. Mr. H. G. Dyar, of the United States National Museum, several years ago made a valuable contribution in the form of a series of head measurements of the first five instars of the Bud-moth larvæ. His notes were published by Prof. M. V. Slingerland (1893).* Further information has been supplied by Prof. Slingerland in the same bulletin. Mr. G. E. Sanders and A. F. Dustan (1919)† in their work on the Bud-moths of Canada, have added likewise to our knowledge of the ecdysis of *T. ocellana* Schiff. The numerous other papers, chiefly of economic importance, add very little to the study.

METHOD OF STUDY.

This study has been divided into four parts. (1) The moulting process, (2) The number of moults, (3) The measurement of the moulted head capsules, (4) The shape and structure of the head capsules.

The larvæ used in obtaining these records were hatched from eggs laid in confinement and were examined and fed at least once a day. Each larva was placed in a separate four dram vial with a small portion of the leaf as food. As soon as the moults occurred, the head capsules were removed and placed in individual jelletin capsules and properly labelled by means of colored papers according to the number of the moult. All measurements were made at the end of the season.

THE MOULTING PROCESS.

The process of moulting, as in all insects, is a delicate one. The larva at this time is weak and helpless and very susceptible to injury. Nature, however, has provided ample means of protection during this period. The larva never moults in the open, but always conceals itself in some manner. Sometimes it may be a curled leaf with a few silken threads, but more often it forms a well constructed silken moulting case. This case may be entirely closed or partly open at one or both ends. The larva often moults within its feeding case, which serves as a means of protection during the entire life of the larva, but at this time provides special protection. As a rule, moulting occurs in a closed moulting case.

The feeding case is composed of a mass of silken threads tightly woven together into a trumpet shaped tube somewhat resembling the feeding tube of the Apple leaf crumpler (*Mineola indigenella* Zell.) but is smaller and neater. The frass is utilized by the larva and woven into this silken tube, giving it a blackish color and forming a hard protective covering. Immediately following a moult, within the feeding case, the moulted skin and head capsule will be found inside the feeding tube. These are pushed by the larva to the end of the case where they become entangled with the silken threads of the case and are later imbeded in the silk and the frass of the case.

It is possible to determine when a moult is approaching. Several hours or even a day before hand the approaching moult is indicated by a whitish membraneous area between the head and the prothoracic shield and a decided constriction at this point. The moult follows shortly afterwards.

When ready to moult the skin loosens at the thorax and the old integument, including the prothoracic shield, moves off the posterior end of the larva. The larva frees itself by crawling out of the skin. The head capsule comes off separately and in several cases under observation popped off about the same time the larva freed itself from its skin. Only a short time elapses from the first indication of a moult until the skin is shed. In one instance a larva was in the process of the fourth moult at 4:52 P. M., the old head capsule had worked half

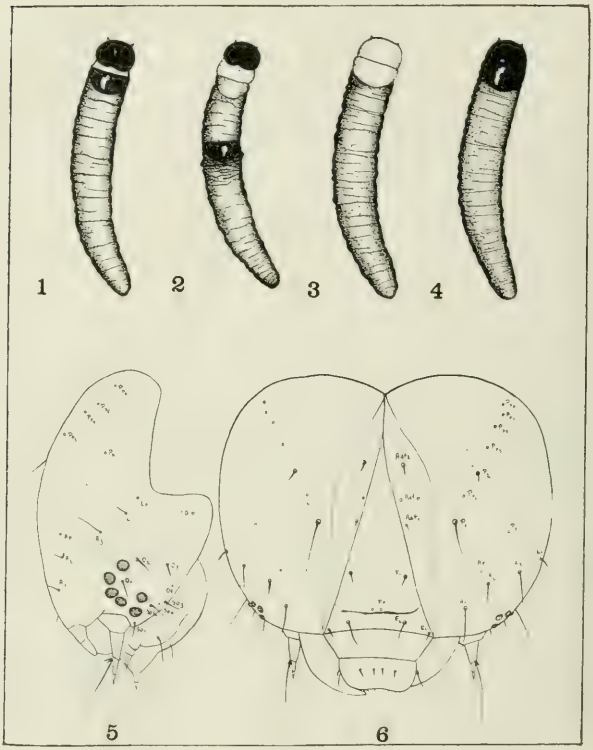

FIG. I.

1, Larva showing first indication of approaching moult. 2, Larva in process of moult. 3, Larva immediately after moult. 4, Larva showing head and thorax fully colored. 5, Lateral aspect of head capsule. 6, Cephalic aspect of head capsule.

Adf_1, Adf_2—Adfrontal setæ.
Adfp—Adfrontal puncture.
F—Frontal seta.
Fp—Frontal puncture.
E_1, E_2—Epistomal setæ.
A_1, A_2, A_3—Anterior setæ.
Ap—Anterior punctures.
L_1—Lateral setæ.
Lp—Lateral puncture.
P_1, P_2, P_3—Posterior setæ.
Pp_1, Pp_2—Posterior punctures.
O_1, O_2, O_3—Ocellar setæ.
Op—Ocellar punctures.
So_1, So_2—Sub ocellar setæ.
Gp—Genæ puncture.
SOp—Sub ocellar puncture.

way off the head and the skin had worked part way off the body so that the prothoracic shield rested over the second abdominal segment. At 4:55 P. M. of the same day the head capsule was cast and at 4:59 P. M. the larva succeeded in freeing itself from its skin.

NUMBER OF MOULTS.

The number of moults apparently varies in different parts of the country. Mr. G. E. Sanders (1919)* found in Canada that there are only seven moults. The majority of the larvæ entered their winter quarters in the third instar, while a few moulted a third time and entered hibernation as fourth instar larvæ. In Pennsylvania the writer has obtained ten larval moults. The majority of the larvæ enter hibernation in the ninth instar, the other two moults occurring the following spring. A small percentage hibernate in the eighth instar. Considerable variation may be expected where the number of instars are as high as in the Bud-moth.

MEASUREMENT OF HEAD CAPSULES.

In moulting, the head capsule and thoracic shield, because of their chitinous nature, retain their original shape and thus lend valuable characters for a study of this kind. Advantage was taken of this fact and the head capsules of a number of each instar were preserved and measured.

TABLE OF MEASUREMENTS OF HEAD CAPSULES OF *T. ocellana* Schiff.

Instar	Number of head capsules measured	Average Length	Average Width	Dyar's* Measurements
1st	30	.142 mm.	.216 mm.	.225 mm.
2nd	34	.188 mm.	.275 mm.	.288 mm.
3rd	21	.258 mm.	.363 mm.	.363 mm.
4th	16	.299 mm.	.436 mm.	.43 mm.
5th	27	.356 mm.	.513 mm.	.56 mm.
6th	28	.404 mm.	.572 mm.	.....
7th	22	.457 mm.	.645 mm.	.....
8th	15	.510 mm.	.733 mm.	.....
9th	23	.517 mm.	.760 mm.	.....
10th	16	.629 mm.	.975 mm.	1.05 mm.

* Cornell Bull. 50, 1893.

SHAPE OF THE HEAD CAPSULES.

There are certain differences in the shape of the head capsules that help to distinguish some of the instars. The head capsule of the first instar is distinctly flattened while the capsules of the remaining instars are rounded and easily separated. A comparison of the heads further show that those of the first seven instars are proportionally longer than broad, while the eighth, ninth and tenth larval heads are proportionally broader than long. These differences in shape, as well as the differences in size, aid in determining the different instars.

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HATCHING IN THREE SPECIES OF NEUROPTERA.*

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This paper deals with the process of hatching in three species of Neuroptera, viz., *Chauliodes pectinicornis* Linn, *Micromus posticus* Walker, and *Chrysopa oculata* Say. The observations were made with special reference to the egg bursters. This account is therefore a brief description of the appearance of the eggs at hatching, the process of hatching and a description of the special structure enabling the embryo to leave the shell. This structure in the three species mentioned is of the same general type, but there are important differences. The general process of hatching in each case, as well as the appearance of the eggs at hatching, are very similar.

1. Chauliodes pectinicornis Linn.

The function of the egg burster in this species was observed in 1912 by H. S. Barber, who did not publish upon the subject. He very kindly sent the writer his sketches and photographs and supplied the fresh material upon which these observations were made. This material consisted of a large number of eggs deposited June 16, 1919, in confinement by a gravid female caught at lights at Plummer's Island, Maryland. When received, June 20th, they showed advanced embryological development and hatched under the writer's observation June 24th.

The eggs all lay on what was the dorsum of the embryo (Fig. 4), the ventral side up, and with the prominent knobbed micropyles all pointing the same direction. When these eggs were ready to hatch, the two black eye spots could be very plainly seen each side the mid-ventral line and near the micropylar region. A little posterior to these were the very prominent bifid amber-colored mandibles. Furthermore, in the mid-ventral line between the eyes and above the mandibles was seen a thin chitinous carina resembling a small knife blade. This

* Contribution No. 78 from the Entomological Laboratory, Kansas State Agricultural College.

was found to be the egg burster. It could be seen that it was bilobed, but the upper lobe showed the more distinctly. In this case the eggs hatched when these characters showed most plainly. The warmth of an electric light bulb after a cool night started the whole mass hatching.

The first evidence of the beginning of hatching observed with a binocular was a very slight raising and lowering of the mandibles, effected, it is believed, by the embryo working itself upward then receding slightly. The upward movement was somewhat quicker than the downward one. The head was gradually advanced, thereby bringing the burster next to the chorion. This movement continued from one to four minutes

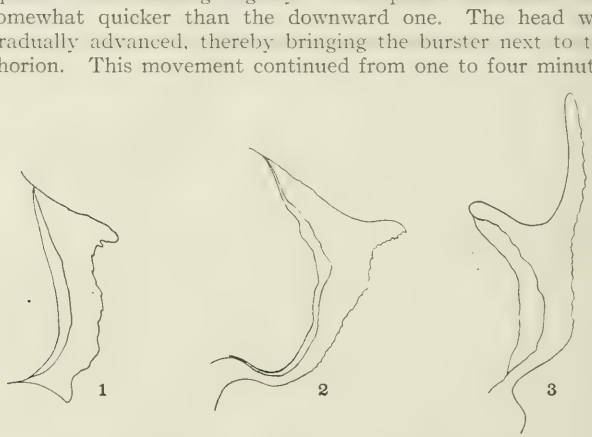

Fig. 1. The egg burster of *Chauliodes pectinicornis* Linn. × 215.
Fig. 2. The egg burster of *Chrysopa oculata* Say. × 300.
Fig. 3. The egg burster of *Micromus posticus* Walker. × 300.

in different eggs observed. Finally the upper lobe punctured the chorion and a slit was cut for the entire length of the burster. The embryo forced the soft clypeal region through the opening, which caused the rent to broaden, then tear, almost entirely at the upper end. The clypeus was translucent to grayish in color, so contrasted sharply with the chorion. The embryo forced its head through the rent, followed by the thorax, but the chief advance was made by the dorsum. When the embryo had emerged to about half its length, it stopped and prepared to cast the embryonic molt.

One could very clearly discern a little stream of silvery bubbles of air entering the pharynx and collecting in the intestine, thereby causing an observable inflation. As a result of this inflation in the thoracic region, together with the shifting forward of the embryo, the thin membrane parted over the prothorax in the mid-dorsal line. This rent rapidly lengthened to the metathorax. The larva then pushed its thorax through the rent, bending its head ventrad. The thin membrane slipped off the mouthparts very slowly. In a minute or so the head was pulled free and the larva rested supported by the end of the abdomen until the chitin hardened. After about thirty minutes the larva pulled its abdomen from the molt and walked away. This molt lay in a crumpled heap in the lower end of the rent. The entire process of hatching from the first visible movements to walking away required about forty-five minutes.

The egg burster (Fig. 1) is a thickening and specialization of the embryonic cuticula* over the anterior part of the head in the median line. The burster proper is an inverted V-shaped ridge, with upper and lower lobes between which the carina bends outward and is beset with about ten minute teeth or irregularities. At the sides, the heavy chitinized parts are continuous with the molt, but the line of demarcation can generally be distinguished.

2. **Micromus posticus** Walker.

Hatching in the Hemerobiidæ has been observed by the writer in four species, viz., *Hemerobius humuli*, *H. stigmaterus*, *Sympherobius amiculus* and *Micromus posticus*. It occurred in the same way in all these species, the few differences recorded are probably individual. As a type for the family, hatching in *Micromus posticus* will be described. This species is one of the most abundant in the eastern part of the United States, and one of the larger ones in size.

The chorion was observed to be entirely smooth, unsculptured, shining and irridescent. As embryological development proceeded, the outlines of the embryo could be readily seen, since the chorion was very transparent. When the eggs were ready to hatch, the three pairs of thoracic gray color patches

* Smith, Roger C. The Process of Hatching in Corydalis cornuta Linn. Annals Ent. Soc. Amer., Vol. XIII, pp. 70-74, 1920.

could be distinctly seen. The posterior three-fourths of the egg was pinkish, even reddish. In the mid-ventral line, just below a line connecting the eyes, could be seen the egg burster. The eggs lie on the dorsum with the venter uppermost. Just before hatching the egg burster and the general coloration of the embryo appeared quite distinct.

The first visible evidence of the beginning of hatching was certain peristaltic movements of the abdomen. The embryo appeared to push itself upward by means of the abdomen. The end of the abdomen was first pulled by these so-called peristaltic movements towards the posterior pole of the egg and as a result of crowding there, pressure was exerted at the anterior pole. This upward pushing, it has been observed, may continue at intervals for ten to thirty minutes. As a result of this pushing, the egg burster was closely applied to the chorion. As the pressure continued, the upper end of the toothed burster was pushed through the chorion. It is difficult to ascertain sometimes the exact time the burster pierces the chorion, for, under pressure the burster often appears through when it is not yet through, due to the transparency of the chorion. After the upper end of the burster was through the chorion, the upward and outward thrusts of the embryo became more pronounced. At each upward thrust, more of the chorion was cut, the cutting proceeding away from the micropyle. By this time the clypeal region of the head of the embryo could be seen in the rent. It was dull and whitish in contrast to the shining glassy chorion. The burster cut to its full length, and in the meanwhile the embryo pushed its head through the upper part of the rent. This is followed by the thorax and a part of the abdomen. At the time that the thorax was well out, the thin embryonic cuticula split over the prothorax, due in part to its being attached to the chorion in the mid-ventral line. The exact time could be ascertained by observing the straightening up of the dorsal setæ. The thorax and a part of the abdomen were pushed through the molt, but the mouthparts and head appendages were retarded so the larva formed an inverted U over the egg. The mouthparts were pulled from this thin membranous cuticula slowly and carefully. The molt with the attached egg burster slipped down between the labial palpi and the antennæ. The burster and the thin shrivelled molt

lodged finally in the lower end of the rent of the chorion. The larva rested until its legs would bear its weight, and then pulled its abdomen from the egg shell and molt. The burster, which is a part of the molt, could be seen with the unaided eye. The entire process from the first piercing of the chorion to walking away requires from 15 to 20 minutes.

The egg burster is again a specialization of the embryonic molt, but differing considerably from those of other families seen. It is a toothed keel, but the upper half is free and extends over the clypeal region of the head. There are no prominent lobes, but the apex of the ridge bears from 15 to 20 small saw-like teeth. There is a rather marked diamond-shaped cap which fits over the buccal region. This cap is thought to be the line of demarcation between the heavier and lighter chitinization of the molt. This burster apparently resembles that of Osmylus as figured by Hagen (1852).

3. **Chrysopa oculata** Say.

Hatching in this species, and in all closely related species of Chrysopidæ so far seen, takes place in a manner almost identical with that described for *M. posticus*. The chief accounts seen in literature concerning hatching in this family are the writings of Hagen (1859, 80) in which reference is made to a cephalic saw by means of which the first opening is effected. Hatching has been incorrectly described by several writers as effected by the mandibles of the embryo piercing the chorion, or the upper end of the egg being cut off. The position of the embryo in the egg would render the first explanation, a priori, impossible and in the case of the second there is no cap on the egg to be lifted.

Eggs ready to hatch show rather clearly the outline and parts of the embryo, as the chorion is transparent to a considerable degree. The two very prominent eyes or ocellar fields stand out clearly and can be seen with the unaided eye. On the ventral side in the mid-dorsal line between the eyes can be seen a short, dark line. This line is the cephalic saw of Hagen, or the egg burster. Just before hatching, it appears quite dark or black, perhaps due to an increase in chitinization. Hatching can be readily observed without a long wait by taking some eggs from a cluster for observation in which most have already hatched.

A brief account of a typical instance of hatching follows: The embryo began a series of movements calculated to pull the tip of the abdomen towards the posterior pole of the egg. This region became crowded and the embryo pushed upwards and outwards slowly. The upward movement was rather quick and with some effort, while the downward one appeared to be a slipping back to its previous position. Along with these movements, there was some outward pressure brought to bear

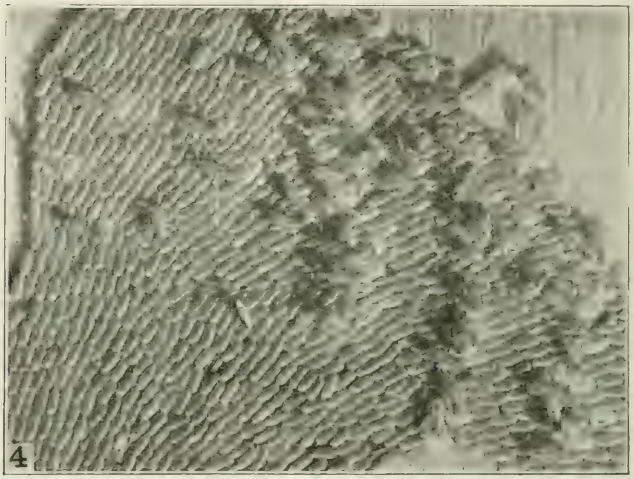

Fig. 4. An egg mass of *Chauliodes pectinicornis* hatching. (Photo by H. S. Barber, 1912).

on the head region which culminated in the penetration of the chorion by the upper lobe of the burster. It was later observed that it is frequently difficult to ascertain if it has cut through the chorion or whether it is merely closely appressed. In this case, two whitish triangular areas appeared on each side of the burster, their bases next to it. The writer interpreted these as air bubbles beneath the chorion, the edges of which had been raised up in the cutting process. As the embryo continued the upward pressure, the burster was pushed through

for its entire length, cutting the chorion before it. The rent was then torn at both ends, chiefly the upper, by the outward pressure of the head of the embryo. The dorsum of the head is pushed through the opening, perhaps aided some by blood pressure, and as a consequence, the slit in the chorion tore anteriorly to the micropyle. The abdomen was the pushing agency. It moved upward by a series of contractions and expansions, pushing the thorax before it. The mouthparts and legs appeared to be held by the embryonic molt so that they lagged behind in emergence. The chorion slipped back over the eyes as the thorax was pushed up and the burster with the molt remained at the lower part of the incision with the cast skin. The embryonic molt was attached to the inside of the chorion in the mid-ventral line just below the rent. Sufficient strain was exerted on this molt by the emergence of the embryo to cause it to tear over the thorax in the mid-dorsal line. The upward pushing continued and the thorax became arched over the egg. As the thorax and abdomen appeared, the setæ thus freed sprang into their normal position. When the abdomen was well out of the egg, the larva began to straighten up. This withdrew the mouthparts and the legs from the molt. They were drawn out slowly and finally the claws were freed after some difficulty.

As soon as the mouthparts and legs were freed, the larva raised itself erect and even bent backwards. By these movements it separated the appendages from each other, for they appeared to adhere slightly. During this performance and until the chitin was hard, the larva supported itself wholly by the end of the abdomen. Finally, after some ten minutes, the larva brought itself forward and rested on its legs. It then rested for a few minutes longer, after which it sought the stalk of the egg by which it descended to the substratum.

Later observations show that it is not always the upper lobe which first pierces the chorion. Sometimes it appears that the whole burster is slowly pushed through the chorion at about the same time. Larvæ rest for a varying length of time on the egg shell. Generally is it about fifteen or twenty minutes, but this period may be much prolonged. One often sees a batch of eggs with a larva resting on each. The empty shells are pure white, and all have a prominent

rent at the upper end to one side of the micropyle. The embryonic molt generally protrudes slightly from the lower end of the rent.

The burster is a saw-toothed carina, .118 mm. long, and .029 mm. wide at the lobe. In cross section the burster is V-shaped, due to the broadening at the base. There are 20 to 30 minute teeth along the cutting edge of the burster. The lobe generally has a sharp tooth at its tip, but not always. The bursters of other species of Chrysopa as far as seen are practically identical with that of this species, and hatching shows no essential variations.

The writer has observed hatching a great many times in each of these families, but especially among the Chrysopidæ and Hemerobiidæ. At no time has the egg bursters been observed to fail in their critical period of usefulness. Embryos sometimes die before hatching, but no case has yet been seen where it was thought that death had occurred because the egg burster had failed to cut the chorion. They are highly efficient structures.

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AN EXTREME CASE OF DELAYED FALL EMERGENCE OF HESSIAN FLY.*

(Phytophaga destructor Say).

By Walter H. Larrimer, Scientific Assistant,
U. S. Bureau of Entomology, West Lafayette, Indiana.

During June, July, and August, 1920, over the northern portion of the east central states, with the exception of a small isolated area in north central Illinois, the mean temperature was from three to six degrees below normal and during September and October for this area the mean temperature was from six to ten degrees above normal. Rainfall was more or less general in occurrence over this area, but the amount varied remarkably in different sections as well as in immediate localities. It is to be expected, therefore, that such irregularities in two of the most important of the controlling factors of Hessian fly emergence would correspondingly influence the emergence and activity of the fall brood of 1920.

The emergence as observed at Lafayette, Indiana, may be indicated by a graphic record of egg counts made daily from September 23 to October 25. Fifty wheat plants of the two leaf stage were marked and each morning the eggs were counted and removed. When the plants grew to a size that was no longer as attractive to the female flies for oviposition as the smaller plants, the markers were transferred to a fresh lot of the desired size from a later planting, care being taken to make sure that these new plants were clear of eggs. In Fig. 1 the graph shows the daily egg record for the period indicated.

Very few wheat plants were available for oviposition at the time of the first peak of emergence and the resulting oviposition was of course concentrated on these few plants, while an almost unlimited supply of wheat was available at the time of the second peak on October 17. Therefore the true relation as to the magnitude of the two waves of emergence is not truly represented by the graph. However, the purpose is not so much to show the proper relative proportion of the waves as to mark the time of each.

* Published by permission of the Secretary of Agriculture.

From a similar set of records made at Centralia, Illinois, by Mr. W. B. Cartwright, of the U. S. Bureau of Entomology, the crest of emergence of the "late wave" at that place was determined to be on October 12, or five days earlier than at Lafayette. From these two records of continuous observations, verified more or less by a number of fragmentary data, it was determined that the emergence of the "late wave" occurred in the reverse order to the normal, that is, it occurred

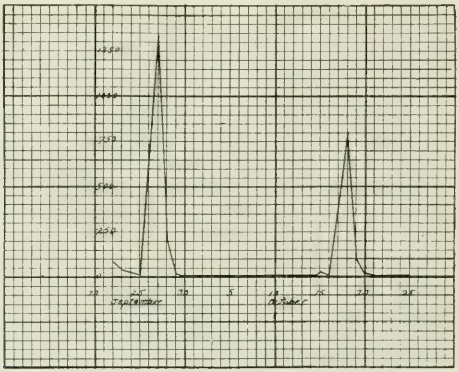

Fig. 1. Graph showing Hessian fly egg counts made at Lafayette, Indiana, September and October, 1920.

earlier instead of later to the southward. The following map (Fig. 2) indicates approximately the dates of emergence of the "late wave" wherever it occurred in the section indicated. From the latitude of Cincinnati southward these dates come within the recommended safe sowing dates and for that area the emergence can be considered normal.

A study of pupation records for the beginning of the period will also be quite interesting. These records were made by frequent examination and dissection of flaxseeds in lots of one hundred each, only those containing either larvæ or pupæ of Hessian fly being included. In the graph of pupation (Fig. 3) the number of pupæ is indicated by the figures on the left and the number of larvæ by the figures on the right.

It may be noticed that the crest of the pupation curve on October 11, did not reach one hundred, indicating that approximately forty per cent of the larvæ did not pupate during the time covered by the graph and subsequent examinations proved that they passed the winter in the old summer stubble.

During the spring of 1921, from pupation records made as previously explained, it was determined that pupation of these "hang-over" larvæ began March 17 and was practically

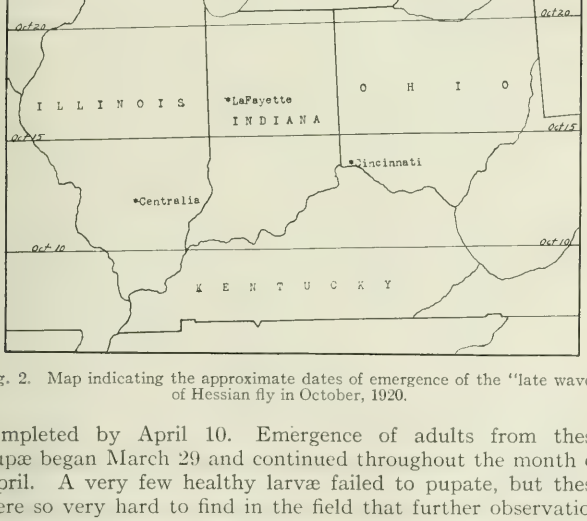

Fig. 2. Map indicating the approximate dates of emergence of the "late wave" of Hessian fly in October, 1920.

completed by April 10. Emergence of adults from these pupæ began March 29 and continued throughout the month of April. A very few healthy larvæ failed to pupate, but these were so very hard to find in the field that further observation on them was not practicable.

Puparіation is a term that it has been found convenient to apply to that activity by which the larvæ of Hessian fly change to the flaxseed stage, as distinguished from actual pupation. Puparіation records were made on the larvæ, offspring of the late wave, in order to determine the condition in which they entered and passed the winter. At frequent intervals 100

specimens of fly were examined as found and the percentage of these larvæ and puparia noted. In one field, pupariation of these larvæ began on November 22, was half completed by December 9, and completed January 4. In another field, pupariation began December 2, was half completed by January 4 and completed February 28. Pupation of these larvæ in both fields began March 18 and was practically completed by April 10. A very small number of larvæ remained to produce stragglers or to hang over until fall. Adults began emerging March 29 and continued throughout April.

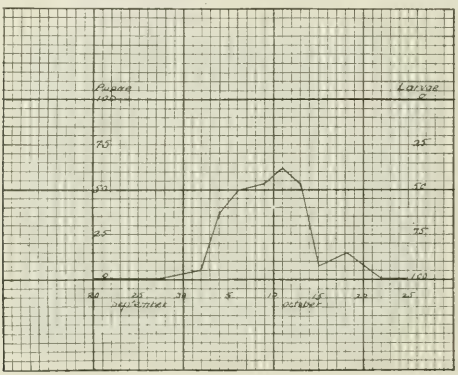

Fig. 3. Graph showing the pupation of Hessian fly of the "late wave" 1920.

By a study of puparia, offspring of the normal emergence the preceding fall, it was determined that pupation and emergence occurred on approximately the same dates as in the case of "hang-over" and "late wave." Thus the pupation of larvæ and the emergence of adults of all Hessian fly in the spring of 1921 took place at about the same time, regardless of their origin.

POLLINATION OF RED CLOVER BY TETRALONIA AND MELISSODES.

JUSTUS W. FOLSOM.

The fact that bumblebees are important as pollenizers of red clover has been established by means of numerous experiments dating from the time of Darwin. Their importance in this respect depends, however, upon their numbers at the time when the clover is in bloom. Thus, in second-year clover, in Illinois, bumblebees are highly important as pollenizers of the second crop, for they are abundant in late July, in August and September. They are unimportant as pollenizers of the first crop, however, for in June the only winged bumblebees in existence are the comparatively few queens that have survived the winter, and these spend a large part of their time in the nest, rather than in the field. The June crop is certainly not pollenized to any considerable extent by bumblebees. In fact, it seldom yields much seed as compared with the second crop in the same locality.

Twenty years ago it was taken for granted that there was not enough seed in the June crop to pay for its extraction, but since then more and more farmers have found it profitable, now and then, to cut the June clover for seed instead of hay, and have obtained from one-half a bushel to two bushels of seed (possibly more) per acre in Illinois.

How is the June crop pollenized? From correspondence and from inquiries at Farmers' Institutes I learned that in a few instances the yield of seed had occurred in a region where Italian honey bees were common and had been seen working on the flowers. Now honey bees of this race are undoubtedly important pollenizers of red clover, as Dr. A. D. Hopkins found, and as I have since ascertained. There were, however, some instances in which seed had been obtained from the June crop in places where there were no Italian honey bees; so there still remained some mystery in regard to the means of pollination of the clover field in June.

Mr. W. P. Flint has had *Tetralonia dilecta* Cress. under observation for several years, and has repeatedly found good yields of seed from fields in which this bee had been abundant.

This *prima facie* evidence, brought to my attention by Mr. Flint, led me to make the following observations and experiments with the object of proving whether certain species of *Tetralonia* and *Melissodes* pollenize red clover or not. In this study I had the assistance of Mr. F. Q. Otanes, a graduate student, who was investigating the general subject of insects in relation to the production of clover seed. The species used in our work were kindly determined by Mr. Henry L. Viereck.

1. *Tetralonia dilecta* Cress. = (*T. speciosa* Rob., not Cress.). May 19, 1921, *Tetralonia dilecta* was present, though not abundant, in fields of red clover on the University farm, Urbana, Illinois, and was working busily on the blossoms. The proboscis, thrust into the flower, was visible through the corolla, and evidently extended to the bottom of the corolla tube. Specimens collected from clover heads, taken to the laboratory and examined under a microscope, showed many pollen grains, especially on the mentum and the branched hairs of the mentum, but also on the maxillæ; in fact, pollen grains occurred almost anywhere on the ventral aspect of the mouth parts. These pollen grains were indistinguishable from those of red clover.

May 24, when the bees were abundant, a root cage with parallel glass sides and a cover of wire screen was taken to the clover field; in it was placed a solid row of clover heads in full bloom, and into the cage were introduced specimens of *Tetralonia dilecta*. Some of the bees set to work on the blossoms, and their operations were studied under a hand lens.

It was essential, of course, to determine if seed would be produced by plants upon which *Tetralonia* had worked, and from which all other insects had been excluded. To this end, red clover plants were taken which bore heads with unopened buds; opened heads having been removed from the plants. These plants were transplanted to a large flower pot covered with a cage of wire screen with a mesh of one millimeter, and placed out of doors. In a day or two some of the heads were in bloom and bees were introduced into the cage. May 26, I put thirty individuals of *T. dilecta* into the cage; a few of them were seen to work on the blossoms during the same day; after twenty-four hours, however, all the bees had died. May 31, Mr. Otanes put several more bees into the cage, and some of these also were observed to work on the flowers. The florets

were then allowed to dry, and were examined for seed July 1, by Mr. Otanes and myself. From 789 florets (not counting undeveloped florets that could not have been pollenized) we found 171 seeds. In other words, 21 per cent. of the flowers had been pollenized by *Tetralonia dilecta.*

As a check experiment, red clover plants with heads in bud, but not as yet in bloom, were planted in two flower pots, covered with wire cages and placed out of doors, just as in the preceding experiment, but no bees were put into the cages. After three weeks, when the heads were examined for seed, the first cage contained 357 florets and no seeds; the second, 287 florets and no seeds.

Tetralonia dilecta, abundant until the middle of June, became rare by June 30, but a second species of bee soon appeared on the scene and engaged our interest.

2. *Melissodes bimaculata* LeP. This black species appeared July 5, was common July 7 and 12, but was falling off in numbers July 21. *M. bimaculata,* swifter of flight and more alert than *T. dilecta,* worked actively on clover blossoms in the field. Specimens taken from clover heads showed much pollen, undoubtedly that of red clover, on the mentum, some pollen on hairs adjacent to the mentum, and considerable pollen among the hairs under the eyes.

As before, red clover plants with unopened heads were potted July 12, and covered with a wire cage. July 14, several heads being partly in bloom, I placed seven individuals of *M. bimaculata* in the cage at 2:30 P. M., and one of these was working on the heads ten minutes later. July 15, six of the bees had died. July 16, Mr. Otanes put in eleven more bees; and July 19, five more, some of which were seen to work on the flowers. In all, twenty-three bees had been introduced.

As several bees had apparently been pollenizing florets, we expected to get some seed, at least; but when the dried heads were examined by Mr. Otanes, August 4, the 216 florets that were present yielded only two seeds. Thus the results of this experiment were negative. In a second experiment, however, the results were different.

In this experiment, plants with unopened heads were potted and covered with a cage July 21. July 23, fifteen specimens of *M. bimaculata* were put into the cage; and July 25, sixteen more. Many of these bees were seen working on the flowers.

August 12, the heads were examined for seed, and the 11 heads present, with 293 florets, yielded 90 seeds, or 30 per cent.

These observations and experiments are simple but conclusive. They prove that *Tetralonia dilecta* pollenizes red clover to an important extent in the latter part of May and in June (in central Illinois), and that *Melissodes bimaculata* also is an efficient pollenizer of plants that bloom during July.

The present summary is simply for the purpose of placing these facts on record; a detailed account of further studies being left for a future article.

ARE THERE TWO SPECIES OF THE OYSTER-SHELL SCALE?*

Grace H. Griswold.

The Oyster-shell Scale (*Lepidosaphes ulmi*, L.) has been a subject of study on the part of the writer since the spring of 1919. During the summer of that year, observations were made on the biological development of this insect on lilac. In the fall, while making egg counts from various host plants, it was noticed that the scales formed on apple trees seemed to differ in appearance from those on lilac and some of the other ornamental shrubs and trees. It was therefore determined to make a comparative study of the biological development of the insect on apple and lilac the following summer.

Studies of this insect have resulted in the finding of three distinct differences between what may be called the apple and lilac forms:

1. Differences in the appearance of the scales.
2. Differences in biological development.
3. Differences in morphological characters.

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* Contribution from the Entomological Laboratory, Cornell University, Ithaca, N. Y.

DIFFERENCES IN THE SCALES.

The new scales formed on apple are of a uniform brown, while the new ones on lilac are traversed by distinct stripes or bands. These bands, three or four in number, are light brown in color and vary in width from those that are quite wide to those that are mere strips. The old scales on apple are of a very dark uniform brown, sometimes of a slight grayish tint. The old scales found on lilac, on the other hand, are of a very pale gray, sometimes almost white, and the bands can be distinctly seen. These differences are uniform and constant in all specimens.

DIFFERENCES IN THE BIOLOGICAL DEVELOPMENT.

During 1919, 1920, and 1921, careful observations were made on the biological development of the insects on lilac. In 1920 and 1921 the biological development of the insects on apple was also studied. The differences in the development of the apple and lilac forms are most clearly shown by means of a table.

	1919	1920		1921	
	Lilac	*Apple*	*Lilac*	*Apple*	*Lilac*
Eggs hatched	June 7	May 31	June 14	May 6	May 27
First molt	June 21	June 16	July 2	June 1	June 20
Second molt	July 17	July 8	July 29	June 24	July 7
Egg laying began	Aug. 19	Aug. 5	Aug. 31	July 22	Aug. 5

It will be seen from the table that the apple form develops from two to four weeks ahead of the lilac form. The cold summer of 1920 seems to have retarded the development of the insects on lilac more than of those on apple, for the lilac insects were nearly four weeks behind those on apple in beginning to lay their eggs. In 1921, however, there was a difference of about two weeks in the development throughout the entire season.

DEVELOPMENT ON DIFFERENT HOST PLANTS.

In connection with the study of the biological development, some transfer experiments were carried on in an effort to learn if the apple and lilac forms are interchangeable as far as host

plants are concerned. Small pieces of twigs, badly infested with scale, were tied to clean, uninfested branches of various trees, each branch being then covered with a bag of fine cheese cloth. In every case the eggs hatched and the young larvæ crawled to the new host plants in large numbers. The results of these experiments were as follows:

Transfers From Apple to Other Plants.

Plants to which transfers were made	Result
Lilac, Poplar.	Very successful. Many completed their development and laid eggs.
Willow, Choke cherry, American ash.	Fairly successful and about in the order named. Some completed their development and laid a few eggs.
Red maple.	Many became adult and started the third or permanent scale.
American elm, Box elder.	On the elm, 2–3 became adult, then died. On box elder only one became adult. In both cases many were found to have died in the second instar.
Pussy willow.	None were found in the adult stage. A few started the second scale and then died.

Transfers From Other Plants to Apple.

Plants from which transfers were made.	Result
European ash, Lilac (2 places), Willow, Lombardy poplar.	All the larvæ died in the first instar.

Transfers From Other Plants to Pear.

Plants from which transfers were made.	Result
Lilac.	Many larvæ were found on the twigs, having died in the first instar. A few had started the first scale.
Large toothed aspen.	Many larvæ formed the first scale, others died without any effort at making one.

It will be noticed that while transfers were successful from apple to other trees, in no case could insects of the lilac form be made to live for any length of time on apple or pear. Although the young larvæ crawled on the apple and pear twigs, in every instance they died while still in the first instar. The scales made by the apple form on the new host plants were always of the uniform brown so constant on the apple.

DIFFERENCES IN MORPHOLOGICAL CHARACTERS.

No differences have as yet been found in the pygidial fringe of the apple and lilac forms. Several writers, however, have called attention to the variation in the number of circumgenital pores of the Oyster-shell Scale from different host plants. For example, Cockerell (1895) mentions finding specimens on dogwood in California that had fewer pores than are usually noted on apple. Frank and Kruger (1900) give sample counts of these pores from apple, plum, thorn, poplar, and willow. Glenn (1920) also counted the pores from various host plants. These observations suggested the desirability of making extensive counts of these pores from insects on apple and lilac. Knowing that a study of the pores would be of little value unless made from a long series of specimens, approximately 550 insects were mounted and their pores counted, 277 from apple and 272 from lilac. Instead of putting the data in tabular form, giving maximum, minimum, and average counts, variability curves were plotted such as are commonly used by workers in genetics to show fluctuating variations. The information desired was not the average number of pores in a group, but the number of pores found to occur most commonly.

The accompanying diagrams show these curves. The abscissæ indicate the number of pores found in the various groups examined, while the ordinates indicate the proportion of groups in which the varying numbers of pores occurred. To make the curve for the posterior lateral groups of the apple form, pores were counted in 496 groups. These pores were found to vary in number from 6–24 in a group. Only one group (0.20% of the total number of groups examined) had as few as 6 pores and only one group had as many as 24 pores. On the other hand, 72 groups (14.51%) had 11 pores, 100 groups (20.16%) had 12 pores, and 80 groups (16.12%) had

13 pores. In the posterior lateral groups of the apple form the number of pores found to occur most commonly, then, is 12. Therefore, speaking technically, 12 is the "mode" of the apple form. The curve for the posterior lateral groups of the lilac form is based on counts of the pores of 485 groups. Of these groups, 64 (13.19% of the total number of groups examined) had 19 pores. The mode of the lilac form, then, is 19. Not a single group of the 485 examined from lilac had 12 pores, while only six (1.20%) of the apple specimens had 19 pores.

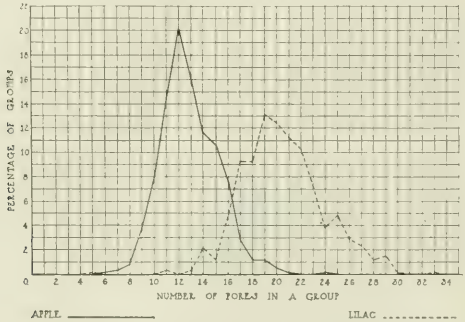

FIG. 1.

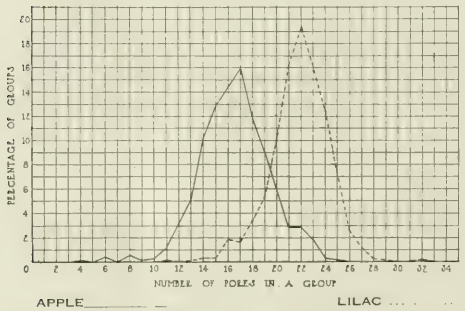

FIG. 2.

Fig. 1. Curves showing variation in the number of circumgenital pores of the posterior lateral groups of the apple and lilac forms. The curves are based on counts of the pores of 496 groups of the apple form and 485 groups of the lilac form.

Fig. 2. Curves showing variation in the number of circumgenital pores of the anterior lateral groups. The curves are based on counts of the pores of 490 groups of the apple form and 485 groups of the lilac form.

Practically the same thing holds true of the anterior laterals. Here the mode of the apple form is 17, while that of the lilac is 22. In the case of the median group the difference is less marked, yet each form has its mode, that of the apple being 11, while that of the lilac is 13. The greatest contrast is seen in

FIG. 3.

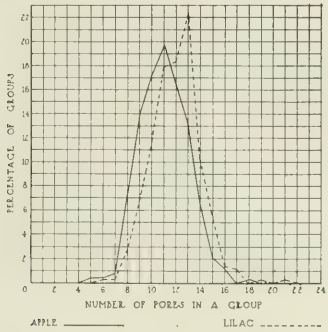

FIG. 4.

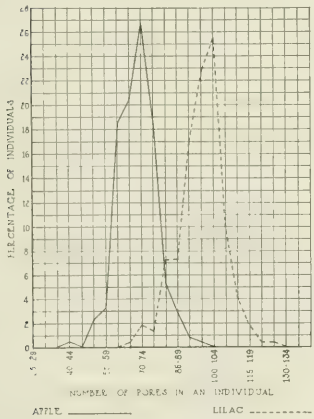

Fig. 3. Curves showing variation in the number of circumgenital pores of the median group. The curves are based on counts of the pores of 243 groups of the apple form and 251 groups of the lilac form.

Fig. 4. Curves showing variation in the total number of circumgenital pores of all five groups. The curves are based on counts of the pores of 210 individuals of the apple form and 220 individuals of the lilac form.

the diagram representing curves for the total number of pores of all five groups. In order to plot these curves at all it was necessary to place the insects in classes with respect to the number of pores, for example, those having 65–69 pores, 70–74, 75–79, etc. The curve for the apple form shows that the total number of pores for an individual is most commonly 70–74. In other words, the mode of the apple form is 70–74, while that for the lilac form is 100–104. Only five insects of the 220 examined from lilac had as few as 74 pores, while not a single apple insect was found to have 100 pores, and only three had as many as 90.

A study has been begun of the pygidium of the second instar. This pygidium resembles, in many ways, that of the adult insect, though of course, it lacks entirely the circumgenital pores. The dorsal and marginal gland openings can be distinctly seen, there being eight marginal gland openings (four on each side) in both the apple and lilac forms. Sufficient material was not available for a careful study of the dorsal gland openings, but all the specimens examined showed more of these openings present in the lilac than in the apple form. In the lilac form they varied from 14–18, while in the apple they ranged from 8–12. It is planned to secure during the coming summer, material for a more careful study of the gland openings of the pygidium of the second instar.

HOST PLANTS OF THE TWO FORMS.

Examination of the scales and counts of the circumgenital pores show that insects found on the following host plants belong to the apple form:

Red dogwood (Cornus alba).
Alternate leaved dogwood (Cornus alternifolia).
Round leaved dogwood (Cornus rugosa).
Mountain maple (Acer spicatum).

The biological development of the insects on red dogwood, which has been studied, paralleled that of the apple form.

The lilac form was found on:

American ash (Fraxinus americana).
European ash (Fraxinus excelsior).
Fringe tree (Chionanthus virginica).
Golden current (Ribes aureum).
Laurel leaved willow (Salix pentandra).
Heart leaved willow (Salix cordata).

New Jersey Tea (Ceanothus americanus).
Large toothed aspen (Populus grandidentata).
Carolina poplar (Populus eugenii).
Lombardy poplar (Populus nigra, var. italica).
Trembling aspen (Populus tremuloides).
Witch-hazel (Hamamelis virginiana).

The biological development of the individuals occurring on American ash, European ash, fringe tree, laurel leaved willow, large toothed aspen, and Lombardy poplar has been followed and found to agree closely throughout the life cycle with that of the lilac form.

In conclusion it may be said that the evidence certainly seems to justify an affirmative answer to the question, "Are there two species of the Oyster-shell Scale?"

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A STUDY OF THE WING VENATION OF THE COLEOPTERA.*

By S. A. Graham.

The purpose of the modern taxonomist is not satisfied by the mere arbitrary naming of an insect. Taxonomy is more than that. If the worker in this field is true to the highest ideals of his profession he must continually strive to clear up some of the multitude of problems associated with the natural relationship of the organisms with which he is dealing, and to show this relationship in his classifications.

Unfortunately valuable phylogenetic characters are sometimes accidentally overlooked and remain in obscurity. It is not until we take advantage of all these available characters that we can hope to arrive at a true expression of phylogenetic relationship.

In the Coleoptera the characters to be found in the hind wings are undoubtedly of considerable value, but have been almost entirely neglected in taxonomic studies. This is

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perhaps partly due to the fact that these organs are hidden from view beneath the elytra and cannot be studied without relaxing dried specimens, and partly due to the fact that the homologies of the wing veins of this order have never been thoroughly worked out. It is the object of this paper to show in a preliminary way some of the neglected possibilities of these organs in the taxonomy of the group, and to show how the venation of the Coleoptera may be homologized with that of other orders. In this study a large series of wings, representing the most important families of the order, has been examined, but the work is still far from complete.

On examining a series of Coleopterous hind wings, several general outstanding features are apparent. First, that there is a distinct type of venation characteristic of the order. This is remarkably constant when the size of the group is considered. Second, there is considerable similarity between the venation of beetle wings and that of other insect orders, indicating the common origin of winged insects. Third, that within the order Coleoptera there are several types of modification which may have phylogenetic significance.

A study of the literature, however, fails to reveal any comprehensive investigations presenting conclusive evidence as to the homology of the wing veins of Coleoptera with that of other insect orders.

THE RELATION OF FOLDING TO VENATION.

One of the most striking features characterizing the wings of the Coleoptera is the fact that they are not only folded longitudinally, but also have at least one definite transverse fold. The advantage to the insect of this type of folding is obvious as it results not only in narrowing, but also in shortening of the wings when these appendages are folded against the body. This brings the wings under the elytra for protection. This protection is particularly essential to an insect of retiring habits living in places where an unprotected wing membrane would almost certainly be torn.

The fact that these folds or furrows necessarily follow the lines of least resistance between veins, usually running parallel with, and often very close to a vein, led Woodworth to associate them with the formation of veins. There is obviously some

correlation between these two structures, but it seems to be more probable that folding was a modification coming after the development of wing veins and that the position of the folds was influenced greatly by the position of the veins. The folds naturally would follow along lines of least resistance, thus bringing about a mutual adjustment of position between folds and wing veins.

As a rule the folds lie parallel to veins, but if the venation becomes so modified that a fold must cross a vein the result is often a thinning if not an actual break in the vein at the point of crossing, similar to the bullæ so common in the Hymenoptera. The crossing of a vein by a fold is usually nearly at right angles in the order Coleoptera.

TRACHEATION AND VENATION.

In most orders of insects the tracheation of the pupal wing furnishes the key to the wing venation, but in the Coleoptera the tracheation is of little assistance. In this study the tracheation of only a few species has been examined, but in these there was considerable variation within a single species, (*Tribolium confusum*). Further study may show a correlation between these structures in the more primitive types, but for the present we may assume that the primitive position of the tracheæ is probably better indicated by the position of the wing veins which, in some groups of this order approach very closely the primitive hypothetical type of Comstock and Needham.

HYPOTHETICAL PRIMITIVE COLEOPTEROUS TYPE.

By the comparison of a large series of wings representing most of the families of the Coleoptera it has been possible to develop theoretically an hypothetical primitive type of venation for this order which does not differ greatly from the hypothetical primitive type of the class Hexopoda as proposed by Comstock and Needham. The Coleopterous type is characterized by a single branched Sc, a fusion of R_3 and R_4 at their tips, and by a similar fusion of R_5 and M_1. Also the first forks of R, M, and Cu are typically well toward the base of the wing. (Fig. 1).

Briefly, costa lies in the front margin. The next vein behind costa is the single branched sub-costa. Radius is five branched, the radial sector leaving R_1 near the base. R_2 turns forward to the front margin, while R_3 fuses with R_4 and R_5 fuses with M_1. The other veins do not depart from the hypothetical type of the Hexopoda in general; media being four branched, cubitus being two branched, and the three anals being present.

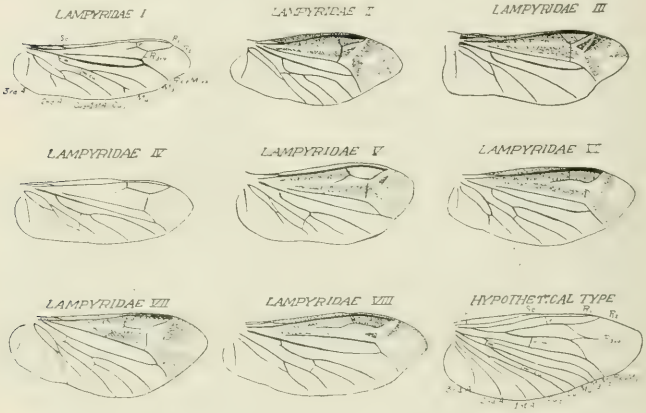

FIG. 1.

I. *Calopteron reticulatum* Fab.
II. *Podabrus tricostatus* Say.
III. *Chauliognathus pennsylvanicus* Fab.
IV. *Photinus pyralis* Linn.
V. *Photinus marginalis* Lec.
VI. *Eros aurora* Herbst.
VII. *Pterotus obscuripennis* Lec.
VIII. *Caenia dimidiata* Fab.
IX. Hypothetical Coleopterous Type.

COLEOPTEROUS WINGS IN GENERAL.

It is possible that costa is not always present, but whenever it occurs, it always lies in the front margin.

Sub-costa lies in the normal position and usually fuses with R_1.

Radius 1 lies just behind Sc and is always close to the front margins of the wing. In some species R_1 is so thickened as to almost obscure Sc.

The Radial sector leaves R_1 near the base of the wing and soon branches. R_2 turns forward to the margin, often fusing

with R_1. R_3 turns backward and fuses with R_4. In the majority of Coleopterous wings R_3 and R_4 form a cross vein between R_2 and R_5, but the various stages leading up to this condition are found in species of several families, for example, Cerambycidæ, Chrysomelidæ, Bostrychidæ, Spondylidæ, etc. (See Fig. 3). In every wing examined, the radial sector is broken at the base and in many cases the basal part is entirely gone.

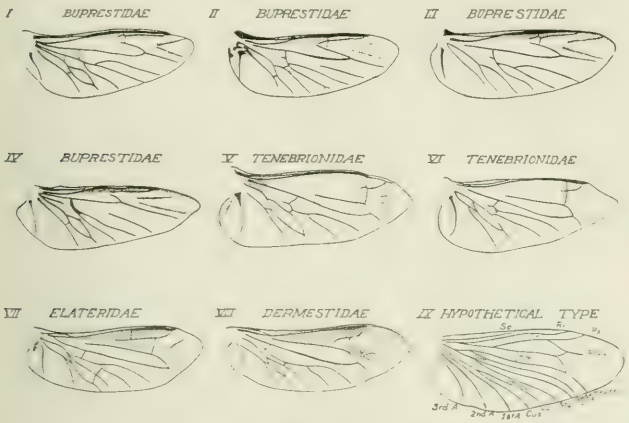

FIG. 2.

I. *Buprestis fasciata* Fab.
II. *Dicerca tenebrosa* Kby.
III. *Dicerca divaricata* Say.
IV. *Choleophora liberta* Germ.
V. *Upis cerambycoides* Linn.
VI. *Nyctobates pennsylvanicus* De G.
VII. *Elateridae*
VIII. *Dermestes lardarius* Linn.
IX. Hypothetical Coleopterous Type.

Media is typically four branched, but in the Coleoptera M_1 and M_2 are always coalesced so that they appear as a single vein. The first fork of M is near the base. Usually the basal part of branch M_3 and M_4 is lost up to the medial cross vein so that the cross vein appears to be the base of that branch. The lost basal part is, however, often indicated by a spur or in a few cases may be present as in *Buprestis fasciata*. (Fig. 2-I).

Cubitus is always two branched, but these may be fused at the tip. Three anals are typically present and the 3 A is

almost always separate from the other two. 1 A may either anastomose or coalesce with Cu and seldom appears as a separate vein for its entire length, while 2 A is usually fused with 1 A at least at the base.

The usual cross veins are found represented in the order, but it is unusual to find a wing in which they all occur. The humeral cross vein is usually either absent or obscured by the thickening of the veins in that region. Radial cross vein is almost always present. The Radio-medial cross vein is absent except in a single group of families of which the Carabidæ are typical. The medial cross vein and the medio-cubital cross veins are usually found normally.

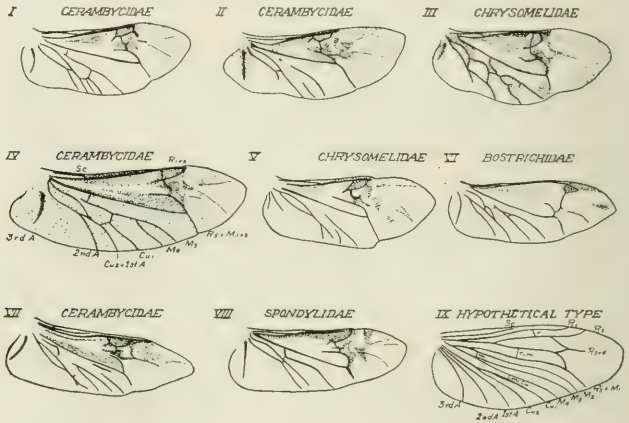

FIG. 3.

I. *Acaemops bivittatus* Say.
II. *Tetraopes femoratus* Lec.
III. *Chrysochus auratus* Fab.
IV. *Desmocerus palliatus* Forst.
V. *Donacia* sp?
VI. *Bostrychus bicornus* Web.
VII. *Monohomus confusor* Kby.
VIII. *Parandra brunnea* Fab.
IX. Hypothetical Coleopterous Type.

LINES OF MODIFICATION.

One of the most striking lines of modification is to be found in the fusion of tips of the veins in the apical area and a pushing back of the primary venation toward the base of the wing. The veins are replaced by secondary solid thickenings or

calosities in the apical area which often resemble veins so closely that it is only by the study of a series of wings that their origin becomes clear. The presence of these secondary vein-like calosities has undoubtedly led to much confusion in studies of the wing venation of this order. In the plates these structures are indicated by stippling, while the true veins are represented by solid lines.

The pushing toward the base of the primary venation, as mentioned above, is apparent in the most primitive types of Coleopterous wings studied, but is much more striking with increased complexity of folding. The extreme of this modification is found in the Staphylinidæ, but a highly specialized condition is also apparent in other widely separated families such as the Scarabaeidæ, Silphidæ, Nitidulidæ, Ipidæ, and Curculionidæ. Thus it appears that this line of modification is correlated with the complexity of folding. Increased complexity of folding is made necessary in two ways. Either by a shortening of the elytra as in the Staphylinidæ or by shortening and thickening of the body, thus decreasing the elytral length as compared with the wing length as in the Scarabaeidæ.

Along with this migration of the primary venation toward the base of the wing and due also to increased complexity of folding, there occurs a reduction of veins. Also many veins become broken and branches become entirely separated from the veins of their origin.

PHYLOGENETIC SIGNIFICANCE.

It is apparent that the final determination of phylogenetic relationship cannot be based upon wing venation alone any more than it is possible to base such relationship upon tarsal, thoracic, or any other set of characters alone. The wings do, however, give some hints which will undoubtedly be of considerable value when correlated with other characters.

The first point which is brought out in this study is that the Lampyridæ, using that term in its broad sense, are characterized by a much simpler type of venation than any other group of the order. The venation of this family approaches very closely what was probably the primitive type. This, coupled with the fact that the Lampyridæ exhibit other primitive characters, such as soft wing-like elytra, soft integument, a larger number

of abdominal segments than usual in this order, elongate body form, and long, many-jointed antennæ, would seem to justify the suggestion that this family may represent the most primitive of modern beetles. If this is true, it seems probable that the Coleoptera had its origin in a Lampyrid-like ancestral form.

On the other hand, the Carabidæ exhibit a distinct and rather a specialized type of venation which is characteristic of a group of families, including the Gyrinidæ, Dytiscidæ,

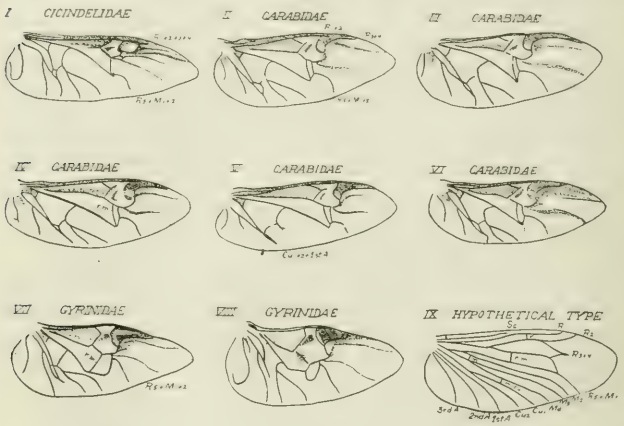

FIG. 4.

I. *Cicindela vulgaris* Say.
II. Carabidae.
III. *Harpalus caliginosa* Fab.
IV. Carabidae.
V. Carabidae.
VI. *Anisodactylus discoideus* Dej.
VII. *Gyrinus analis* Say.
VIII. *Dineutes assimilis* Aube.
IX. Hypothetical Coleopterous Type.

Cicindelidæ, and probably others. (Fig. 4). This group is characterized by the presence of cross veins r – m, by the persistence of the fused part of R_3+R_4 which turns forward to the margin of the wing, and by the fact that the transverse fold cuts through branches R_{2+3} and R_{4} leaving these veins in the apical part of the wing.

The Cerambycidæ and Chrysomelidæ typify another group of families having similar venation. This type includes a large

proportion of the families of Coleoptera, for example, Buprestidæ, Tenebrionidæ, Elateridæ, Bostrychidæ, Spondylidæ, Cistelidæ, Melandryidæ, Oedermeridæ, Pythidæ, Trogositidæ, Erotylidæ, Colydidæ, Mycetophagidæ, Mordellidæ, Meloidæ, and others.

This group is characterized by the fading out of the fused part of R_{3+4}, leaving a straight vein between R_2 and R_4. The

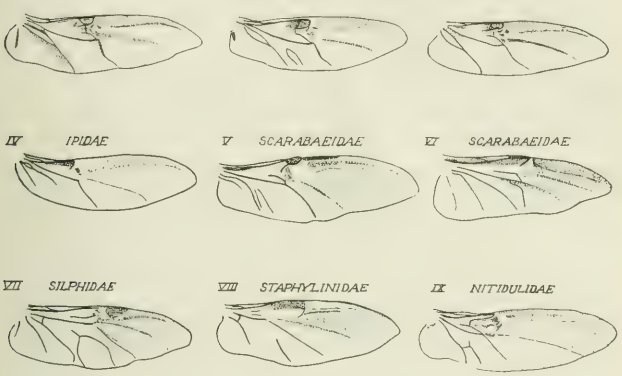

FIG. 5.

I. Curculionidae.
II. *Pissodes strobi* Peck.
III. *Hylobius* sp?
IV. *Ips* sp? (Ipidae).
V. *Bolbocerus lazarus* Fab.
VI. *Osmaderma eremicola* Kn.
VII. *Silpha inaequalis* Fab.
VIII. Staphylinidae.
IX. *Ips sanguinolentus* Oliv. (Nitidulidae).

various steps of this process are shown in species of Cerambycidæ, Chrysomelidæ, Spondylidæ, and Bostrychidæ. The transverse fold in this group cuts off the primary venation from the apical area of the wing.

We still have left a group of wings which have become so specialized that the venation gives very little hint of possible relationships and need not be discussed except to say that a number of widely separated families are represented. (Fig. 5).

SUMMARY.

1. A large series of hind wings, representing most of the important families of the Coleoptera, have been examined and the following conclusions seem justified:
2. The hypothetical primitive type of Coleopterous wing does not differ greatly from the Hypothetical type proposed by Comstock and Needham for the Hexapoda in general.
3. The hypothetical Coleopterous type is characterized by a fusion of R_3 with R_4 at the tip and by a similar fusion of R_5 and M_1.
4. The usual cross veins are typically present.
5. Modification of the venation goes hand in hand with an increase in the complexity of folding.
6. In general there are two types of modification:
   (a) A pushing back of the primary venation toward the base of the wing and the substitution of secondary thickenings in the apical area.
   (b) The reduction and breaking up of the veins.
7. The types of venation fall naturally into four groups.
   (a) Represented by the Lampyridæ which is the simplest type and may indicate the possibility of a Lampyrid-like ancestral form for the Coleoptera.
   (b) Represented by the Cerambycidæ and Chrysomelidæ in which R_3 and R_4 have become a simple cross vein between R_2 and R_5, and where the primary venation is cut off from the apical area.
   (c) Represented by the Carabidæ which is characterized by the persistence of the fused portion of R_3 and R_4, the presence of cross veins $r-m$, and the cutting of R_{2+3} and R_4 by the transverse fold.
   (d) A group of widely separated families where the venation is too highly specialized to show any relationship.

ANNALS

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THE GENITALIA OF THE AUCHENORHYNCHOUS HOMOPTERA.

By J. C. Kershaw and F. Muir. (Honolulu)

Most students of insect morphology consider that the male and female genitalia of insects are homologous, but it is also considered that in some groups of insects the female genital opening, or gonopore, is situated between the eighth and ninth abdominal sternites and the male gonopore between the ninth and tenth. So far as the Hemiptera are concerned these two views have never been reconciled, and the fact that the gonapophyses of the two sexes appear to pertain to different segments has been ignored, or used as an argument against the organs being homologous.

Observations made by one of the authors in England upon Cercopidæ and by the other in Honolulu upon Cicadellidæ and Fulgoroidea, agree in showing that the difference is only apparent and is due to development during the last nymphal instar. The gonopore in both sexes is between the eighth and ninth abdominal sternite (or at the base of the ninth sternite) and the three pairs of gonapophyses form the genital appendages.

CERCOPID FEMALE.

Observations were made upon more than one species of this family and our remarks in general apply to all, but the details refer to *Philaenus leucophthalmus* (Linn) which was the chief species used.

In the nymphs the sexes can be recognized in the second instar and it is possible that in carefully prepared specimens they could be recognized in the first instar. In the later nymphal stages they are quite distinct.

Between the eighth and tenth sternites there is an area the anterior portion of which we will call the genital area; anterior to this is the eighth sternite, which is well defined; posterior to it, and between it and the tenth, is an area which may represent the ninth, or it may represent the conjunctiva between the ninth and tenth, and the ninth may be represented in the genital area. From the genital area arises the gonapophyses.

In the female nymphs during the last instar the gonapophyses consist of three pair of subangular, fairly flat processes reaching more than half way back to the tenth sternite. The anterior pair (Fig. 1, g1) arise from the posterior edge of eighth sternite, although at an earlier period their connection with that sternite is not so apparent. The median pair (Fig. 1, g2) are smaller and lie immediately posterior to g1, and as they both point backward and g1 are larger than g2, therefore they lie beneath, or are covered up by g1. The posterior pair (Fig. 1, g3) are larger and hold a more lateral position and are concavo-convex. The genital opening or gonopore is at the base of g2.

In the adult female the eighth abdominal segment is short but well defined. That the segment in question is the eighth can be demonstrated by counting them, especially on the dorsal aspect; the presence of the last, or eighth, spiracle also indicates which segment it is. From the hind margin of the eighth sternite arises two processes (Figs. 2, 3, g1), which form the anterior or ventral process of the ovipositor. These are long, thin and narrow and *their outer basal angles are joined to the outer basal angles of the ninth tergite.* The eighth sternite overlaps their bases, but the membranous connection shows the relationship to the posterior margin of that segment. The ninth segment forms the pygofer (Fig. 2, pg), the tergite being large, but the extent of the sternite obscure and depends upon the composition of the genital area of the nymph. Two sclerites (Fig. 2, bp) which appear to be the valvifers of

Orthoptera, may represent the only chitinized portion of the ninth sternite; they form the supports of the posterior processes.

The median processes (Figs. 2 and 4, g2) lie immediately posterior to the anterior processes and are represented by a single, median process bifurcate on apical third and grooved along the ventral surface. This process is joined to the anterior processes by a tongue and groove joint and together they operate as the ovipositor, the gonopore opening at the base of g2 and the eggs passing along the ventral groove between g1 into the puncture made by the ovipositor. The posterior processes (Figs. 2 and 4, g3) are large and hold a lateral position slightly posterior to g2, and form a sheath for g1 and g2 when at rest. Beyond the pygofer is the anal segment (Fig. 2, 10 and 11) which is composed of the tenth and eleventh segment. Beneath the anus is the anal style (Fig. 2, a. s.), a median organ grooved along its dorsal surface. In no Homopteron, in either the young or adult, are the cerci present so far as we have observed.* Whether an anal style is present in Psocidæ where cerci are absent we are unable to say.

If we dissect an immature imago from the nymphal skin just before it moults we find that the apices of the adult, g1, g2 and g3 rest within the nymphal g1, g2 and g3 so there can be no question as to their homology.

Walker† in his admirable study of the ovipositor of Orthoptera, has shown good reasons for considering g3 as the coxites of the ninth sternite. In the nymphal stages of some Orthoptera g3 carry the styles which are lost before the adult stage is reached. In many Odonata these styles are retained in the adult. In the Cercopidæ there is evidence to indicate that g1 are the coxites of the eighth sternite but none to indicate that g3 are the coxites of the ninth. If they be, then the area between them and the tenth sternite is not the ninth sternite. This leaves g2 as the only true gonapophyses and their origin is open to speculation.

If we consider the genital organs as representing the "legs" of the eighth and ninth segments, then g1 would represent

*Huxley, in The Anatomy of Invertebrated Animals, p. 364, fig. 104, figures an Aphis in which cerci are present. Whether this is supposed to be drawn from an actual specimen or is only a composite figure, we are unable to state.

†Walker, 1919, Ann. Ent. Soc. Am. XIII, p. 267-316.

the coxites* of the eighth sternite, g2 the endopodites and g3 the coxites of the ninth sternite. The style of the abdominal sternites cannot represent the "legs" (endopodites) but the exopodites, unless we consider that the styles on the thoracic coxæ are not their homologies. In *Machilis heteropus* Silv. the "ovipositor" consists of two pair of appendages, one of which represents the endopodite of the ninth sternite and the other the endopodite of the eighth. A careful comparison of the male and female genitalia in a representative series of species of *Machilis* and allied genera would be of great morphological value.

CERCOPID MALE.

In the male nymph of *Philaenus leucophthalmus* (Linn) the gonapophyses arise in exactly the same place as in the female. In the earliest instar of the nymph g2 is a small, single median process, in the following instar it is bilobed at the apex (Figs. 5 and 6). In the last instar the genital processes are smaller than in the female and g1 are not in such close connection with the eighth sternite. A comparison of Figures 1 and 7 indicates the differences between the sexes.

In the adult male the segment behind the eighth forms a ring-like pygofer with the ventral margin produced into a pair of narrow, flat processes (gp) with a longitudinal line of weakness along the middle of the ventral surface (Figs. 8 and 9, g1 or gp). The tenth and eleventh segment form the anal segment, the posterior margin of the former being produced into two large, thick spines curved downward (Fig. 8) and the anterior margin into two small curved processes (Fig. 8). From the middle of the area between the anal segment and the gp of the pygofer arises three processes, a median penis or aedeagus (Fig. 8, p) and a pair of genital styles (Fig. 8, gs). The latter project well into the pygofer as apodemes (Fig. 8, gss) for the attachment of muscles.

If we dissect out an immature imago from the nymphal skin shortly before the final moult we find that the apices of gp lie

*Walker considers g1 and g2 to be similar organs of the eighth and ninth segments. This would make them both endopodites. Certain of the evidence appear to favor his view and we are quite prepared to accept it, but we have used the term coxites as their development in the Homoptera appear to indicate that they are those organs, rather than the endopodites.

within g1, the apex of p within g2 and the apices of gs within g3, but the last is obscure and the more difficult to trace. This shows their true homologies and also shows the homologies of the male and female, which can be represented as follows:

	Nymph	Adult ♂	Adult ♀
Anterior gonapophyses	g1	Genital plates	Outer { Processes of
Median gonapophyses	g2	Aedeagus	Inner { ovipositor
Posterior gonapophyses	g3	Genital styles	Ovipositor Sheaths

In many species of Cercopidæ g1 in the adult male are joined together into a single plate.

COMPOSITION OF THE ÆDEAGUS.

The ædeagus is a complex structure and the homologies of its parts not clear. In the adult *Philaenus leucophthalmus* (Linn) there is a large, chitinous bulb (Fig. 8, pa) which may represent the periandrium, and a straight penis (Fig. 8, p). On the ventral aspect of the apex of the penis is the orifice or gonopore (Fig. 8, gpr). It is possible that during copulation the ejaculatory sac may be protruded or evaginated and the gonopore or functional orifice be situated upon it. Figure 8 shows this sac slightly protruded. At the apex of the penis there are two large, curved hooks, the penis hooks (Fig. 8, ph), and below them four smaller processes in a circle. In the later nymphal stages the area around the base of g2 is invaginated, carrying with it both g2 and the bases of g3, (Fig. 10). The penis hooks (ph) of the adult lie within the bifurcations of g2, (Fig. 11). The bulb or periandrium (pa) evidently arises from the body wall, round the base of g2. The fact that g2 first arises as a single lobe and the bifurcation arises later may indicate that it is only the penis hooks that are homologous to the paired processes of the female and the rest of the ædeagus (the penis and bulb) are formed by outgrowths of the body wall.

Membracidæ

One of the authors* has published notes on the development of the genitalia of a membracid (*Tricentus*). In all its main features it is similar to the Cercopidæ.

Cicadellidæ.

Observations on *Eurymela* and *Deltocephalus mollipes* also show the same development as in the Cercopidæ.

Cicadidæ

No remarks are needed on the female genitalia, as they are the same as in Cercopidæ.

In the male Cicadidæ we have a very distinct type of genitalia. Although we have not followed the details of development so thoroughly as in Cercopidæ, yet enough is known to clearly indicate the line of development and the homologies.

In forms such as *Pompomia maculaticollis* the seventh sternite is large and produced considerably posteriorly where it is slightly emarginate in middle or broadly and slightly bilobed. Whether this extension represents a development of the seventh coxites we cannot say. The eighth sternite forms a large plate which almost conceals the pygofer from below. Posteriorly it narrows to a blunt point at apex, which has a cleft in middle, thus making it bilobed. This represents the eighth sternite and coxites and the eighth spiracles are situated near its basal angles. The pygofer is large, its medioventral surface membranous. From the lateral margins arise a pair of non-articulated processes which represent the much reduced g3. From the middle of the opening of the pygofer arises the ædeagus, which in most Cicadidæ is long, thin and tubular, but in some complex and trilobed. The anal segment is similar in composition to that of the Cercopidæ; in some species it is complex.

If our interpretation of the large plate below, or anterior to, the pygofer, be correct, then it will represent a more generalized type than the Cercopidæ so far as this structure is concerned; but the reduced and non-articulate genital style is a specialization. The plate in question represents the hypandrium.

*Kershaw, 1913, Ann. Soc. en Belgique, 57 (191-201).

The Cicadidæ differ from all other Cicadoidea and Fulgoroidea in that the coxites of the eighth sternites, or g1, are not incorporated into the pygofer, whereas in all the other families they are.

Fulgoroidea.

In the Fulgoroidea we have a third type, which is a development of the Cercopid type. There is a complete pygofer often forming a more or less complete chitinous ring, one pair of articulate genital styles and an ædeagus, which is often very complex. The genus *Tettigometra* is an exception, for along with other Cicadoidean characters it has a pygofer similar to Cercopids, with two pairs of styles. In the genus *Hilda* g1 are more completely amalgamated to the pygofer. On account of the availability of material *Perkinsiella saccharicida* Kirk (Delphacidæ) has been selected as a type, although its small size makes it unsuitable for observing the development.

In the female nymph the ninth tergite forms nearly a complete circle, having a small opening on the ventral aspect (Figs. 12, 9), the anal segment and genital area being sunk into this ring. At the posterior edge of the eighth sternite, between the lateral margins of the ninth tergite, arises the gonapophyses. Only the paired g1 and the single, median g2 are visible, but upon dissecting the g3 are found beneath the larger anterior processes (Fig. 13); g2 is not bilobed at the apex. The homologies of the adult processes can be demonstrated by the apices of the processes of the immature imago lying within the nymphal processes. They are similar to those of the Cercopidæ, but much longer, and as the imago develops within the nymph the base of the ovipositor has to move forward towards the thorax, taking along with it the median portion of the preceding sternites. This causes the abdominal sternites of the adult to be V-shaped and the ovipositor to appear as if arising far anterior to the apex of the abdomen. The pygofer is also carried forward so that it is long and narrow. In many Fulgorids the ovipositor is short and projects beyond the end of the abdomen, or is nearly or quite abortive; in these cases the abdominal sternites are not V-shape.

In the male nymph of *P. saccharicida* the ninth tergite is similar to that of the female, but the gonapophyses are much

smaller and more obscure. In the adult the pygofer forms a ring; from its medio-ventral edge arises two small, laterally flattened spines; a pair of moderately small, flattened genital styles arise near the ventral margin, with a more or less chitinous wall, the diaphragm, dividing them from the ædeagus which is subcylindrical, flattened laterally, with the orifice at the apex on dorsal aspect, with two spines near the orifice. A chitinization of the body wall connects the base of the ædeagus with the base of the anal segment, and there is a chitinous connection between the base of ædeagus and the base of the genital styles.

If we dissect out the immature male from the nymphal skin we find that the body wall at the base of the ædeagus is invaginated, but the genital styles are not carried with it, there being a fold of the body wall between them, (Fig. 19, dia). It is this fold which forms the diaphragm of the adult. At an early stage of development the ædeagus is a simple tubular body with the opening slightly before the apex; the genital styles are proportionally short and flat and the two processes on the ventral margin of pygofer (g1) are relatively large. (Figs. 15, 16 and 17). At the stage shown in Figure 19 they are more than half the length of the genital styles.

In most of the Delphacidæ there is no trace of g1 in the fully developed pygofer; in a few there is a single median process, but the genus *Perkinsiella* has a pair of processes which varies in shape and size in each species. The genus *Pissonotus* shows g1 very well developed (Fig. 20). Among other fulgorids g1 are often well developed (i. e., *Olonia picea*, Eurybrachidæ and *Eurynomeus granulatis*, Achilidæ).

Among the thousand and more genera of the Fulgoroidea the differences of ædeagus are very great, but they can be reduced to three sub-types, which we will refer to as Tettigometroid (A), Delphacoid (B) and Flatoid (C). The Tettigometroid, for other reasons besides the type of male genitalia, we consider as the most primitive type of fulgorid. In the genus Tettigometra the pygofer is of the Cercopid type. In *Hilda breviceps* g1 are incorporated into the pygofer; the periandrium is large and bulb-like and the ædeagus very short, the conjunctiva being distinct; the penis-styles apodemes are well developed. The medio-ventral margin of pygofer is produced.

The more common form of this subtype is found among the Cixiidæ (i. e., *Oliarus*), where the periandrium forms a fairly long tube more or less chitinous and often bearing large spines and other processes, the penis is often complex and produced into processes and more or less membranous so that the conjunctiva is not sharply defined; the penis apodeme passes through the periandrium and joins the base of the penis. The following families have this subtype: Tettigometridæ; Cixiidæ in part; Delphacidæ in part; Tropiduchidæ in part; Derbidæ modified.

In the Flatoid subtype the periandrium is shorter and wider, and generally funnel shape and the penis is invaginated into the periandrium and is also often funnel shape. Both the periandrium and the penis often form a short tube or ring bearing lateral processes. The complexity is very great in some forms (i. e., *Capelopterum maculifrons*, Issidæ). The Meenoplinæ of the Cixiidæ come under this type and thereby add one more character by which they approach the Flatidæ. The following families have this type of ædeagus: Flatidæ, Acanaloniidæ, Ricaniidæ, Issidæ, Dictyophoridæ, Fulgoridæ, Achilidæ, Eurybrachidæ, Lophopidæ and Cixiidæ in part.

The Delphacoide subtype contains Delphacidæ in part and Tropiduchidæ in part. In it the periandrium is greatly reduced or absent and the penis alone forms the ædeagus and is generally tubular. The periandrium generally forms a small ring at the base of the ædeagus and is joined by a chitinous structure to the base of the anal segment.

FURTHER SPECULATIONS.

We consider that the facts briefly stated in this paper are sufficient to demonstrate the homology between the genitalia of the two sexes, and between the Fulgoroidea and the Cicadoidea. There is much work still to be done in all the groups, especially in the Fulgoroidea where the variation in detail, especially in the ædeagus, is very great. Exactly what becomes of the ninth sternite has yet to be shown, also the nature of the area between the ædeagus and the anal segment.

Muir does not accept Theory of Crampton's Segments

Turning to other orders we find that the Lepidoptera and Trichoptera appear to be built upon the same morphological plan as the Fulgorids. There is a ring-like segment which

appears to be the ninth, a small anal segment, one pair of articulate genital styles and a median ædeagus. They are so similar that it appears only logical to conclude that they have a similar origin and development. At least it urges us to study the pupal stage and the immature imago to see if any evidence of such a development can be found. The Lepidoptera possess no cerci in the males while the Trichoptera possess cerci.

Elsewhere one of the authors has insisted that no evidence has been brought forward to show the homology between the male and female genitalia of Coleoptera, and that in many forms the male gonopore appears to open between the ninth and tenth sternites. If in the Homoptera the coxites can be disassociated from the eighth sternite and become amalgamated with the ninth tergite so as to appear as the ninth sternite, it is highly probable that the same has happened in Coleoptera. But until direct evidence is brought forward showing that such is the case, we must not dogmatically assert that it has. Wherever the hypandrium appears as the ninth sternite we must bear in mind the possibility of it being the coxites of the eighth sternite.

If this homology of the sexes in Coleoptera can be demonstrated, it helps us to understand the wonderful coadaptation between the internal sac and the uterus, for they are then true homologies and the cause which modifies one can modify the other in the same manner. The question is worthy of further study.

EXPLANATION OF PLATE XIII.

Philænus leucophthalmus.

Fig. 1. ♀. Ventral view of VIII-X sternites of nymph, last instar.
Fig. 2. ♀. Lateral view of apical abdominal segments of adult.
Fig. 3. ♀. Anterior processes of ovipositor.
Fig. 4. ♀. Median and posterior processes of ovipositor.
Fig. 5. ♂. Gonapophyses at an early stage.
Fig. 6. ♂. Gonapophyses penultimate nymphal stage.
Fig. 7. ♂. Ventral view of VIII-X sternites of nymph, last instar.
Fig. 8. ♂. Lateral view of apical segments of adult.
Fig. 9. ♂. Ventral view of pygofer.
Fig. 10. ♀. Aedeagus and one genital style of immature adult.
Fig. 11. ♂. Median gonapophyses, last nymphal stage, showing the immature adult stage within it.

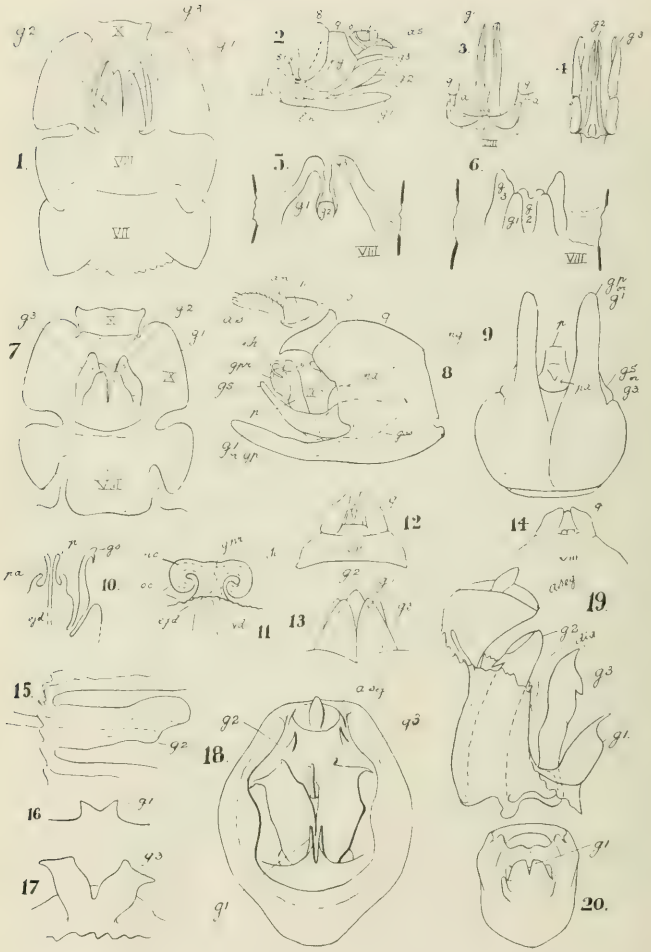
Perkinsiella saccharicida.

Fig. 12. ♀. Ventral view of last abdominal segment of nymph, last instar.
Fig. 13. ♀. Gonapophyses of same, enlarged.
Fig. 14. ♂. Ventral view of last abdominal segments of nymph, last instar.
Fig. 15. ♂. Aedeagus of immature adult.
Fig. 16. ♂. Anterior gonapophyses of immature adult.
Fig. 17. ♂. Posterior gonapophyses of immature adult.
Fig. 18. ♂. Full view of pygofer of immature adult.
Fig. 19. ♂. Lateral view of anal segment, ædeagus, anterior and posterior gonapophyses of immature adult just before final larval moult.

Fig. 20. *Pissonotus frontalis.* Full view of ♂ pygofer.

LETTERING OF FIGURES.

a. seg.=Anal segment.
an=Anus.
as=Anal style.
bp=basal plate.
dia=diaphragm.
ejd=ejaculatory duct.
gpr=gonopore.
gss=apodeme of genital style.
g1=anterior gonapophyses=*gp* or genital plates.
g2=median gonapophyses.
g3=posterior gonapophyses=gs or genital styles.
nc=new cuticle.
oc=old cuticle.
p=penis.
pa—periandrium.
pg=pygofer.
ph=penis hooks.
8 stg=8th stigma.
8, 9, 10, 11=tergites.
VIII, IX, X=sternites.



Kershaw and Muir.

THE PHYLOGENY OF THE GALL MITES AND A NEW CLASSIFICATION OF THE SUBORDER PROSTIGMATA OF THE ORDER ACARINA.

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Of all the major groups of the Acarnia it is doubtful if any are more aberrant than the gall mites, and but few show such unity of organization or sameness of habits. Because of this there has been in the past but little evidence upon which to establish any natural affinities between them and any of the other groups, while suggestions as to their origin have been but little more than conjectures.

RECENT VIEWS IN REGARD TO THE AFFINITIES OF THE GALL MITES.

By way of both introduction and review, here are given some of the more recent views in regard to the relationships of the gall mites.

In 1910 Dahl commited himself to the belief that the gall mites were related to the other Acarina through the Tarsonemidæ. He regarded the genus *Tarsonemus* as representing a transitional stage between the Eriophyidæ and the Acarina proper. This belief was held largely because of the nature of the last pair of legs. These legs, normally developed in the free-living Tarsonemidæ, are shortened and almost rudimentary in some of the parasitic species. He found in this group the tendency toward leg reduction which has been so completely effected in the Eriophyidæ.

Banks (1915) champions the Tarsonemid theory. In his well known treatise on the mites he states: "The Eriophyidæ are, perhaps, more closely related to the Tarsonemidæ than to any other group. Many of the Tarsonemidæ feed exposed on the leaves or stems of a plant; some of them cause swellings or deformities of the plant, and some have the body more or less distinctly segmented. Moreover, in several genera of the Tarsonemidæ there is a tendency toward reduction in the number of legs, and in other genera the hind legs are very

slender and of little use in walking." Banks' basis for a belief in Tarsonemid relationship is the existence of similar feeding habits of the two groups and the fact that in the Tarsonemidæ there is "a tendency to the reduction in number of the legs."

Oudemans (1910) states in his review of the families of the Acarina* that the Eriophyidæ are probably most nearly related to the spinning mites or "perhaps even an earlier stage of the Tetranychide." This suggestion that the gall mites are an earlier stage of the Tetranychidæ requires some evidence for its support and an elaboration of explanations based on such evidences. Until such are brought forward the suggestion falls far short of a theory which can be used constructively in the advancement of our knowledge of natural relationships.

A THEORY AS TO THE PHYLOGENY OF THE ERIOPHYIDÆ.

It is my purpose here to state and then substantiate a definite theory as to the origin of the gall mites. The theory is this: The gall mites, a highly aberrant and degeneratively specialized group of phytophagous parasites, have arisen through the process of profound morphological change and adjustment, from a recently discovered group of gall-making spider mites. This group the writer has recognized as a family, the Phytoptipalpidæ, and it is to be regarded as a transitional group between the Eriophyidæ and the Tetranychidæ. I would not derive the gall mites from any living species of the family Phytoptipalpidæ or even from the genus *Phytoptipalpus;* yet it appears from the evidence at hand that the two or more living species of *Phytoptipalpus* are barely out of a line of direct descent between the spider mites and the gall mites.

THE GENUS PHYTOPTIPALPUS—ITS DISCOVERY AND THE INTERPRETATION OF ITS RELATIONSHIPS.

The genus *Phytoptipalpus* was established in 1905 by Tragardh for a very peculiar mite species named by him *paradoxus*, which was found in galls of an African species of *Acacia*. The species was very peculiar in several respects. It evidently was a true gall making species, yet did not belong to the group known as the gall mites. The mites were red,

*Oudemans, A. C. A Short Survey of the More Important Families of Acari. Bul. Ent. Research, Vol. 1, pp. 105-119, figs. 1-22.

with a somewhat elongate body, and had even in the adult stage only six legs. The mouth-parts were all but identical with those of the Eriophyidæ, while the tarsal armature was quite similar in some respects to that of certain genera of the Tetranychidæ. The species was oviparous and differed very markedly in its development from that of the spider mites.

Recently the present writer has described* another species of *Phytoptipalpus* taken from the jujube tree (*Zizyphus jujuba*) in India. This species is quite similar to the one described by Tragardh. It makes galls on the bark of the jujube and lives inside of these galls. So similar is this species to Tragardh's *paradoxus* that any phylogenetic significance that attaches to the one should usually apply to the other. The two species are not only congeners, but are very closely related.

The interpretation which the present writer places on the meaning of the peculiar structure of *Phytoptipalpus* is exactly the reverse of that given by Tragardh. Tragardh held that the similarity between the mouth-parts of *Phytoptipalpus* and the Eriophyidæ was due to convergence, hence attached no phylogenetic significance to them and was content to place his new genus in the subfamily Tetranychinæ next to the genus *Tenuipalpus*. He states: "Die so geartete umbildung der Mundteile von *Phytoptipalpus*, welche bei der Gattung *Tenuipalpus* gewissermassen vorbereitet ist, ist ein sehr schones Beisipel von Konvergenz unter dem Einfluss von gleichen ausseren Lebensbedingungen. Die Gattung *Phytoptipalpus* lebt namlich wie die Phytoptiden in Pflanzengallen und ernahrt sich von den Pflanzensaften."

This resemblance which Tragardh explains as being due to convergence, the present writer would ascribe as due chiefly to inheritance. In other words, the Eriophyid type of mouth-parts is similar to the *Phytoptipalpus* type, not because both Eriophyids and the Phytoptipalpi inhabit galls, but chiefly because they have the same ancestry. This thesis I now will attempt to both explain and establish. It involves a consideration of other characters than the mouth-parts and other mites than the two groups mentioned. We will start, however, with the mouth-parts. I will compare first the mouth-parts of the Eriophyidæ with the species of *Phytoptipalpus* with which I have worked. The name of this species is *Phytoptipalpus transitans*.

*Proc. Ent. Soc. Wash., Vol. XXIV, p. 108.

THE MOUTH-PARTS OF THE ERIOPHYIDÆ AND THOSE OF PHYTOPTIPALPUS TRANSITANS EWING.

The close resemblance between the mouth-parts of *Phytoptipalpus* and those of gall mites were clearly recognized when Tragardh established the genus for his species, *paradoxus*. This resemblance was emphasized by giving the genus its name, *Phytoptipalpus*.

In the Eriophyidæ the mouth-parts have been reduced and consolidated. The palpi are no longer free, but have become shortened and fused with their bases to become a trough (Fig. 1) in which lie the needle-like cheliceræ. Evidences of segmentation is retained by the palpi, and three indistinct segments are usually recognized. The cheliceræ (Fig. 1, c) are minute, very slender and needle-like. Those of *Eriophyes pyri* I have detached from the body and find that they arise

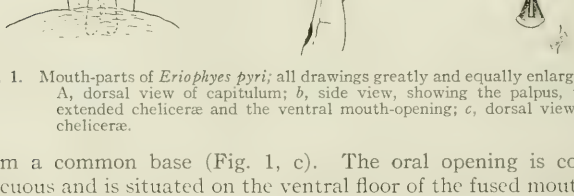

Fig. 1. Mouth-parts of *Eriophyes pyri;* all drawings greatly and equally enlarged. A, dorsal view of capitulum; *b*, side view, showing the palpus, the extended cheliceræ and the ventral mouth-opening; *c*, dorsal view of cheliceræ.

from a common base (Fig. 1, c). The oral opening is conspicuous and is situated on the ventral floor of the fused mouth-parts. This position is typical for other Acarina.

In *Phytoptipalpus* the palpi are reduced and fused so as to form a trough for the cheliceræ. This fusion has been even more complete than in the Eriophyidæ, as only a single segment remains discernible. The cheliceræ are small, very slender and needle-like. They are elbowed near their bases, and the latter are lodged in a well defined mandibular plate. On the ventral side of the fused maxillæ is a conspicuous opening. According to Tragardh it is through this opening in *paradoxus* that the cheliceræ are thrust. In *transitans* the cheliceræ lie in an almost capillary gutter and are thrust from the tip of the capitulum and not at all through this opening. According

to the view of the present writer this opening is no other than the mouth-opening which leads to the pharynx.

So nearly alike are the mouth-parts of *Phytoptipalpus* and those of the Eriophyidæ, that to explain their complete homology it is only necessary to point out their few differences. The maxillæ and the maxillary palpi are practically the same in both cases except in *Phytoptipalpus* only a single fused palpal segment is distinguishable, while in the Eriophyidæ three are usually recognizable. The stylets of the cheliceræ of the two groups are the same, except that in *Phytoptipalpus* they are elbowed near the base. In *Phytoptipalpus* and all of the spider mites the bases of the cheliceræ are lodged in a flat chitinous structure which may be in certain species

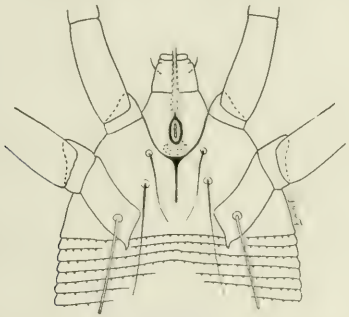

Fig. 2. Ventral view of anterior part of body of *Eriophyes pyri;* greatly enlarged.

protrusible. This structure has long been known as the mandibular plate. In working on the homologies of the mouth-parts of the Eriophyidæ the writer has found that in *E. pyri* that the cheliceræ both arise from a common base, and that this base could logically be regarded as the same structure which in the Tetranychidæ and in *Phytoptipalpus* is called the mandibular plate. It is a greatly reduced structure in the Eriophyidæ and in fact is vestigial.

The pharynx and oral opening in the two groups of mites are, as I have found, identical, although Tragardh regarded the ventral opening in *paradoxus* as being a provision for the thrusting out of the cheliceræ.

THE TARSAL ARMATURE IN THE ERIOPHYIDÆ AND IN PHYTOPTIPALPUS.

The Tarsonemid theory of the origin of the Eriophyidæ fails utterly to explain the presence of the peculiar tarsal armature of the gall mites. In the Eriophyidæ each tarsus is armed at its tip with a simple claw and below it with the pectinate structure known as the "feather hair" (Fig. 3, *c*). The so-called "feather hair" is composed of an almost straight central part from which branch off below four or five pairs of barbs.

Of all the groups of the Acarina no other group gives as close an approximation to the Eriophyid type of tarsal armature as the red spiders, or spider mites. Of the various genera of

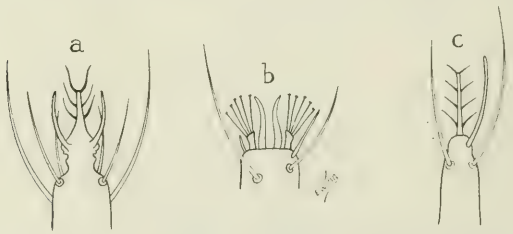

Fig. 3. Tarsal armatures of *Syncaligus, a;* of *Phytoptipalpus, b;* and of *Eriophyes, c.*

the spider mites the genus *Syncaligus*, a genus showing many relationships with *Phytoptipalpus*, has a tarsal armature most nearly like that of the Eriophyidæ. In this genus there is a ventral structure, the empodium (Fig. 3, *a*), which differs from the "feather hair" of the Eriophyidæ only in being stouter and having one or two less barbs, or branches. In addition to the empodium in *Syncaligus*, two tarsal claws are present. It is from the *Syncaligus* type of tarsus that the tarsal armature of both *Phytoptipalpus* and the Eriophyidæ have probably been developed; in *Phytoptipalpus* by the splitting of the empodium into two and an increasing of the number of its branches, and in the Eriophyidæ by the atrophy of one of the tarsal claws. That one of the tarsal claws is easily lost is shown repeatedly in the Acarina. Even in the Tetranychidæ it is now

taking place in the genus *Paratetranychus*, has taken place in genera *Tetranychus* and *Oligonychus;* while in another genus in the same family, the genus *Anychus*, both claws are gone.

Thus it is seen that not only is the Eriophyid tarsus structurally more nearly related to a type found in the Tetranychidæ, but it can be homologized with the latter type, and the evolutionary changes necessary to give the exact Eriophyid tarsus are actually observed now in progress in the group from which we would derive the Eriophyids.

THE FORM OF THE BODY IN THE ERIOPHYIDÆ AND THE TETRANYCHIDÆ.

Next in morphological importance to the structure of the mouth-parts and of the tarsal armature and number of legs in the Eriophyidæ, is probably the form of the body. It is in nearly all species vermiform, in fact one of the common names of the suborder of gall mites is Vermiformia. In addition, the long-drawn-out body is ringed with many circular folds of the integument.

This ringed, vermiform condition is only matched in the hair follicle mites of all the other major mite groups, and the hair follicle mites are so different from the gall mites in practically all other respects that a suggestion of their affinity with the Eriophyidæ has never even been made.

Undoubtedly the vermiform body of a hair follicle mite is an adaptation—an absolutely necessary adaptation—to its life in the hair follicles, and with almost complete assurance we can accept it that their origin and descent is from some ectoparasitic zoophagous group, probably from the parasitic Cheyletidæ as held by Hirst.

Searching elsewhere in the different groups of the Acarina, instances of a vermiform tendency are found in several of them and as has been noted, exists in the Tarsonemidæ, more particularly, however, in the female, for the males of the Tarsonemids are as a rule short-bodied. In the Tetranychidæ we find not only examples of this tendency to develop the vermiform type of body, but it is correlated with the development of the gall-producing habit.

In such free-living and active genera as *Tetranychus* and *Paratetranychus* the body is stout, but in other genera where the attacks of the mites are so restricted that they live almost

as fixed parasites, the body becomes more flattened and usually elongate. Then in such species as *Stigmaeus floridanus* Banks, which lives in colonies at the bases of imbricated leaves of the pineapple, the body becomes markedly lengthened. Finally, in the genus *Phytoptipalpus* we find not only a lengthened body, but in the male particularly the body ringed in almost the same way as in the Eriophyidæ. (Fig. 4).

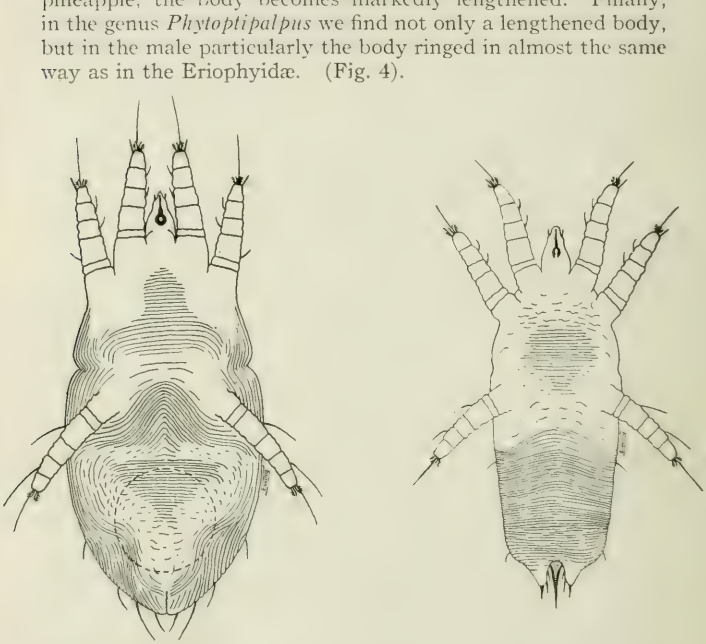

Fig. 4. *Phytoptipalpus transilans* Ewing. Ventral views of male (smaller individual) and female (larger individual) equally enlarged.

SUMMARY OF RELATIONSHIPS.

Thus it is found that in what probably constitutes the three most important groups of morphological structures in the gall mites, that these structures can be homologized with those of the same groups in the Phytoptipalpidæ. Further, it is observed that all modifications necessary to give the types of these three important group of characters in the Eriophyidæ can be explained, and what is more important, the processes of change

can actually be traced out not only in other groups of mites, but in the Tetranychidæ and the Phytoptipalpidæ the two families held to be the most nearly related to the Eriophyidæ. Lastly the morphological changes thus traced out are correlated with changes in habits which give finally a high degree of approximation between the hypothetical ancestral group and the group whose origin is to be explained.

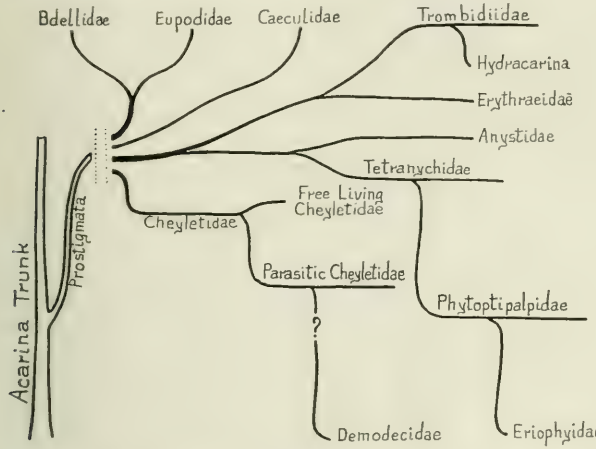

Fig. 5. A "tree" diagram illustrating the origin and relationships of the families of Prostigmata.

The relationship and origin of the Eriophyidæ is indicated in the following diagram (Fig. 5). For sake of completeness the relationships of other families of the order Prostigmata are also shown according to the writer's interpretation.

The same relationships can be shown in the form of a key to the families of Prostigmata; not so clearly, yet some practical advantage may be obtained in the key by enabling one to place properly a given species to family. A key to the families of the suborder Prostigmata is here given in the form of a new classification. In this classification the mouth-parts are made, to a large extent, the basis for family differentiation.

A New Classification of the Suborder Prostigmata.

A. Cheliceræ chelate; adapted for biting; palpi without thumb, Section Adactylognatha
  B. Mouth-parts not formed into a beak; palpi neither geniculate or raptorial. *Eupodidæ*
  BB. Mouth-parts formed into a conspicuous beak; palpi either geniculate or raptorial. *Bdellidæ*

AA. Cheliceræ either falcate or needle-pointed, adapted for piercing.
  B. Legs usually adapted for swimming. Aquatic mites, Section Hydracarina
    C. Mouth-parts not situated on a beak. Fresh water mites, *Hydrachnidæ*
    CC. Mouth-parts situated on a more or less distinct beak. Marine mites *Halacaridæ*
  BB. Legs not adapted for swimming. Mites not aquatic.
    C. Legs composed of more than three segments; palpi provided with a thumb, except in degenerate forms, in which case they are fused with the maxillæ. Section Dactylognatha
      D. Cheliceræ falcate; palpi free, five-segmented and with the last segment always formed into a thumb.
        E. First and second legs provided with processes bearing large spines; integument with large chitinous shields, *Caeculidæ*
        EE. First and second legs without processes bearing spines; integument without any large chitinous shield.
          F. Cephalothorax with a rod-like structure at the bottom of a median dorsal groove; legs stouter and usually with swollen tarsi. *Trombidiidæ*
          FF. Cephalothorax without rod-like structure and median dorsal groove; legs more slender and tarsi never swollen. *Anystidæ*
      DD. Cheliceræ not falcate but either styletiform or needle-like; palpi frequently reduced in size and number of segments, and variously modified.
        E. Cephalothorax with a rod-like structure at the bottom of a median dorsal groove; tarsi not attenuated, but on the contrary frequently swollen; body well clothed with short setæ. *Erythraeidæ*
        EE. Cephalothorax without rod-like structure and median dorsal groove; tarsi tapering from base to apex; body sparesly clothed with setæ of varying lengths.
          F. Each tarsus provided with either a pectinate distal appendage or tenent hairs, or both of these; palpi moderate or small; phytophagous in habits.
            G. Adults with four pairs of legs; palpi free; never producing galls. *Tetranychidæ*
            GG. Adults with less than four pair of legs; palpi greatly reduced and united ventrally to form a trough for the needle-like cheliceræ; usually producing and inhabiting galls.
              H. Body not vermiform; adults with six legs; each tarsus provided with two claws and two "feather hairs;" gall makers. *Phytoptipalpidæ*
              HH. Body vermiform; adults with only four legs; each tarsus provided distally only with a single claw and "feather hair". *Eriophyidæ*
          FF. Tarsus usually without pectinate appendages and always without tenent hairs; palpi usually large; predaceous or parasitic in habits. *Cheyletidæ*
    CC. Legs stumpy and composed of only three segments; body vermiform. Parasitic mites. Section Brachypoda
      One family. *Demodecidæ*

UNDESCRIBED SPECIES OF CRANE-FLIES FROM NEW ZEALAND.

(Tipulidæ, Diptera).

By Charles P. Alexander.

The new species of New Zealand Tipulidæ described in this paper were included in extensive collections sent to the writer by Dr. Campbell, collected by Messrs. Gourlay, Harris, Howes and himself; collections from Dr. Tillyard and Mr. Philpott in the Cawthron Institute; and a small but interesting lot from the alpine zone of Mt. Ruapehu, sent by Mr. Watt. The writer is very greatly indebted to all the above mentioned gentlemen for this material. The holotypes are preserved in the writer's collection except where stated to the contrary.

Mr. F. W. Edwards, of the British Museum of Natural History, has recently completed a monographic review of the New Zealand Tipuloidea. The writer would express his most sincere gratitude to Mr. Edwards for the privilege of studying this manuscript in advance of publication. The appearance in press of this great work will do much to stimulate the study of the very interesting crane-fly fauna of New Zealand. In addition, the writer has availed himself of the opportunity to submit certain doubtful species of the very large genus *Gynoplistia* to Mr. Edwards for his expert opinion and comparison with the unrivalled series of types of New Zealand Tipuloidea in the collection of the British Museum.

Dicranomyia subviridis, sp. n.

General coloration light yellow; antennæ dark brown; wings nearly hyaline, the costa tinged with green; *Sc* ending far before the origin of *Rs*; *Rs* short, about equal to the deflection of R_{4+5}.

Male.—Length about 5.5 mm.; wing 6.5 mm. *Female.*—Length 6.2 mm.; wing 7.2 mm.

Rostrum pale obscure yellow; palpi light brown. Antennæ dark brown, the scapal segments very little paler; flagellar segments submoniliform in the female, slightly more elongate in the male. Head yellow, paler posteriorly, passing into gray on the genæ.

Mesonotum clear yellow, unmarked, scutellum and median area of scutum almost white. Pleura concolorous. Halteres pale, the knobs a little darker. Legs with the coxæ and trochanters pale, tinged with green; remainder of legs pale, the terminal tarsal segments dark brown. Wings nearly hyaline, iridescent, the veins strongly tinged with green, especially the outer end of costa. Venation: *Sc* short, Sc_1 ending far before the origin of *Rs*, the distance being nearly, if not quite, twice *Rs*; Sc_2 apparently lacking; *Rs* short, subobsolete, entirely without macrotrichiæ, subequal to, or shorter than, the deflection of R_{1+5}; cell *1st* M_2 closed; basal deflection of Cu_1 before the fork of *M*.

Abdomen pale brownish yellow, unmarked; in the female, the basal segments are infuscated but this is apparently due to dried egg-masses within the body; ovipositor reddish, the bases of the valves tinged with green.

Hab. New Zealand (South Island). *Holotype*, ♂, Nelson, November 8, 1920 (*A. Philpott*). *Allotopotype*, ♀, October 23, 1920. *Paratopotype*, ♀, October 23, 1920.

Type in the collection of the Cawthron Institute.

In its general appearance, *D. subviridis* is strikingly like *D. conveniens* (Walker), a very different fly. It belongs to the *monilicornis* group, distinguished by the short subcosta, very short sector and closed cell *1st* M_2.

Dicranomyia sperata, sp. n.

General coloration obscure brownish yellow; head dark brownish black; wings whitish subhyaline with conspicuous pale brown washes, the most conspicuous at the wing-tip; *Sc* long; *r* long and strongly arcuated; cell *1st* M_2 long and narrow, the basal deflection of Cu_1 at the middle of its length.

Female.—Length 9 mm.; wing 10.5 mm. Described from an alcoholic specimen.

Rostrum and palpi dark brown. Antennæ dark brown, the second scapal segment a little paler. Head dark brownish black.

Mesonotum light brownish yellow, the præscutum with three slightly darker brown stripes; scutal lobes also darker brown; scutellum more yellowish. Pleura obscure yellow, the mesosternum faintly darkened. Halteres obscure yellow, the knobs dark brown. Legs light brown, the femoral bases a little lighter, the terminal tarsal segments dark brown. Wings whitish subhyaline with conspicuous pale brown washes; cells *C* and *Sc* light brown; a brown wash along vein *Cu* and another near midlength of *1st A*; anal angle of wing faintly darkened; cord and outer end of cell *1st* M_2 narrowly seamed with brown; stigma elongate, brown; the most conspicuous brown wash occupies the wing-tip beyond cell *1st* M_2 including about the outer half of cells *2nd* R_1 and R_3; all except the base of R_5; all of *2nd* M_1; the cephalic half of M_3;

veins dark brown. Venation: *Sc* long, Sc_1 ending just beyond midlength of *Rs*, Sc_2 near mid-distance between the origin of *Rs* and the tip of Sc_1; *Rs* long, provided with seven macrotrichiæ; *r* very long and strongly arcuated, longer than the basal deflection of Cu_1, located at the tip of R_1; deflection of R_{1+5} angulated and spurred; cell *1st* M_2 long and narrow; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdominal tergites yellowish brown, the sternites a little darker with the incisures narrowly and indistinctly pale. Ovipositor with elongate valves.

Hab. New Zealand (South Island). *Holotype*, ♀ Mt. Grey, Canterbury, November, 1916 (*J. W. Campbell*). *Paratypes* ♀♀, Ben Lomond Otago, December 30, 1921, January 2, 1922, (Geo. Howes).

Amphineurus senex, sp. n.

General coloration brown; wings and legs unvariegated; *Rs* square at origin; R_{2+3} short but evident; cell 1st M_2 closed. *Male.*—Length 4.3 mm.; wing 5.5 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown; flagellar segments obscure yellow, with conspicuous erect, black verticils. Head greyish ochraceous, the vertex with very conspicuous, light yellow, scale-like hairs.

Mesonotal præscutum greyish ochraceous with two narrow dark brown intermediate stripes, very narrowly and indistinctly separated by a capillary pale line; lateral stripes not indicated; pseudo-sutural foveæ very conspicuous, elongate, lying transversely, dark brown; tuberculate pits lying a little cephalad of the level of the foveæ, pale, one on either side of the capillary pale line; remainder of mesonotum light brown. Pleura light brownish grey variegated with darker brown; a group of conspicuous yellow hairs beneath the wing-root. Halteres yellow, the stem, except the base, densely clothed with appressed, dusky scale-like hairs; apex of knobs yellowish. Legs with the coxæ and trochanters obscure yellow, the former clothed with yellow scale-like hairs; remainder of the legs dark brown. Wings greyish subhyaline, the veins and membrane densely clothed with brown macrotrichiæ to almost completely conceal the coloration; veins pale brown. Venation: *Rs* almost square at origin, feebly spurred; R_{2+3} short, about equal to the deflection of R_{1+5}; *r* on R_2 about twice its length beyond the fork; cell *1st* M_2 closed, long and narrow, gradually widened distally; *m* nearly three times as long as the outer deflection of M_3; basal deflection of Cu_1 just before the fork of *M*.

Abdomen dark brown, clothed with yellow hairs. Male hypopygium with the apices of the pleurites long-drawn-out, contiguous at their tips; the forceps at base of pleurites slender, acicular, curved, clothed on the inner face with pale erect hairs; second pair of forceps larger, black, compressed, the tips slender, curved and directed laterad.

Hab. New Zealand (South Island). *Holotype*, ♂, Old Man Range, Otago, January, 1920 (*Geo. Howes*). *Amphineurus senex* is allied to *A. perdecorus* Edwards.

Gynoplistia lyrifera, sp. n.

Head grey; mesonotal praescutum and scutum shiny brownish black, the lateral margins of the præscutum and the postnotum with a microscopic grey pubescence; scutellum obscure yellow; wings subhyaline with a heavy brown pattern; abdominal tergites bicolorous; gonapophyses of male hypopygium lyriform. *Male.*—Length 11 mm.; wing 10.6 mm.

Rostrum dark, dusted with gray; palpi dark brown. Antennæ with the first scapal segment dark brown; remainder of antennæ broken. Head light gray.

Pronotum light grey. Mesonotal præscutum shiny brownish black, more reddish near the suture, the humeral region and lateral margins conspicuously light grey; it is possible but scarcely probable that the specimen may be rubbed and the disk of the præscutum normally dull; scutal lobes shiny brownish black, the caudal lateral margin yellow, the caudal median area gray; scutellum conspicuously obscure yellow with a median spot at the base, the caudal margin with conspicuous setæ; postnotum shiny reddish brown with a sparse microscopic grey pubescence. Pleura brown with a heavy microscopic grey pubescence, the dorso-pleural membrane and the lateral sclerite of the postnotum brownish black, the latter heavily grey pubescent; mesosternum dark brown laterally, narrowly pale medially. Halteres with the stem obscure brownish yellow, the knobs broken. Legs with the coxæ pale brownish yellow, covered with a heavy whitish microscopic pubescence; trochanters obscure yellow; remainder of the legs broken. Wings subhyaline, heavily spotted and clouded with brown; cell *Sc* pale brown on the basal half; a large subquadrate dark brown spot at origin of *Rs*, not attaining *M;* stigmal area large, continued caudad along the cord to *r-m*, this area including the apices of cells *1st* R_1 and *R* and the bases of cells R_3 and R_5; remainder of cord and outer end of cell *1st* M_2 narrowly seamed with paler brown; wing-apex broadly pale brown, including the tip of cell R_2, a little less than the outer half of cells R_2 and R_5 and all of M_1 except the base which is clear; a pale brown cloud in the end of cell Cu_1; an extensive pale brown cloud occupies the basal half of cell *Cu* and the outer end of cell *1st A* above the end of vein *2nd A;* no darkening at base of cells *R* or *M;* veins dark brown. Venation; Sc_1 ending about opposite midlength of R_{2+3}; R_{2+3} and basal deflection of R_{4+5} subequal; tip of R_1 and *r* subevanescent, without macrotrichiæ; petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 at from two-thirds to three-fourths the length of the cell.

Abdominal tergites indistinctly bicolorous, the apical half of the segments shiny black, the basal half reddish brown with a sparse light

grey microscopic pubescence; a darker subterminal ring; hypopygium orange-yellow. Hypopygium with the pleurites short and stout, the caudal-proximal angle produced into a short stout lobe that bears a dense tuft of short bristles; a yellowish flattened lobe at base of pleurite on proximal face; the two usual pleural appendages are broadly united basally, the outer lobe broad-based, tapering distally, the tip suddenly narrowed into a curved point, not blackened or provided with spines; inner lobe broad-based, suddenly narrowed to the slender neck, the head slightly enlarged but unarmed. The two gonapophyses are very conspicuous, taken together appearing lyriform, each about as long as the pleurite, gently curved outwardly, deeply bifid at tip, the arms not divergent, lateral arm twice as long as the straight inner arm and curved strongly laterad. Penis-guard broad-based, tapering suddenly to the apex, much shorter than the gonapophyses.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*).

Gynoplistia trispinosa, sp. n.

General coloration reddish brown, the mesonotal præscutum more blackened, especially laterally; pleura whitish, the dorso-pleural region narrowly blackened; femora without pale rings; wings subhyaline with a very restricted pattern; abdomen reddish brown; male hypopygium with the outer pleural appendage a paddle-like, blackened blade; gonapophyses on either side with three spines. *Male.*—Length 14 mm.; wing 13 mm.

Rostrum reddish; basal segment of palpus reddish, the terminal segments dark brown Antennæ with the scapal segments yellow, the flagellum dark brown with only the base of the first segment a little paler; antennæ 21-segmented, the formula being 2+2+14+3; longest flabellation about six times as long as the segment. Head black, the occiput more reddish; a very faint, appressed, gray pubescence.

Pronotum brown, the scutellum shiny yellow, only slightly infuscated medially. Mesonotal præscutum shiny brownish black, the stripes entirely confluent, the median stripe tinged with reddish; humeral region reddish brown; remainder of mesonotum shiny reddish brown. Pleura reddish brown with a heavy, microscopic, white pubescence, the dorso-pleural region narrowly blackened; mesosternum more reddish. Halteres brownish yellow, the knobs darker. Legs with the coxæ heavily white pubescent as on the pleura; trochanters reddish; femora reddish brown, the tips slightly darker; tibiæ brown, the tips narrowly darker; tarsi dark brown. Wings subhyaline; cell *Sc* and stigma brown; a small, circular, brown spot at origin of *Rs;* very narrow brown seams along the cord and outer end of cell *1st* M_2; wing-tip in cells R_3, R_5 and M_1 very faintly clouded with brown; a faint brown seam along vein *Cu* to the wing-margin; a faint wash near midlength of vein *1st A;* veins

dark brown. Venation: *r* at tip of R_1 and at two-thirds R_2; cell M_1 only a little longer than its petiole; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdomen uniformly reddish brown; a very faint and indistinct, capillary, brown, median line, broadly interrupted at the posterior margin of the segments. Male hypopygium reddish brown; outer pleural appendage broad at base, the apex dilated into a dark brown paddle-like blade; inner pleural appendage with the apical half considerably narrower than the basal half and provided with numerous tiny setæ. Gonapophyses complex, each side with three spines; the most cephalic of these is the smallest and very slender; the second spine is a powerful horn directed proximad, lying immediately caudad of the basal spine; besides these there is an elongate spine on either side of the penis-guard, directed caudad, gradually narrowed to the tip. Penis-guard very small and weak.

Hab. New Zealand (South Island). *Holotype*, ♂, Otatara, Otago, November 25, 1906 (*A. Philpott*).

Gynoplistia spinigera, sp. n.

General coloration light gray; antennæ of male 17-segmented; wings sybhyaline, the pattern almost obliterated; stigma distinct; abdomen light brown with a subterminal black ring; penis-guard with conspicuous serrations before the apex. *Male.*—Length 11 mm.; wing 10 mm.

Rostrum light gray; palpi broken. Antennæ brown, the first scapal segment slightly dusted with gray; basal flagellar segment paler on basal half; antennæ 17-segmented, the formula being 2+2+9+4, the longest flabellation about four times the segment; eleventh flagellar segment with only a tiny protuberance and may not be considered pectinate by some, in which case the formula would be 2+2+8+5. Head light gray with a U-shaped mark on the vertex, the arms becoming evanescent behind.

Pronotum light gray. Mesonotal præscutum gray with four rust-brown stripes, the intermediate pair becoming obsolete behind, being replaced by the ground-color; lateral stripes much broader; humeral region darker gray; pseudosutural foveæ very large, deep reddish brown; scutum gray medially, the centers of the lobes darker; scutellum destroyed by pin; postnotum gray. Pleura pale reddish brown, dusted with gray. Halteres broken. Legs with the coxæ pale reddish brown, dusted with gray; trochanters yellow; femora and tibiæ brown, pale ring on femora almost obliterated; tarsi dark brown. Wings subhyaline, the pattern very reduced; cells *C* and *Sc* very pale brown; stigma conspicuous dark brown; a small brown cloud at basal deflection of R_{4+5}; very indistinct brown seams at origin of *Rs;* along the cord; a small, faint cloud at outer end of vein Cu_2 and another on vein *1st A* immediately above the end of vein *2nd A;* wing-tip clear; veins brown.

Venation: Sc_1 ending opposite one-fourth R_{2+3}, Sc_2 reduced to a point by the downward bending of *Sc;* *Rs* long, strongly arcuated at origin, in alignment with R_{2+3} which, in turn, is in alignment with R_3; r near midlength of R_2; *r-m* reduced, about equal to, or shorter than, *m;* petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 near midlength of the cell.

Abdominal segments light brown, the basal tergite dusted with gray; a small, circular, darker brown median spot on each tergite; seventh segment black; hypopygium light brown. Male hypopygium with the ninth tergite broad at base, narrowed distally, the apex with a broad V-shaped notch. Pleurites comparatively slender, the apex a little produced; a small, cylindrical lobe on proximal face at base; outer pleural appendage angularly bent just before midlength, the tip very obtusely rounded and here microscopically spinulose: two small spines immediately before the apex; inner pleural appendage smaller, the proximal face beyond midlength slightly notched. Gonapophyses not developed. Penis-guard long and straight, the apex slightly curved, before the tip the lateral margins of the guard with conspicuous serrations.

Hab. New Zealand (South Island). *Holotype,* ♂, West Plains, Otago, November 5, 1900. (*A. Philpott*).

Gynoplistia cladophora, sp. n.

General coloration shiny black; antennæ of male 16-segmented; wings with a faint yellow tinge; cell *Sc* dark brown; wing-pattern very restricted; abdomen dark reddish brown, shiny; gonapophyses of male hypopygium widely separated, each appearing as a slender curved horn that bears a small lateral spine near midlength. *Male.*—Length 9 mm.; wing 9.2 mm.

Rostrum black, bearing a conspicuous brush of long, yellow hairs; mouthparts and palpi black. Antennæ black, 16-segmented, the formula being 2+2+10+2; longest flabellation about seven times as long as the segment that bears it; pectination of twelfth segment shorter than the segment; terminal flagellar segment larger than the others. Head rather dull black.

Pronotum with a grayish yellow pubescence medially, shiny reddish laterally. Mesonotal præscutum shiny reddish laterally, with a sparse microscopic pubescence, the entire disk occupied by three confluent shiny black stripes; scutal lobes likewise largely shiny black, the remainder brown; scutellum brown; postnotum brown basally, shiny black on the posterior half; lateral sclerites of postnotum reddish brown. Pleura dark liver-brown, sparsely pubescent, most conspicuous on the mesepisternum. Halteres yellow. Legs with the coxæ dark brown; trochanters slightly paler brown; femora brown, the tips dark brown; tibiæ and tarsi black; legs comparatively short and stout.

Wings with a faint yellowish tinge; cells *Sc*, Sc_1 and a seam along vein *Cu* dark brown; stigma dark brown, continued caudad as a comparatively narrow seam along the deflection of R_{4+5}; cord, outer end of cell *1st* M_2 and most of the longitudinal veins very narrowly and indistinctly seamed with pale brown; a quadrangular brown area at origin of *Rs*, this not attaining *M;* wing-tip scarcely darkened; veins dark brown. Venation: Sc_1 ending just before the end of *Rs*, Sc_1 about twice Sc_2; *Rs* very long, angulated and spurred at origin; R_{2+3} short, about equal to or shorter than *r-m; r* at about two-thirds R_2; cell R_2 very wide at outer margin; inner ends of cells R_4 and *1st* M_2 proximad of inner end of cell R_5; petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Abdominal tergites shiny, dark reddish brown, the lateral margins more blackened. Hypopygium with the pleurites short and stout; a short spine on proximal margin at base; distal ends of pleurites produced caudad into a flattened, obtuse lobe that is about one-half the length of the pleural appendage; outer pleural appendage stout, flattened, with a conspicuous notch before the tip; inner pleural appendage subequal in length but more slender, gently curved. Gonapophyses very complicated in structure, widely separated from one another, each side appearing as a long, slender, curved horn that bears a small lateral spine near midlength; the long, curved apex is directed laterad, thence proximad and caudad, almost in a circle. Penis-guard small and slender.

Hab. New Zealand (South Island). *Holotype*, ♂, Bluff, Otago, November 29, 1914 (*A. Philpott*).

Gynoplistia spinicalcar, sp. n.

General coloration shiny yellowish brown; head coal-black; tibial spurs flattened, the margins microscopically serrulate; wings nearly hyaline, rather heavily marked with brown; a brown spot at the base of cells *R* and *M*. *Female.*—Length about 12 mm.; wing 8.3 mm.

Rostrum and palpi dark brownish black. Antennæ with the scapal segments reddish fulvous; flagellum broken. Head shiny coal-black.

Pronotum black dorso-medially, obscure yellowish laterally. Mesonotum shiny yellowish brown without well-defined markings; scutum shiny yellow. Pleura dark brown, the mesepisternum with an area of appressed, silvery-white pubescence. Halteres yellow, the knobs brown. Legs with the coxæ and trochanters yellow; femora yellowish testaceous, the dilated apices conspicuously and extensively blackened; tibiæ dark brown, the tips blackened; tarsi black; hind legs missing; tibial spurs flattened, narrowed basally, slightly enlarged distally and with the margin microscopically serrulate. Wings nearly hyaline; cell Sc_1, except the outer end, dark brown; a large brown blotch at origin of *Rs*, extending from *R* to *M;* stigma dark brown, the color continued caudad along the cord as a very broad seam that continues across the

wing, cell Cu_1 being dark except at the outer anterior angle; cell *1st* M_2 with a circular hyaline centre; wing-tip in cells R_2 to M_4 narrowly darkened; a conspicuous brown cloud at the end of vein *2nd A* including the adjoining parts of cells *Cu*, *1st A* and *2nd A;* a conspicuous, oval, brown spot at the origin of *M*, almost equally distributed in cells *R* and *M;* veins dark brownish black. Venation: Sc_2 at tip of Sc_1 and much exceeding it in length; *Rs* gently arcuated at origin; R_{2+3} shorter than *r-m;* R_2 almost perpendicular at origin; *r* near tip of R_1; petiole of cell M_1 about as long as the cell; cell *1st* M_2 rectangular, the basal deflection of Cu_1 just beyond one-third its length.

Abdomen with the basal tergites greenish black; remaining tergites brown with blue and purple reflexions; sternites lighter brown. Ovipositor reddish horn-color, the valves very long and slender.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 feet, March 1, 1919, (*T. Harris*).

The type of *Gynoplistia spinicalcar* was sent to Mr. Edwards for comparison with his numerous types of New Zealand Gynoplistiæ. He writes "Closely allied to *G. tridactyla* Edw. and *G. speciosa* Edw. but I think certainly distinct. Note the peculiar spurs of the middle tibiæ which are quite similar in the two species mentioned."

Gynoplistia harrisi, sp. n.

General coloration of mesonotum shiny brownish yellow; pleura shiny black, including the posterior and middle coxæ; legs orange, the femora with a conspicuous, dark brown, subterminal ring; wings with a strong yellowish tinge and a heavy brown pattern; cell R_2 sessile; abdominal tergites shiny obscure yellow, segments six to eight metallic purple. *Female.*—Length 8 mm.; wing 8 mm.

Rostrum obscure yellow; palpi dark brown. Antennæ with apparently only 14 segments, all flagellar segments, except the terminal four, pectinate; terminal flagellar segment enlarged, apparently formed by the fusion of two segments; scapal segments obscure chestnut-brown; flagellar segments one and two obscure yellow, the pectinations dark brown; remainder of the antennæ dark brown. Head obscure brownish yellow, somewhat darker between the eyes.

Pronotum obscure yellow. Mesonotal præscutum shiny brownish yellow with an indistinct, median, brownish black line; remainder of mesonotum shiny brownish yellow. Pleura shiny brownish black. Halteres short, pale, the large knobs darker. Legs with the posterior and middle coxæ shiny brownish black; fore coxæ obscure yellow; trochanters yellow; femora yellow with a narrow but conspicuous, subterminal, dark brown ring; tibiæ obscure yellow; posterior tibiæ

brown with the bases and tips paler; metatarsi obscure yellow, the terminal tarsal segments dark brown; the posterior legs are longer than the others, the femora somewhat swollen, the tibiæ more or less curved and only the terminal two tarsal segments infuscated. Wings with a strong yellowish tinge, brightest in cells *C*, *Sc* and *2nd A;* a conspicuous brown pattern distributed as follows: a brown area in the base of cell *R;* a large, quadrate area at origin of *Rs* that barely reaches *M;* the broad stigmal area extends as a solid block to cell *1st* M_2 where it splits, the center of the cell being of the ground-color; wing-tip broadly pale brown, including the apices of cells R_2, R_3, R_5, M_1 and *2nd* M_2; a conspicuous brown cloud in cells *Cu* and *1st A* at the end of vein *2nd A;* veins dark brown, more flavous in the yellow areas; microtrichiæ abundant in all cells beyond cord; in the radial cell they are practically lacking outside of the darkened areas. Venation: Sc_1 ending just before the tip of *Rs*, Sc_2 faint, at the tip of Sc_1; *Rs* long, feebly angulated at origin; cell R_2 sessile, the petiole entirely lacking; *r* close to tip of R_1; *r-m* very short, the deflections of R_{4+5} and M_{1+2} being correspondingly longer; petiole of cell M_1 a little shorter than the cell; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdominal tergites shiny obscure yellow; segments six to eight metallic purple; lateral margins of tergites narrowly blackened; ninth segment and ovipositor orange; basal sternites obscure yellow; subterminal segments dark. Ovipositor with the valves very long and slender, straight.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 ft., February, 1920. (*T. Harris*).

Gynoplistia harrisi is a very distinct species of the genus. It is dedicated to the collector, Mr. Thomas R. Harris.

Gynoplistia unimaculata, sp. n.

Allied to *G. cuprea* Hutton; a conspicuous, slender tubercle on lateral sclerite of mesonotal postnotum; wings yellow, unmarked except for the dark brown stigma; abdomen with the basal tergite purple, segments two to six orange-yellow. *Sex?*—Wing 12 mm. Head destroyed by insect pests.

Mesonotum shiny reddish brown. Pleura reddish brown, the mesepisternum and dorsal parts of the mesosternum with a golden-yellow pollen; ventral portions of the mesosternum with metallic purple reflexions; lateral sclerites of postnotum immediately cephalad of the base of the halteres with a conspicuous, slender tubercle, directed laterad and slightly caudad. Halteres yellowish ochreous. Legs with the coxæ and trochanters reddish brown; femora light orange; tibiæ dark brown, the extreme base paler; tarsi dark brown. Wings with a strong brownish yellow tinge, clearer yellow in the costal region and the cells basad of the origin of *Rs*; no markings on the wing except the conspicuous, dark brown stigma; veins dark brown, more yellowish in

the flavous areas. Venation: Sc_1 ending beyond the fork of *Rs*, Sc_2 longer than Sc_1; R_{2+3} shorter than the deflection of R_{4+5}.

Abdomen with the basal tergite brilliant, dark metallic purple; segments two to six conspicuous orange-yellow with very faint purplish tints on the sternites; no trace of the coppery tints of *G. cuprea*.

Hab. New Zealand. *Holotype*, Sex?, exact locality unknown (Received from Dr. Campbell).

Although the unique type of this species is in poor condition, there can be no question of its specific validity. The almost unicolorous yellow wings with the stigma dark brown render the fly a conspicuous one.

Gynoplistia splendens, sp. n.

General coloration shiny reddish brown; antennæ 19-segmented; mesopleura with a patch of golden-yellow hairs; a conspicuous tubercle on mesepimeron; femora fulvous; wings bright yellow, marked with brown, including a broad apical and caudal margin. *Female.*—Length about 19 mm.; wing 15.5 mm.

Rostrum shiny yellowish brown; palpi dark brown. Antennæ dark brown; antennæ 19-segmented, the formula being 2+2+9+6; the twelfth flagellar segment bears a small lateral tubercle that is shorter than the segment but which might be considered as being a pectination, in which case the formula would be 2+2+10+5; longest flagellar pectination between three and four times as long as the segment. Head shiny brownish red, black between the eyes.

Pronotum dark reddish brown. Mesonotum shiny reddish brown, the median area of the præscutum almost black; median sclerite of postnotum paler laterally. Pleura dark chestnut brown with an extensive area of short, dense, appressed, golden-yellow hairs on mesepisternum and cephalic margin of mesepimeron; dorsal margin of mesepimeron, immediately beneath the wing-root, produced laterad and caudad into a stout, conspicuous tubercle. Halteres dark brown, the knobs conspicuously orange-yellow. Legs with the coxæ and trochanters dark chestnut-brown; femora rich fulvous, the tips narrowly blackened; fore tibiæ brown, the tips dark brown; mid-tibiæ reddish brown, near midlength passing into dark brown; posterior tibiæ fulvous, concolorous with femora, only the tips narrowly blackened; tarsi black. Wings bright yellow with a rather extensive brown pattern; a large spot at origin of *Rs*, barely confluent with the proximal end of a conspicuous brown seam along the distal half of vein *M*; the stigmal area includes the outer end of cell *Sc*, base of Sc_1 and a broad seam along the cord and outer end of cell *1st* M_2; wing-tip broadly and conspicuously infuscated, extending from cell R_2 to the end of *2nd A*, in cell *1st A* continued basad along vein *1st A* to beyond one-third the length of the

vein; vein *Cu* narrowly seamed with dark brown Venation: Sc_2 much longer than Sc_1; *r* at tip of R_1; R_{2+3} shorter than *r-m;* petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 just before midlength of the cell.

Abdomen shiny dark brown with conspicuous coppery and purple reflections as in the *cuprea* group. Ovipositor with the valves gently upcurved, reddish horn-color.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 feet, February 15, 1920 (*T. Harris*).

Gynoplistia splendens belongs to the *cuprea* group. The unique type was submitted to Mr. Edwards who has kindly compared it with related species in the British Museum. He writes "Rather near *tuberculata* Edw. and *cuprea* Hutton but equally distinct from both." The collector states that this fly mimics a Hymenopterous insect, determined by the British Museum authorities as *Prionocnemis wakefieldi* Kirby.

Macromastix flavoscapus sp. n.

General coloration light yellow, including the frontal prolongation of the head and the first scapal segment; mesonotal præscutum with three brownish black stripes, the median stripe ending near midlength of the sclerite; each scutal lobe with two brownish black spots; a small spot on each side of scutellum; pleura yellow, in some cases with a small spot above the fore coxa and middle coxa; wings subhyaline, the costal region and stigma brownish black; wing-tip narrowly darkened; abdomen yellow, the tergites with three narrow black stripes. *Male.*—Length 12.5 mm.; wing 18 mm.

Female.—Length 12 mm.; wing 18.5 mm.

Frontal prolongation of the head entirely light yellow, only the tip of the slender nasus a little darkened; palpi black. Antennæ short in both sexes; first scapal segment entirely light yellow; remainder of antennæ black. Head light yellow, unmarked.

Pronotum yellow, unmarked. Mesonotal præscutum orange-yellow with three brownish black stripes, the lateral stripes remote from the median stripe the latter tending to be evanescent behind, always indicated on the anterior half of sclerite, replaced by deep orange posteriorly; scutum yellow, each lobe with two black areas, the largest lying more proximad and caudad; scutellum orange-yellow with a small black spot on the caudal margin on either side of the median lobe; postnotum orange-yellow. Pleura orange-yellow; in some cases a small black spot above the fore and one above the mid-coxa. Halteres brown, the extreme base of the stem yellow, the knobs darker brown. Legs with

the coxæ orange-yellow; hind and mid trochanters brownish black; fore trochanters yellow with a black spot on the lower face; remainder of the legs black, the fore femora narrowly yellow basally. Wings nearly hyaline, the extreme tip clouded with darker; cells *C*, *Sc* and the stigma dark brownish black; veins black. Venation: *r* present; petiole of cell M_1 variable in length, sometimes longer than *r-m*, in some cases entirely lacking.

Abdomen light yellow, the tergites with three narrow black longitudinal stripes, the median stripe narrower than the yellow sublateral stripes; caudal margin of tergite seven and all of segments eight and nine black; sternites with a narrow median stripe.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*). *Allotopotype*, ♀. *Paratopotype*, ♂.

Macromastix atroflava, sp. n.

General coloration orange-yellow; antennæ and palpi black; a capillary black line on vertex; mesonotal præscutum with three stripes; legs black, the coxæ and trochanters orange; wings subhyaline, the costal region and stigma dark brown; abdomen yellow, the tergites with three, narrow, black, longitudinal stripes. *Male.*—Length 11.5–12 mm.; wing 16 mm. *Female.*—Length 11 mm.; wing 14 mm.

Frontal prolongation of the head yellow, the nasus and a linear triangle behind it, black; palpi black. Antennæ dark brownish black throughout. Head yellow with an elongate, capillary dark brown streak on vertex.

Pronotum entirely light yellow. Mesonotal præscutum orange-yellow with three conspicuous black stripes that are narrowly margined with brown; in the paratype, and less distinctly in the allotype, the stripes are entirely black; median stripe narrowed behind, not attaining the suture; lateral stripes narrower, crossing the suture and suffusing the lateral margins of the scutal lobes; remainder of mesonotum orange-yellow, immaculate. Pleura orange-yellow, immaculate, the dorso-pleural region light yellow. Halteres dark brown, the base of the stem narrowly orange. Legs with the coxæ and trochanters orange; remainder of legs black. Wings subhyaline, the costal region and stigma dark brown, this including cells *C*, *Sc*, Sc_1 and the stigma; wing-tip, in cells R_2, R_3, and R_5 very indistinctly darkened; veins dark brown, slender. Venation: *Rs* about one-third longer than R_{2+3}; petiole of cell M_1 very short, about equal to or a little longer than, *r;* basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Abdomen yellow, the basal tergite orange, the caudal margin of the other tergites except the last two, narrowly orange; tergites narrowly trilineate with black, the broad, yellow, sublateral stripes from two to three times as wide as the mid-dorsal black stripe; segments eight and nine black.

Hab. New Zealand (South Island). *Holotype*, ♂, Blackball, West Coast, December 1916 (*J. W. Campbell*). *Allotopotype*, ♀, December, 1917. *Paratopotype*, Sex?, with the type.

Macromastix lunata fuscolatera, subsp. n.

Female.—Length about 12 mm.; wing 16.5 mm.

In general appearance, very similar to *M. lunata* Hutton, differing as follows:

Head and thorax with the erect, pale hairs much less conspicuous than in *lunata*, these being short and subappressed.

Head dark brown, the lateral margins of the vertex adjoining the eyes broadly ochreous. Mesonotal præscutum light gray with three distinct, dark brown stripes, the broad median stripe narrowly split by a capillary pale line; scutal lobes with dark centers; remainder of mesonotum and the pleura light gray. Legs with the coxæ gray; trochanters yellow; femora and tibiæ light yellowish brown, the tips dark; tarsi dark brown. Wings brown, the stigma darker; wing-tip entirely dark; an interrupted subhyaline, lunate band in cell *M*, the proximal end barely extending into cell *R*, the distal end occupying the outer end of cell *R*, this subhyaline band narrowly interrupted across cell *M*; cell R_5 clear except the extreme outer angle; basal half of cell R_5 subhyaline; bases of cells *Cu*, *1st A* and *2nd A* pale. Venation: cell *2nd A* narrower than in *lunata*.

Abdomen with the four basal tergites dull rufous, with three very broad and conspicuous blackish stripes; extreme lateral margins of these tergites, and the succeeding segments, dusted with gray, more whitish on the lateral margins of tergites five and six. In typical *lunata*, the erect setæ on the head and thorax are much more conspicuous; basal abdominal tergites unmarked except medially; basal half of tergite two clear gray, in marked contrast to the posterior half and the other basal tergites. I have before me one of Hutton's paratypes of *lunata*, through the kindness of Mr. R. Speight. It is possible that the male of this species will be found to have short antennæ, in which case the form would take full specific rank.

Hab. New Zealand (North Island). *Holotype*, ♀, Mt. Ruapehu, alpine zone, 4000–5000 feet, January, 1921 (*M. N. Watt*). "In thick bush."

Macromastix intermedia, sp. n.

General color gray, the præscutum with four brown stripes; wings comparatively long and narrow, dark brown, with a subhyaline vitta extending from before midlength of the wing in cells *R* and *M*, through the bases of cells R_2 and R_3 to the margin, narrowly interrupted along the cord; cells M_1, *2nd* M_2

and M_3 pale; abdomen beyond the basal segment dark grayish brown throughout. *Male.*—Length about 9 mm.; wing 14 mm.

Frontal prolongation of the head gray, more brownish laterally; nasus very long; palpi dark brown. Antennæ very short, brown. Head grayish brown, paler gray adjoining the inner margin of the eyes.

Mesonotal præscutum gray with four brown stripes, the intermediate pair only narrowly separated by a capillary line; scutum pale buff, each lobe with a brown discal area; scutellum and postnotum pale buff. Pleura gray. Halteres dark brown. Legs with the coxæ gray; trochanters brownish yellow; remainder of the legs broken. Wings comparatively long and narrow, more than four and one-half times as long as wide; dark brown with a conspicuous, subhyaline, vittate pattern, this appearing as a lunate area in the outer end of cell *M*, including also the distal end of *R* and the proximal end of *1st* M_2; bases of cells R_2 and R_3 rather narrowly pale; cells M_1, *2nd* M_2 and M_3 and the bases of cells *Cu*, *1st* A and *2nd A* are much paler than the ground-color; veins dark brown. Venation: Basal section of M_{3+4} subequal to basal section of M_{1+2}; petiole of cell M_1 about equal to *m;* cells M_1, *2nd* M_2, M_3 and Cu_1 deeper than in *M. alexanderi* Edw.; cell *2nd A* narrower than in *alexanderi* but wider than in *M. vittata* Edw.

Abdomen dark grayish brown throughout, only the basal tergite a little paler; ninth tergite of male hypopygium with a deep notch.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*).

Macromastix hudsoniana, sp. n.

Size small (wing of ♂ under 10 mm.); antennæ of male longer than body; general coloration pale brown, the præscutum quadrivittate with darker brown; thorax without conspicuous erect setæ; wings with a brown tinge, cells *C*, *Sc* and the stigma darker brown. *Male.*—Length 7 mm.; wing 9.5 mm.; antenna 10 mm.

Frontal prolongation of head brown; palpi dark brown. Antennæ of male elongate, greatly exceeding the body, dark brownish black throughout; first flagellar segment a little longer than the combined scapal segments, only indistinctly separated from the second flagellar segment; flagellar segments beyond the third gradually decreasing in length, the last segment very small, subglobular; flagellar segments six to nine each with a pair of long, verticillate bristles immediately before midlength. Head brown, more grayish adjoining the inner margin of the eyes.

Mesonotal præscutum pale brownish testaceous with four darker brown stripes; scutum similar, the lobes darker brown; scutellum and postnotum brownish testaceous; mesonotum subglabrous. Pleura pale

grayish pruinose. Halteres brown, the knobs a little darker. Legs with the coxæ and trochanters brown; femora, tibiæ and metatarsi light brown, the tips dark brown; remainder of tarsi dark brown. Wings with a strong brown tinge; cells C and *Sc*, and the stigma, darker brown; veins dark brown. Venation: *Rs* rather long, about one-third longer than R_{2+3}; basal section of R_2 about one-third the distal section; petiole of cell M_1 longer than the cell; basal deflection of Cu_1 fused with *M* at about two-fifths the length of cell *1st* M_2; cell *2nd A* comparatively narrow.

Abdomen uniformly dark brown, the hypopygium and preceding segment brighter.

Hab. New Zealand (South Island). *Holotype*, ♂, Port Hills, Banks Peninsula, Canterbury, February 8, 1917.

Macromastix hudsoniana is distinguished from all described species by the combination of small size, subglabrous thorax and elongate male antennæ. It is named in honor of the veteran student of New Zealand Tipulidæ, George V. Hudson to whom I am indebted for many favors.

THE SYRPHID GENERA HAMMERSCHMIDTIA AND BRACHYOPA IN CANADA.

By C. Howard Curran,
Orillia, Ontario.

In presenting the present paper the author must offer apologies for its evident incompleteness, as it has been found impossible in the short time available to complete the drawings so necessary to illustrate the distinctive characters in a genus which is evidently somewhat confusing. A paper on the genus *Sphegina* was practically completed, with the necessary drawings, when it was learned that Dr. C. L. Metcalf already had a paper prepared on this genus, and it was therefore decided to review the genera indicated in the title, in so far as they are known in North America, with especial reference to the Canadian species.

According to my observations it is essential, in dealing with the majority of genera of *Syrphidæ* which occur in Canada, to include practically all the North American species, in any discussion which relates to their classification. For this reason the scope of the present paper is larger than the title may indicate.

Both *Hammerschmidtia* and *Brachyopa*, as genera, cannot be looked upon as well represented in most collections, although it seems that none of the species can be regarded as actually rare, and are, with the exception of *B. gigas*, probably of general distribution, and occur over the greater part of the United States and Canada. In Ontario I have records of six species of *Brachyopa* and one species of *Hammerschmidtia*. While the genitalia are not discussed in the present paper, they have been studied, and in every case bear out the apparent specific limitations.

Brachyopa Meigen.

Medium sized flies; head narrower than the thorax; face moderately produced downwards and forwards, concave, not tuberculate; antennæ short, third joint oval, rarely more roundish; arista basal, bare, pubescent or short plumose; eyes touching for a greater or less distance, bare; front in female narrowed above. Thorax a little narrowed in front, usually with some stouter hairs on the meospleuræ

above, on the postalar callosities and on the margin of the scutellum, which is rather large, squarish or more or less triangular. Abdomen roughly triangular in shape, broader, and not much longer than the thorax, broadest at the second segment, thence quickly narrowing to the apex, but less so in the female. Legs simple, the femora a little strengthened, and usually with short bristles below, especially the hind pair. Wings longer than the abdomen, anterior cross-vein before the middle of the discal cell, first posterior cell ending in an acute angle near the apex of the wing. Squamæ of medium size.

GENERIC RELATIONSHIP AND LIMITATION.

It seems that this genus cannot really claim close relationship to other genera found in North America, although certain characters indicate a common origin with several genera. In Europe it is even more isolated. I cannot agree that *Hammerschmidtia* is very closely related, because in that genus the wing venation is quite distinct, the face bears a distinct tubercle in the male, the tibiæ are all armed with spines, as are the femora, and the thorax and scutellum bear strong bristles. The fact that both may possess plumose arista does not constitute a close affinity.

It is perhaps as well to clear up the question of these two genera here. I would distinguish between them as follows: In *Hammerschmidtia* the abdomen is slender, twice as long as the thorax; the face is tuberculate in the male; thorax armed with very evident spines; the legs are armed with spines and the anterior four tibiæ terminate in a row of bristles; the first posterior cell is not acute, and ends well from the apex of the wing. In *Brachyopa* the abdomen is triangular, only a little longer than the thorax, the face is concave in both sexes, the thorax has sometimes very small bristles, the legs may have spines below the femora, but not elsewhere; the first posterior cell is acute and ends near the apex of the wing. Thus it will be seen that even leaving the plumosity of the arista out of consideration, there are ample grounds for separating the two genera.

The genus which appears to be most closely allied to *Brachyopa* is *Chalcomyia*, notwithstanding the separated eyes in the latter genus. The shape of the abdomen is very similar, the eyes of several species of *Brachyopa* are not actually contiguous, the facial profile is more similar, and the wing venation is identical. Moreover, I have taken representatives of both

genera together, and both occur early in the season. *Myiolepta* is probably closer to *Brachyopa* than is *Hammerschmidtia*, as is demonstrated by the maculation of the wings, the venation, and the facial profile of the females, but it differs in having the slender abdomen, as in *Hammerschmidtia*, except in *M. bella* Will., from the Pacific coast.

BIOLOGY.

I have not observed the immature stages of any species of *Brachyopa*, but according to Lundbeck, they are fairly well known. In Diptera Danica, part v, pp. 386-7, Lundbeck deals extensively with what had previously been published regarding the developmental stages. The conclusion arrived at (and bearing his own observations) is as follows: That the larvæ live in sap exuding from trees; the eggs are laid in the spring of the year, and the larvæ pass the summer feeding upon the sap, and hibernate in the autumn; pupation takes place in the spring, and the life cycle is completed with the emergence of the adult; there is only one brood. That this applies to the American species is borne out by what has already been published on the subject, and also by my own observations regarding the occurrence of the flies.

HABITAT AND HABITS OF THE ADULTS.

Both Verrall (British Flies, Vol. VIII) and Lundbeck state that the adults occur about exuding sap, upon which they apparently feed. While I have never observed them in such places I must say that the woods in which I found them so abundant in 1921 was in process of extermination, and hundreds of tree trunks were exuding sap. Muscids were swarming around these when I examined them in April in the hope of finding *Merapioidus villosus*. Also in the other woods where I took specimens many trees had exuding sap.

The species of *Brachyopa* all occur early in the season and specimens taken after the middle of June in Ontario must be looked upon as unusual captures. During 1921 I was able to do considerable collecting during May and June, and collected on Wild Plum and several species of Wild Cherry for the first time, which resulted in many things new to me, including six species of *Brachyopa*, one of which proved to be undescribed. The first specimen was captured on May 4th,

and was teneral. It was taken on wild black cherry. I had observed several specimens on plum blossom in a neighbor's garden about a week earlier. It is therefore safe to say that specimens may be looked for from the time plum begins to bloom, until towards the latter part of June. Choke cherry bloom followed the black cherry, and while not as productive, a stray specimen was taken. The vast majority, however, were taken in open, sub-swampy woods on bloom of Asmorrhiza clatoni, and in a single hour I captured over forty specimens, including four species. Where they appeared from so suddenly I cannot imagine, as I had collected in the same spot for several days previously without a sign of one. This was in June, and by the 14th they had disappeared entirely, having been present for less than a week.

The adults are rather peculiar in habit, and invariably appear to arrive on a blossom from nowhere. Only one specimen was observed arriving on bloom and it appeared to fly quickly, and settle solidly at once and commence feeding. They are diligent feeders, and hence are usually easy to capture. Unlike *H. ferruginea*, they frequently are found high up on a tree.

DISTRIBUTION.

In Ontario I have taken six of the ten known species, and in view of the fact that some of these are recorded from the Pacific coast, while others are supposedly more or less southern, I conclude that all the species may be expected to occur at least in the northern States and Canada, with the exception that *B. gigas* Lovett probably occurs only in the Rockies and west. *B. media* was described from California, but occurs in Ontario, while *B. notata*, originally described from New Hampshire, occurs in British Columbia, Oregon and Washington Territory.

CHARACTERS USED IN CLASSIFICATION.

Several of the characters which might be used in classification are not employed here because they are often open to dispute and may cause confusion. One such character is the pilosity of the arista, which may vary somewhat in the same species, as is the case in the British Columbia specimen of *B. notata*, which has the pile distinctly longer than in any of the eastern specimens which are before me. While the structure of the

genitalia in the male is of great importance and of unusual value in this genus, as has been explained, they are not employed in the descriptions, as it is my belief that they must be demonstrated by means of drawings to be of greatest value, especially when the use of this character is still in its infancy.

The characters chiefly used are the color of the thorax and abdomen, and it may be safely said that this is sufficiently stable to permit of identification with certainty; and moreover, the structure of the hypopygia bears out the specific limitations in every case where I have males. I am therefore able to state that at present the only species of which there might be any doubt are *B. media*, *flavescens* and *rufiabdominalis*, all of which are closely related to *B. bicolor* of Europe. I do, however, believe the species mentioned above to be distinct, although one of the American species may be *B. bicolor*. Dr. Johnson* also remarked upon the constancy of the thoracic lines and abdominal coloration. It frequently happens that the terminal abdominal segments may appear darkened, but this is due to internal coloration and not to the pigmentation of the chitinous material.

TABLE OF SPECIES.

1. Second and third abdominal segments with posterior pollinose bands.....2.
   Second and third segments without such bands.....3.
2. Thorax with anterior median darker stripes and interrupted sublateral stripes; all the abdominal segments with roundish shining spots on each side. (Length about 5 mm.).....*cynops* Snow.
   †In addition to the stripes as in *cynops*, the thorax with a roundish spot at inner ends of the suture and a slightly oblique stripe on each side posteriorly, second and fourth segments entirely shining anteriorly, *diversa* Johns.
3. Abdomen entirely black.....*daeckei* Johns.
   Abdomen ferruginous, yellowish, or partly yellow.....4.
4. Last two or three segments shining black; second segment chiefly translucent yellowish.....*vacua* O. S.
   Abdomen not so maculated.....5.
5. Abdomen with median longitudinal stripe, interrupted before the sutures or entire; or arista distinctly plumose.....6.
   Abdomen without median longitudinal stripe.....8.
6. Thorax grayish black or slaty; abdomen luteous.....*perplexa* Curr.
   Thorax ferruginous or yellowish red.....7.
7. Thorax and abdomen ferruginous (about 10 mm.).....*gigas* Lovett
   Thorax more yellowish red, with lighter stripes; color of abdomen more clear yellow (8 mm.).....*notata* O. S.
8. Thorax reddish yellow; at any rate not at all blackish on the posterior half.....*flavescens* Shan.
   Thorax blackish.....9.
9. Eyes narrowly separated, most nearly contiguous near the ocelli, *rufiabdominalis* Jones
   Eyes distinctly contiguous, the vertical triangle long and narrow..*media* Will.

*Can. Ent., Vol. XLIX, p. 361, (1917).

†The character of most importance here is the color of the abdomen. Snow's description of thorax was incomplete.

Brachyopa cynops Snow.

Length 5 mm. Female. Head light yellowish brown, largely concealed beneath glistening pollen; the shining ground color shows just above the antennæ and in a stripe on the cheeks, extending from the eye to the mouth opening. Antennæ wanting. Dorsum of thorax brown, covered with grayish pollen, anteriorly with two approximated linear blackish stripes; laterally with a broad interrupted stripe. Scutellum light brown, with yellowish pollen. Abdomen but little longer than broad; yellowish gray pollinose; second segment with a circular brown spot on the anterior corners; the two following segments are marked with corresponding elliptical spots, and, in the middle anterior border with a triangular spot; on the fifth segment are two small round spots. Legs uniformly reddish brown, with light colored pollen and short whitish pile. Wing hyaline, distinctly clouded at anterior cross-vein, on the veins at the anterior outer corner of the discal cell and on the ultimate section of the fourth vein; posterior cross-vein about as long as the ultimate section of the fourth vein, the included angle obtuse. One specimen, Colorado. (Snow).

Snow does not state the sex, but the figure is that of a female; also the figure shows the posterior oblique stripes on the thorax as in *diversa*, but not the spot inside the suture.

Brachyopa diversa Johnson.

Abdomen with grayish yellow pollinose posterior bands, the second segment chiefly pollinose.

Length, 6 to 8 mm. Male. Face and front brownish red, covered with whitish pollen which leavse the oral margin in front, a spot above the antennæ and a stripe on the cheeks, shining brownish. Antennæ brownish red, the first joint darker, shining. Vertical triangle blackish, with short brown pile; posterior orbits brownish red, pollinose, with whitish pile. In profile the face is concave above, a little convex below, prominent below, and moderately produced downwards. Eyes practically touching, the vertical triangle long and narrow. Dorsum of thorax grayish pollinose, leaving shining brownish stripes as follows: a median pair on the anterior two-thirds, an interrupted stripe on each side of these, and the sides of the dorsum, a slender median one in front of the scutellum, slightly oblique ones running from the corners of the scutellum to just outside the ends of the antero-median stripes, and a spot on the inner ends of the suture. Pleuræ brownish red, with lighter pollen. Pile of the dorsum black, but with yellowish pile between the humeri and across the posterior margin: pleuræ with yellowish pile, a cluster of black hairs on the upper part of the mesopleuræ. Scutellum reddish, yellowish pilose, with a few longer, but not bristly hairs on the margin. Abdomen shining black, the first and second segments grayish yellow pollinose; second segment with a median longitudinal line, not reaching the posterior margin, and an oval spot, reaching the sides, on the anterior portion, shining black; third and fourth segments shining

black, with the hind margins grayish yellow pollinose, the pollen extending forward in the middle to the anterior third, but there is a roundish notch centrally in front, corresponding to the median stripe on the second segment. Hypopygium yellowish red. Abdomen with light yellow pile, longer basally. Legs black, anterior four trochanters, tips of the femora, the anterior ones beneath apically, basal third of tibiæ, tips of the tibiæ and tips of the tarsal joints, luteous or yellow. Wings slightly yellowish anteriorly, the veins all a little crowded, the region of the anterior cross vein and a streak between the spurious vein and the fourth vein beyond the cross-vein, brownish; wings more yellowish basally.

Female. Front golden yellow pollinose, leaving the ocelli and a streak in front shining black, a large area above the antennæ, cut off truncately above, and the face below, on the sides, shining yellowish, although the lower part of the face is slightly pubescent. The pollen on the thorax and abdomen is more yellow; fifth abdominal segment yellow pollinose, except an anterior broadly interrupted cross-band; third antennal joint broader, a little darker.

Description drawn from 9 specimens, taken at Orillia on May 5th to 18th, 1921.

This species is easily distinguished from the preceding by the less pollinose abdomen, as the anterior half of the median segments is wholly shining, whereas in *cynops* there are very distinct oval shining spots on the anterior angles, the balance of the segment being shining.

Brachyopa vacua O. S.

Abdomen with the second segment pallidly yellowish, the apical segments shining blackish.

Length, 7 to 9 mm. Male. Face and front of a dirty yellowish color, clothed with whitish pollen, which leaves a brown stripe on the cheeks and an area above the antennæ shining. Antennæ colored as the face, arista black, and almost bare. Vertical triangle long, the eyes touching for only a short distance, a distinct median groove in front of the ocellar triangle, which is brownish; occiput with grayish pollen and head with entirely pale pile. Dorsum of thorax obscured by grayish yellow pollen, which leaves the usual double median stripe, an interrupted stripe on each side and a spot above the wings, brownish. The pleuræ are ferruginous, the sternum blackish, but thickly whitish pollinose. Pile of thorax yellowish on the dorsum, whitish on pleuræ. Scutellum luteous yellow, subtranslucent, squarish, with short, white pile. First abdominal segment brown, the anterior angles yellowish, the whole whitish pollinose; second segment except the apical sixth, the lateral margin posteriorly and a median dash, usually not reaching the black posterior border, shining yellowish. The rest of the abdomen, except the small anterior angles of the third segment, which are yellowish, shining brownish black. Pile wholly white. Legs brownish, the femora thinly

whitish pollinose; coxæ, trochanters and bases of the femora narrowly, tips of the femora, bases of the tibiæ and their tips and the first one or two tarsal joints more or less yellowish or luteous. Hind femora a little produced beneath near the end. Wings a little darkened, yellowish basally.

Female. Similar. Front, except the shining yellowish area above the antennæ which is thinly whitish pollinose, brownish, and with reddish brown or grayish pollen. (Neither of my specimens have the front as light colored as indicated in Osten Sacken's description.) One male has the narrow, irregular anterior margin of the third abdominal segment yellow, and the thorax a little more brownish.

It is probable that the type specimen was teneral. The species was originally described from Quebec, but since that time, except for a single specimen recorded by Williston from California, it has apparently not been recorded. The above description is drawn from eight specimens taken at Orillia, May 4th to 30th, 1921.

This species cannot well be confused with any other in the genus.

Brachyopa daeckei Johnson.

"Length, 6 mm. Front black, grayish pollinose, a shining spot above the base of the antennæ, yellow, bordered with black; face below the antennæ grayish pollinose, sides shining, yellow, with two spots of black, antennæ dark yellow, arista brown. Thorax black, grayish pollinose, with five sub-shining lines, the three inner ones slightly diverging, but not reaching the scutellum. Pleuræ brownish grayish pollinose, scutellum brown, the apical half much lighter than the base Abdomen black, shining, hairs white. Legs brown, hairs white, outer half of the posterior femora blackish, tarsi yellowish; halteres yellow. Wings hyaline, veins brown, stigma yellow, anterior cross-vein slightly clouded with brown, tegulæ white.

"One specimen, Castle Rock, Delaware County, Pa., May 19, 1902, collected by Mr. V. A. E. Daecke. This specimen has been referred to as a dark variety of *B. media* (Psyche, Vol. XVII, p. 230, 1910) but further study in connection with the following species convinces me that it is distinct." (Johnson).

Brachyopa rufiabdominalis Jones.

"Length, 7 mm. Face light reddish brown, prominently produced forward, with light, silvery, glistening pollen and very fine white pubescence; slightly concave beneath the antennæ; frontal triangle shining, prominent, with or without a median suture. Cheeks a little darker red than the face and with a shining stripe from the eye to the oral margin; sparsely covered with long white pile. Antennæ situated on a semi-conical projection, of the same general color as the face, but slightly darker; first joint about half as long as the second, of a slightly

deeper red than the third, dorsally, with a tuft of black hairs on each joint; third joint light red, about as long as the first two together, ovate; arista basal, bare. Vertex black, frontal portion with or without silvery pollen, eyes narrowly separated. Dorsum of thorax brown, with black pile, covered with grayish pollen, anteriorly with two approximate dorso-medial blackish stripes, laterally with a broad interrupted stripe; the transverse suture deep, shining; humeri with a reddish spot; pleuræ reddish brown; a reddish brown stripe extending from the scutellum to the base of the wing. Scutellum light reddish brown, beset with blackish and reddish pile, shining, with a very narrow median light stripe; abdomen slightly longer than the thorax, but little longer than wide, light reddish brown and entirely shining, with reddish pile; the posterior portions of segments one, two and three with a posterior shining, brownish, transverse band, either entire or interrupted in the middle. Legs of the same color as the abdomen, principally with light colored pile, on the under side of the hind femora and the apex of the anterior four femora with stout black pile; tarsi darker brown, light at apex; hind basitarsi slightly thickened at base and thence gradually tapering to apex. Wings hyaline with a reddish tinge, anterior cross-vein before the middle of the discal cell and almost rectangular. (Colorado). (Jones).

"*B. rufiabdominalis* differs from *B. cynops* in that the scutellum and abdomen are entirely shining, etc. Differs from *B. bicolor* of Europe in that the occiput of the latter is pale gray and with gray pile, the face is without pubescence, the eyes touch for about one-third the distance from the ocelli to the antennæ; the scutellum has eight long marginal hairs and is covered with short black pile, while in *rufiabdominalis* the occiput is black, whitish pollinose and has black and whitish pile; the face has fine whitish pubescence on it; the eyes are distinctly separated, the nearest point of contingency being immediately below the ocelli; the scutellum has black pile dorsally, and the remainder is covered with reddish pile and lacks the eight black marginal bristles." (Adapted from Jones). For further remarks see *B. media* Will.

Brachyopa media Will.

Small, dorsum of thorax blackish or slaty, abdomen reddish yellow, the hind borders of the segments narrowly brownish; front in female brownish.

Length, 6 to 7 mm. Male. Face and front reddish yellow, the cheeks and most of the frontal triangle shining, elsewhere whitish pollinose. Antennæ reddish yellow, arista black, its base reddish. Vertical triangle long, narrow, the eyes touching for only a short distance; occiput brownish above. Dorsum of thorax blackish or brownish black, the sides usually reddish, covered with whitish yellow pollen, leaving a median double stripe, and an interrupted stripe on each side, brownish; humeri yellowish; pleuræ reddish brown above, brownish below, thinly whitish pollinose. Scutellum reddish yellow. Pile of thorax and scutellum yellowish, on the pleuræ whitish. Abdomen

reddish yellow, more reddish apically; second, third and fourth segments and their lateral margins, except anteriorly, very narrowly brownish or reddish brown; pile short, yellowish. Legs yellowish, including the coxæ; hind tibiæ with a slightly darker pre-apical band; hind tarsi brownish. Wings very slightly darkened with luteous, the tip a little blackened.

Female. Face shining, except below the antennæ; front blackish above, whitish pubescent except a median longitudinal shining stripe connecting with the shining area above the antennæ; pollen of the thorax more whitish; wings almost hyaline; legs somewhat paler. Otherwise as in the male.

B. media was originally described from California from a single female specimen. I have before me a female from Teulon, Manitoba, May 15, 1920, and two males taken at Orillia, Ontario, on May 30, 1921.

The specimens described above agree perfectly with Williston's description and I consider them absolutely typical. *B. rufiabdominalis* agrees fairly well with the above description, but the color appears to be darker and the eyes are narrowly separated and approach each other near the ocelli which would make the vertical triangle short, while in *media* the vertical triangle is long and the eyes touch nearer the antennal base than the ocelli. The only other species which is really confusing is *flavescens*, which has a wholly pale thorax (Johnston says the thorax may be brown before the suture) and a yellowish front in the female. The face is also more concave. I believe these three species are abundantly distinct, but a large series of all the species, and a comparison of the male genitalia will be necessary to definitely determine this point. A comparison with *B. bicolor* is necessary. Strangely enough Jones did not even mention *media* in establishing his *B. rufiabdominalis*, which seems rather strange in view of the fact that only the female of the former had been described.

Brachyopa flavescens Shannon.

Thorax wholly reddish yellow (or brownish before the suture—Johnson); abdomen with narrow posterior segmental margins brownish.

Length, 3.75 to 6 mm. Female. Face, except below the antennæ, lower part of the front, and a slender median frontal stripe, shining reddish yellow; front yellow pollinose, face with whitish pollen except where shining. Occiput above darkish, with whitish pollen; face a little more concave than in *media*. Thorax wholly reddish yellow, with the usual stripes shining. Abdomen reddish yellow, the narrow posterior margins of the segments brownish, their lateral margins

very narrowly or obscurely brownish on their posterior half. Legs yellow; hind femora, sub-base and preapical band on hind tibiæ and the hind basitarsi and last segment, brownish or darkened. Wings hyaline.

"Male, rather robust, small, yellowish, eyes strongly contiguous; vertex yellowish gray, with pale, very short pile; vertical triangle narrow and acute, reaching forward to about the middle of the eyes; frontal triangle yellow, bare. Antennæ orange-yellow; third joint ovate, longer than broad; arista darkened distally and with very fine microscopic pubescence along its entire length. Face moderately produced, light yellow, dusted with white and with fine white hairs, the lower half produced and truncate, its upper angle slightly acute. Mesonotum dark ocher yellow, dusted with brownish gray, at the sides and behind, broadly ferruginous and more shining; two narrow and approximated stripes medianly on the anterior two-thirds, two broad, anteriorly and posteriorly abbreviated stripes outwardly, hairs rather short and dense, yellow. Pleuræ brown and black, thickly dusted with gray; mesopleuræ with somewhat longer hairs than those on mesonotum. Scutellum convex, broadly rounded, much broader than long, shining ocher yellow, rather evenly punctured, with light yellow hairs and a few bristle-like ones on the posterior margin. Abdomen much broader than thorax, broadest at posterior margin of second segment; color light yellow, more or less stained with dark by body contents; second segment more or less translucent. Coxæ yellow. Anterior and middle pairs of legs yellow, with white pile. Hind pair somewhat darker, the femora distally tinged with brown and with minute black spines along ventral surface; tibiæ tinged with brown on distal half; first tarsal joint grayish brown, paler distally and ventrally. Wings hyaline, faintly smoky, without trace of maculation, slightly darkened distally along anterior margin; stigma yellow. Halteres pale yellow." (Shannon).

The species has been sufficiently discussed under the preceding species. It has been reported from Fairfax County, Virginia, (type locality), Massachusetts and New Hampshire (Johnson), and I have two female specimens from Orillia, Ontario, taken by myself, May 5th and 21st, 1921. The description of the female given here is made from local specimens, while the description of the male is that of Shannon.

Brachyopa perplexa Curran.

Closely related to *B. notata*, but arista not as pubescent and epistoma more produced; larger than *B. media* and with black abdominal markings, and the median longitudinal black line practically complete.

Length, 6.5 to 8.5 mm. Male. Face and front pale yellow, thickly covered with white pollen, the cheeks and frontal triangle, except narrowly next to the eyes, shining; a brownish or ferruginous stripe from the eyes to the oral margin; occiput below shining ferruginous,

but above and near the eyes, grayish pubescent. The face is considerably produced downwards and forwards; in profile moderately concave from the antennal base to the prominent oral margin. Antennæ reddish yellow, third joint longer than broad, its lower end more pointed, not large, arista brownish, slightly noticeably pubescent. Vertical triangle and a narrow V on the occiput behind the ocelli, grayish yellow (sub-golden) pollinose, the ocellar triangle shining brown. Pile of the head: A few pale hairs on the cheeks, posterior orbits with long pale pile below, and short black pile arranged in definite rows above. Thorax reddish brown, the sternum more blackish, but covered with grayish pollen. Disc of the dorsum grayish pollinose, leaving four stripes of a dark reddish brown or blackish, the median ones very narrowly separated and expanded posteriorly to unite with the sublateral bands, which are also entire; the opaque area is strictly confined to the disc. A darker, thickly black pilose opaque stripe runs from the postalar callosity to the suture; dorsum of thorax with short black pile, the pleuræ with longer, white pile. Scutellum brownish yellow, with short black pile, with a few longer, bristle-like hairs apically. Abdomen: First segment black, its anterior border yellow; second segment pale yellow to slightly reddish yellow, with a median longitudinal black stripe narrowly separated from the anterior margin, and often joined to the black posterior margin or slightly separated from it (the mark is ! shaped, without the dot below); hind border narrowly black and sides of segment, except anteriorly, black; third segment similar, darker colored, but the median stripe entire and the lateral margins usually entirely blackish; fourth segment similar, but the lateral margins more brownish. Hypopygium yellowish red. Pile of abdomen fine, whitish, except on the apical half of segments two and three, where it is black. Legs reddish brown; tarsi all brown or blackish, except that the first three joints are yellow apically; hind femora darker on apical quarter; hind tibiæ darker, with a pale median band; anterior four tibiæ sometimes darker apically. Wings slightly yellowish tinged, stigma pale luteous. Squamæ clear white, with white pile. Halteres slightly yellowish. In somewhat teneral specimens taken in early May the abdominal markings are more brownish, and in fully mature specimens the abdomen may be more reddish, and is always wholly shining. The thorax may be slightly darker or paler than described.

Female. Averages .5 mm. smaller than the male. Face a little more deeply excavated; front shining ferruginous with a very narrowly interrupted whitish pollinose band below the middle; stripe on the cheeks only a little darker than facial color or concolorous; median abdominal stripe broader, complete on second, third and fourth segments; transverse bands broader and successively narrower apically; fifth segment yellowish ferruginous with the narrow hind border blackish and the lateral margins ferruginous or brownish. The general color is more ferruginous than in the male.

B. perplexa is evidently widely distributed, but it is impossible to state its distribution owing to its confusion with

media and *notata*. Altogether I took over sixty specimens at Orillia in 1921, between May 8th and June 14th. I have also specimens from Maine (C. W. Johnson).

B. perplexa differs from *notata* in shorter pile on arista, dark thorax and abdominal markings, paler general ground color, more produced face, and unclouded wings. It is at once distinguished from *media* by the presence of the median line. From *gigas* it is readily distinguished by its darker thorax, smaller size, and less pilose arista. Dr. Johnson had also this species before him when he discussed *B. media* (Can. Ent., Vol. XLIX, p. 362) as is quite evident from his remarks, and I have two males received from him, as *B. media*.

Brachyopa notata Osten Sacken.

Arista short plumose; thorax yellowish red; abdomen with an interrupted median stripe.

Length, 5.5 to 7 mm. Male. Face and front yellow, whitish pollinose, leaving the frontal triangle chiefly, and a broad stripe on the cheeks shining ferruginous. Antennæ reddish yellow, third joint elongate oval, more pointed below; arista reddish, short plumose; vertical triangle tinged with brownish, with very short brownish pile; eyes touching for almost the same length as the vertical triangle; posterior orbits dull yellow, with whitish pile. Thorax yellowish red, thinly whitish pollinose, leaving a shining double median stripe and sub-lateral stripe, interrupted at the suture, and the margins of the dorsum, shining. Pile of dorsum black, but whitish between the humeri. Pleuræ with yellowish pile, the long hairs on the upper portion of the mesopleuræ may be more or less blackish, although usually all pale. Scutellum triangular, the apex rounded, lighter colored than the thorax, with black pile and some slightly longer marginal hairs. Abdomen yellow or reddish yellow; all the segments with a narrow brown posterior border, which is continued forward on the sides of the segments to near the anterior angles. In the middle, the second and third segments with a longitudinal dash of brown, not reaching the posterior brown margin; sometimes a small spot on the fourth segment. Pile of the abdomen pale yellowish, but black on the posterior half of segments two and three. Legs reddish yellow, the last two tarsal joints brown; anterior basitarsi, hind basitarsi with the two following joints, more brownish. Legs chiefly short stout pilose, the femora with stiff hairs below. Wings tinged with luteous or yellowish, the stigma luteous; a dark cloud follows the border of the wing from the stigma to the tip of the fourth vein, a distinct spot at the end of the fifth vein, and the region of all the veins dilutely clouded.

Female. Front only a little narrowed above, dull yellow; a large shining spot above the antennæ; ocellar triangle brownish; pile of front

brownish; third antennal joint oval, larger than in the male; markings on thorax more distinct; abdominal markings a little broader, the median stripes complete. Legs a little darker, wings with more distinct clouds.

In some specimens the terminal segments may appear brownish. This condition is not natural, but is caused by internal organs, or staining.

B. notata has been reported in Canada from Ottawa, Ont. I have a male before me from Ottawa, a male from Vancouver, B. C., a pair from Orono, Maine, and a pair from White Mountains, N. H. Likely to be confused only with *perplexa*, from which it is readily distinguished by its pale thorax, more distinctly maculated wings, etc. The male from British Columbia appears to be teneral, and the median stripes are very faint, practically wanting and the fourth segment has no brown hind margin, but the sides are narrowly brownish. The color is a little paler yellow, but darker than in most specimens of *flavescens*, from which it is readily distinguished by the larger scutellum and distinctly plumose arista.

Brachyopa gigas Lovett.

The largest known species in the genus; arista very distinctly plumose; thorax ferruginous yellowish; abdomen of same color, with four darker stripes.

Length, 10 mm. Male. Face and front yellow, whitish pollinose, the cheeks and the greater part of the frontal triangle, shining, darker; face produced downwards and forwards. Antennæ reddish yellow, third joint elongate oval, flattened above on the apical third or more, making the end appear more pointed below; arista brown, its base yellow, short, sparse plumose, but longer than in other species. Vertical triangle brown, with mixed yellow and brown pollen and short brown pile; occiput shining below, gray pollinose above, and with light colored pile. Eyes touching for moderate distance. Thorax ferruginous reddish, with a median double stripe and an interrupted stripe on each side, reaching quite to the scutellum, more brownish; a brown spot behind the front coxæ. Scutellum concolorous with thorax. Pile of the thorax and scutellum black, across the front between the humeri and the sides of the dorsum and corners of the scutellum with yellow pile. Abdomen ferruginous reddish, all the segments with brownish posterior margins, and the lateral margin entirely narrowly bordered with shining brown; second to fifth segments with an elongate median dash in front, brownish. Legs yellowish brownish, the last two tarsal joints brown. Wings yellowish in front, the stigma yellow.

Originally described from Washington State from a single male. According to Lovett and Cole there are several specimens

in the Collection of Washington State College. The above description is made from two specimens from British Columbia, and there are three specimens in the Canadian National Collection from British Columbia.

A very distinct species by its large size and rather distinctive color. The arista is most conspicuously plumose, and the species would be included in *Hammerschmidtia* in Europe.

Hammerschmidtia.

The characteristics of this genus have been sufficiently dealt with under *Brachyopa*. The species discussed below is the type of the genus, and possibly the only representative.

Hammerschmidtia ferruginea, Fallen.

Length, 9 to 11 mm. Male. Head yellowish red, antennal base, a median facial stripe and the cheeks shining; in profile a little excavated below the antennæ, and a little below the middle with a longish tubercle, below which it is slightly retreating to the oral opening, or the face may be more excavated below the antennæ; it is considerably produced downwards. Antennæ shining yellowish red, arista black, its base reddish, plumose. Pile of occiput wholly yellowish. Thorax brownish, sometimes ferruginous, the side margins always ferruginous reddish, on each side of the middle with rather broad, posteriorly abbreviated grayish or silvery pollinose stripes. The pile is chiefly short, pale yellowish, but there are some longer, black, stout hairs behind the suture and on the darker stripes. There are bristle-like hairs on the mesopleuræ, in front of the suture at the side, above the base of the wings, on the postalar calli and the apex of the scutellum, which is reddish, with short black pile. The abdomen is very variable in color, but seems to be chiefly shining brownish with quadrate reddish or ferruginous spots on the anterior angles, occupying about half the length of the segment, and broadly separated, in mature specimens; or the spots may occupy most of the segment and form a complete anterior band, or the second segment may be entirely ferruginous. The fourth segment is usually all brown, except the anterior corners, but may be only brownish posteriorly in light colored specimens. The hypopygium is always light reddish to reddish. The pile is very short, blackish, except basally, on the anterior angles of the segments and on the hypopygium, where it is whitish and longer. The legs show the same variation in color from ferruginous brown to ferruginous, the hind legs always darker; four anterior coxæ reddish or yellow; hind tibiæ arcuate and paler basally; last two tarsal joints blackish. All the femora, which are a little thickened, the hind ones more so, are armed with short black spines beneath and long black bristles posteriorly and anteriorly; the hind tibiæ bear several short, stout bristles exteriorly, and all the tibiæ, the hind ones less prominently so, bear a terminal

fringe of black spines. The veins are all more or less clouded, more marked anteriorly; stigma brownish yellow.

Female Facial tubercle practically wanting; front reddish, a little shining, a shallow median groove extending between the ocelli and antennal prominence; indistinctly finely wrinkled, especially above; thorax lighter colored; abdomen more yellowish red, the darker areas more restricted and more ferruginous; legs paler. Pigment of the wings more blackish, and a little more extensive anteriorly. Possibly there is as much variation as in the male.

This description is drawn from 9 males and 1 female taken by myself at Orillia, May 18th to 30th. The species has been reported from Manitoba, B. C., Washington, and other places and is probably to be found over the whole of Canada and the northern States.

I do not think that *H. ferruginea* can be classed as a rare species, but it is most certainly not common in collections. This is, I think, due to the fact that its habits are not well understood. While it is true that it occurs in company with *Brachyopa* spp., it seems to have slightly different habits generally. I have found it more often on very low blooms of choke cherry, that is about two or three feet from the ground, but I took one specimen on bloom about eight feet up, and another specimen was taken on bloom in open sub-swampy woods. Another peculiarity is that I have never seen the species flying before four o'clock in the afternoon, but this may be due to the fact that my collecting in May was practically all done after two-thirty P. M.

Since the above paper was prepared several additional specimens belonging to these two genera have been examined, including two additional new species.

Brachyopa cynops Snow.

I have examined the type of this species, and find it to be a female. The description covers all the essential points. The dorsum of the thorax is rusty yellow rather dull, the disc, occupying about half the width of the dorsum, black; the pollen is greyish yellow, not grey and the shining stripes are not distinct.

Brachyopa vacua O. S.

About thirty specimens from Kansas and Missouri show no differences from the description.

Brachyopa rufiabdominalis Jones.

Three specimens of this species from Washington State. The color of the thorax is more slaty than in *media*, the third antennal segment is longer and larger. In the female the front is a little wider, the sides less parallel, more evidently dusted on the black portion and therefore appearing lighter in color. The legs are all reddish, the tarsi brownish red. Abdomen wholly rusty reddish yellow. I could not see that the eyes of the male differed greatly from *media*, but the chief difference seems to be in the fact that the abdomen entirely lacks any darker lines on the apices of the segments, more slaty color of the thorax and slightly larger size. My three specimens are all between 7.5 and 8 mm.

Brachyopa notata O. S.

Five additional specimens from Washington State and Idaho. These agree with the specimen mentioned from British Columbia, and may be distinct. Two additional specimens from New York agree with the eastern specimens.

Brachyopa perplexa.

Two additional specimens from New York State agree perfectly.

Brachyopa gigas Lovett.

A specimen from Washington State and a second from Idaho.

Brachyopa basilaris n. sp.

This species traces out to *notata* in the key. It is distinguished by the wholly red first two abdominal segments, the remaining segments being black. Female from Washington State.

Brachyopa nigricauda n. sp.

Traces out to *dæckei* Johnson in the key. Distinguished from that species by the presence of six shining stripes on the dorsum of the thorac, more reddish pleuræ and humeri, more extensively yellow scutellum, yellowish wings and paler legs; the anterior tarsi are all blackish as are the two apical segments of the remaining tarsi.

The descriptions of these two species will be published in the Kansas University Science Bulletin during the current year.

I have also examined a male specimen of *Brachyopa bicolor* Fallen, from Europe and can say definitely that none of our North American species is conspecific.

A CONTRIBUTION TO THE KNOWLEDGE OF THE INTERNAL ANATOMY OF TRICHOPTERA.*

By Hazel Elisabeth Branch,
Wichita, Kansas.

NERVOUS SYSTEM.†

The nervous system of the trichopterous larvæ is comparatively primitive and agrees with that of the lepidopterous larvæ in the number of pairs of ganglia and also resembles, in some respects, the arrangement in relation to the body segments. Exclusive of the ganglia in the head, which are normal in number and position, there are three pairs for the thorax and eight pairs for the nine abdominal segments, the seventh abdominal segment being the most posterior in which ganglia are found.

In the head of *Limnophilus indivisus* the supra-œsophageal ganglia are situated with their anterior margin on a line immediately posterior to the eyes. The combined width of the ganglia is about one-half that of the head. Each ganglion gives off laterally and in a forward direction, an optic nerve which branches to supply each of the simple eyes of the visual area. In front of the junction of the two ganglia is the frontal ganglion, small and shield shaped, connected to the supra-œsophageal ganglia by a pair of arms Proceeding from each arm of the frontal ganglion, close to its attachment with the supra-œsophageal ganglion, is a nerve which extends forward and sends an outer branch to the labrum, and an inner branch to the dorsal region of the buccal cavity, see Plate XIV, Figs. 4 and 5, at lb_1 and b. Between the point of attachment of the arm of the frontal ganglion with the supra-œsophageal ganglion, and the optic lobe, (opt), is the slender antennal nerve rising from the anterior margin of the ganglion and possessing a fellow in like position upon the other ganglion, see Plate XIV, Figs. 4 and 5 at ant. Upon its posterior face, each ganglion gives rise to a protuberance from which issues a nerve that converges toward its fellow and meets it upon a median line. At this union a small ganglion is formed and to this are also joined, the nerves coming from the sympathetic ganglia. These sympathetic ganglia are single, one upon each side of the œsophagus and possessing a nerve connection with the posterior protuberance of the supra-œsophageal ganglion of its respective side, See Plate XIV, Figs. 4 and 5.

The recurrent nerve of the frontal ganglion extends in a posterior direction between the supra-œsophageal ganglia and the œsophagus

* A contribution from the Department of Entomology, Cornell University, prepared under the supervision of Dr. O. A. Johannsen, to whom and also to Dr. J. G. Needham and Dr. J. T. Lloyd, I wish to express my gratitude for the valuable assistance rendered.

† In gross dissection, hot water killing and Gilson's fixing solution were found to be most advantageous.

and fuses with the nerve which extends posteriorly from the ganglion situated at union of the nerves from the posterior protuberances of the supra-œsophageal ganglia and the sympathetic ganglia of each side

From the ventral face of the supra-œsophageal ganglia, arises a pair of connectives, the crura cerebri, which connect the supra-œsophageal ganglia with the sub-œsophageal ganglion.

Immediately in front of the union of the crura cerebri with the supra-œsophageal ganglia, the œsophageal ring of the tritocerebrum arises. This is a loop which encircles the œsophagus and has its ends connected with the supra-œsophageal ganglia, see Plate XIV, Fig. 5 at or. The supra-œsophageal ganglia does not fit closely upon the œsophagus normally, but leaves some space laterally and ventrally for the expansion of the tube in feeding. Faivre 1857, states that the supra-œsophageal ganglia possess the seat of motive power and will power and Binet, 1894, strengthens this statement by the results of his own experiments which show that an insect will live for months with the supra-œsophageal ganglia removed but will not eat unless the food is placed in its mouth as it has no power to move toward the food.

The sub-œsophageal ganglion is situated slightly back of the posterior margin of the supra-œsophageal and below the œsophagus but well within the limits of the head cavity. This ganglion gives off three pairs of nerves, the most ectal and dorsal of which extends in a forward and upward direction and, upon a level with and in front of the frontal ganglion, branches. One branch extends to the base of the labrum, see Plate XIV, Figs. 5 and 6 at lb2, while a second branch extends to the dorsal side of the mandible, see Plate XIV, Figs. 5 and 6 at md2. The second pair of nerves from the sub-œsophageal ganglion arises ventrad of the first pair and extends forward also branching. The ectal branch of each nerve reaches the musculature of the maxilla, mx1; and an ental branch divides and one part goes to the maxillary sclerite and the other to the labium, see Plate XIV, Figs. 5 and 6, at mx2 and li2. This pair is connected by a nerve just below the frontal ganglion, and the cross nerve bears a small median ganglion. The third pair of nerves is ventrad of the second pair and extends forward directly to the labium, which it innervates, li1.

The above description is made from several dozen specimens of the species *Limnophilus indivisus* Walker. The head ganglia of the other species studied do not vary materially.

Posteriorly the sub-œsophageal ganglion gives off a pair of commissures which connect to the first thoracic* ganglion lying in the prothorax. In the thorax and abdomen there is much variation among the species as to the relation of the ganglia to their respective segments. Upon observation of these three species (*Limnophilus indivisus* Walker, *Hydropsychodes analis* Banks and *Phryganea interrupta* Say,) two centers of fusion will be found, one in the thorax and one in the abdomen at the posterior end of the chain. As above stated, there are three thoracic and eight abdominal ganglia. The prothoracic and

* Each ganglion of the thorax and abdomen is a pair of fused ganglia.

mesothoracic ganglia are about the same size as the sub-œsophageal ganglion and are each situated equidistantly from the anterior and posterior margins of the segments and this condition prevails for the three species. The metathoracic ganglion is larger than those of the preceding segments and its position is not the same in the different species for it is here that the thoracic fusion point occurs. In *Phryganea interrupta* the ganglion is centrally located with the ganglion of the first abdominal segment just within the posterior border of the metathorax. In *Limnophilus indivisus*, the metathoracic ganglion has migrated forward and the first abdominal ganglion has followed until the latter occupies the central position with the metathoracic ganglion well in the front half of the segment. In *Hydropsychodes analis*, the condition is the same as in *L. indivisus*

In the abdomen of the three species the positions of the ganglia are more noticeably variable. In *P. interrupta* the first abdominal segment bears at its posterior margin, the ganglion of segment two and segment two is void of any ganglion, but receiving its innervation from its respective ganglion located in segment one. The ganglia of segments three, four, five and six occur in their respective segments near the front margins. Segment seven bears in its front half, two ganglia; these are the ganglia for segments seven and eight and they are very closely united, but not fused at all, Plate XIV, Fig. ?. In *L. indivisus*, the ganglion of segment two occupies a central position in segment one, indicating a forward migration. Segments three, four and five have their ganglia in the front half of the segment as in *P. interrupta*. In segment six all the ganglia of the three segments, six, seven and eight, are placed; those relating to segments seven and eight are closely united, practically fused, and take a position in the posterior half of the segment. The ganglion for segment six is in the anterior half of the segment, Plate XIV, Fig. 1. In *H. analis* we find an arrangement in the abdomen which varies from that which Pictet, 1834, observed in Hydropsyche, for he saw all the ganglia here upon the divisions between the segments. In this particular species, the ganglion for segment two is in segment one as usual, and the ganglion for segment three is on the margin between segments two and three which is a forward migration. The ganglion for segment four is in front of the center of the segment and the ganglion for segment five is back of the center of its respective segment. In the sixth abdominal segment are three ganglia for segments six, seven and eight respectively and all are in a line and practically fused, Plate XIV, Fig. 3.

The thoracic ganglia and the abdominal from one to six innervate their respective segments and appendages, the seventh abdominal appears to have only one pair of nerves which extend backward into segment seven, the eighth abdominal ganglion innervates segment eight and nine, as well as the swimmerets, which extend out from segment nine. There are various ways for the eighth abdominal segment to innervate segment nine. In *P. interrupta* and *H. analis* it sends a nerve directly to the segment, but in *L. indivisus* the nerve which extends to segment eight branches and sends a branch to segment

nine, this arrangement leaves one less pair of nerves arising from ganglion eight in *L. indivisus* than in *P. interrupta* or *H. analis*.

Upon a comparison of the three Figures, Nos. 1, 2 and 3, Plate XIV, a sequence of fusion is evident. This sequence places *P. interrupta* as the most generalized and *H. analis* as the most specialized and *L. indivisus* as intermediate. Vorhies, 1905, has described the nervous system of *Platyphylax designatus* Walker and it falls between *P. interrupta* and *L. indivisus* for the ganglia of the seventh and eighth segments have migrated so that the ganglion for segment seven is just inside the posterior margin of segment six and the ganglion for segment eight remains in segment seven, but very close to its anterior margin. Betten, 1901, in his description of *Molanna cinerea* does not show it to vary from *P. designatus*. Pictet, 1834, figures *Phryganea striata* Fab. to fall between *P. designatus* and *L. indivisus* with the ganglia for segments six, seven and eight in segment six, but ganglia seven and eight not fused. Klapalek, 1888, does not note any variation of position, but merely gives the number of ganglia and their general distribution.

From the above it seems reasonable to think that the nervous system of the order will reveal grades of consolidation of the ganglia which may have a decided bearing upon classification.

REPRODUCTIVE SYSTEM.

The writer has done very little in this system beyond the mere location of the organs, for the matter seems to have been given adequate attention by Zander, 1901, Lubben, 1907, and Marshall, 1907. As to the period of the appearance of the organs there is a difference of opinion. Pictet, 1834, Klapalek, 1888, and Vorhies, 1905, make the statement that the organs do not appear until near the period of pupation or at least in a very old larva; Lubben, 1907, discusses conditions in a transforming larva, while Marshall, 1907, speaks of the condition of the organs in the youngest larva he had, but does not give the stage. In all the specimens observed by the writer, the gonads appear in the early forms, showing clearly both in gross dissection and sections. In *P. interrupta* taken in October and *H. analis* taken in late December from under the ice in streams, the gonads are distinct and developed far enough so that tubules may be seen, Plate XIV, Fig. 7. This period is long before there are any signs of pupation either in case or larva.

Within the species two shapes of gonads appear. In *P. interrupta* some are elongate and flat, while others are spherical. This seems to point to a sex differentiation, the elongate one probably destined to become female organs and the spherical ones male organs, Plate XIV, Fig. 2. In gross dissection in *L. indivisus* only one kind of a gonad was observed, this circular and plate-like of five pairs of tubules. Plate XIV, Fig. 1, at gd. In each gonad there are two outgrowths or attachments; one from the outer side and extending to the ventral body wall of the second abdominal segment and resembling a supporting thread or tissue, the inner side outgrowth appears as a duct and the tubules of the gonad may be seen converging toward the head of this duct.

The duct extends in a posterior direction and extends to the ventral side of the eighth segment, where it is lost. Lubben, 1907, shows that these ducts pass into external, sculptured plates in the eighth segment but I have been unable to find any such structure or any opening whatever at this point on any of the specimens. In *H. analis* the gonad is oval, but appears spherical in frontal section as the long axis of the gonad is at right angles to that of the body of the larva. The gonads of the above three species are in pairs and lie in the fifth segment of the abdomen. Betten, 1901 finds the gonads for *M. cinerea* in segment four; Lubben, 1907, records *Anabolia nervosa* and *Limnophilus stigma* as having the organs in segment five, *Rhyacophila septentrionis* and *Brachycentrus montanus* in segment four. Klapalek, 1888, gives the gonads a general location of segment three, but neither literature nor my own observations uphold this statement. From a compilation of records the position appears to be in either the fourth or fifth segment.

ALIMENTARY CANAL.

General description: The alimentary canal, in the order Trichoptera, passes as almost a straight tube from buccal cavity to anus. Pictet, 1834, figures the tube as practically undifferentiated in its shape and only varying slightly in size at the extreme ends. Klapalek, 1888, states that the regions merge imperceptibly into each other. Although this condition may be true in a specimen gorged with food, the writer has never seen a specimen where the three main divisions of stomodeum, mesenteron and proctodeum were not distinctly marked one from the other. The lack of convolutions as are normal in the alimentary canals of insects which are herbivorous, is unusual, as Siltala, 1907, shows that the order is in the main herbivorous and yet this general type of a straight tube prevails. There are a few semi-carnivorous species, but even here there is no variation from the above condition. The assimilative area is increased by an unusual width in proportion to that of the body, for in many places and especially the mesenteron, the width is equal to one-third and frequently more than one-third the width of the abdomen. Another device adds to this area or surface for the wall of the mesenteron is folded into transverse ridges which increase the surface by three times that actually occupied by the wall, Plate XV, Fig. 10. These folds are deeper in the strictly herbivorous types, such as *L. indivisus*, than in those which are more or less carnivorous, as *H. analis*. We will pass now to a discussion of the alimentary canal in the three species. *Hydropsychodes analis* Banks, Plate XV, Figs. 7, 8 and 9. The surface of the stomodeum of the alimentary canal presents a silvery appearance, due to the peritoneal covering of the muscles which surround and control the activities of this portion of the canal. This portion is much darker than the remainder of the canal, due to the food within. If this be cleaned, the wall appears transparent. Beneath the peritoneal membrane can be seen the longitudinal muscles arranged in pairs in six equi-distant places around the canal. Underneath these longitudinal muscles lie the circular muscles, which are so

heavy and thick that they give the canal the appearance of having great rings around it. The stomodeum is composed of four parts, namely: buccal cavity, œsophagus, crop and proventriculus. The buccal cavity is large, including half the depth of the head capsule, it narrows rapidly and passes over into a slender tube which passes beneath the supra-œsophageal ganglia as the œsophagus. The œsophagus extends backward through the head and prothorax with only slight expansion. At the posterior margin of the prothorax it begins to enlarge and extends through the length of the mesothorax with a diameter one-third that of the thorax and four times the diameter of the œsophagus in the prothorax. This is the crop. At the posterior margin of the mesothorax the stomodeum is suddenly constricted to about half its width and within a longitudinal distance of .5 mm. suddenly enlarges to form a cylindrical structure, the wall of which becomes resistant to dissecting instruments and is very hard. The circular muscles are larger and heavier in this region and inside the tube are chitinized teeth. This portion is the proventriculus, which functions as a grinding organ and possibly as a straining device.

The cylindrical shape ends suddenly at the posterior margin of the metathorax and the transition into the mesenteron is well indicated by change in color, texture and structure of the wall and by a deep fold. The proventriculus pushes into the forward end of the mesenteron and forms there an œsophageal valve. The mesenteron folds up over the proventriculus and causes a distinct line to appear between the two portions. The silvery tone of the wall is lost at this juncture; the longitudinal muscles break up to form a layer of muscles around the mesenteron and this layer extends the full length of the mesenteron. Beneath these muscles can be seen the very thin layer of circular muscles. The mesenteron enlarges at its beginning to at least a third the diameter of the abdomen of the larva and increases slightly toward the fourth segment and then returns to its width at the beginning before it reaches its length. This division arises at the posterior end of the metathorax and extends through the length of the abdomen as an almost straight tube, varying only as above in diameter, circular in cross section, and possessed of an extremely thick wall, but one that is easily torn apart. In the sixth segment the mesenteron becomes about two-thirds the diameter at its beginning and passes over into the proctodeum. The proctodeum is composed of intestine, both large and small, and the rectum. The mesenteron pushes into the intestine in much the same manner that the proventriculus pushes into the mesenteron, but the distance is not as great and the valve formed is not a distinct one in this species, although the division between the two main divisions of the canal is clearly marked. At the point where these two portions meet, the Malpighian tubules, of which there are six, make their appearance upon the surface. These tubules are situated upon the lateral and ventral faces of the alimentary canal and the dorsal face is void of them; however, the first pair may be easily seen from a dorsal view, each member of this pair lies upon the upper portion of the lateral face and extends forward through the abdomen and into the metathorax. Slightly

below the first pair, the second pair arises and extends, each member of the pair upon its respective side of the alimentary canal, forward for the remaining distance of the sixth segment where it turns backward and taking an upward and lateral direction, with regard to the intestine, curves and coils about in the lower part of the abdomen back of the sixth segment. The third pair of tubules is situated upon the venter about equidistant from each other and from the corresponding members of the second pair. This third pair extends backward immediately and each member comes to lie beneath and to the side of the intestine, intertwining with the corresponding member of the second pair. The tubules are irregular in outline, appearing like small oval beads strung upon a thread. In general color they are a pale, clear yellow, but blotched at irregular intervals with a kidney-brown pigment. They weave in and out among the fat bodies and tracheæ, and into blood sinuses to perform their function of the removal of nitrogenous waste.

The front end of the intestine is cup-shaped with the larger end forward. This portion represents the small intestine. The tube grows smaller as it proceeds toward the caudal end but in the seventh segment is greatly constricted; it enlarges immediately and passes through segment eight with a diameter of about a fourth that of the segment and two-fifths of the diameter of the mesenteron in the first segment. This portion represents the large intestine.

At the posterior margin of segment eight, the intestine is again constricted and passes over into the rectum. At this juncture there is a semi-valve formed by the invaginated walls of the intestine. These folds become longer and fewer in number and form the blood gills which lie in the rectum. The rectum extends through the ninth segment. In some forms examined, the small diameter of the constricted region at the posterior end of segment seven prevails through the eighth, widening suddenly at the beginning of the ninth to accommodate the invaginations forming the blood gills; in other forms the widening is gradual through the eighth and passes over gradually into the rectum without any noticeable constriction. The wall of the small intestine is heavy and surrounded with circular muscles. It becomes thinner as it extends toward the large intestine. When the rectum is reached the wall is exceedingly thin and almost transparent. Through the wall can be seen the four pockets or invaginations which form the blood gills, and into these muscles extend from the lateral and ventral walls at the conjunctiva between segments eight and nine. The rectum now serves a double function, that of elimination of fecal matter and secondarily that of respiration, when oxygen cannot be obtained by means of the tracheal gills. These blood gills have no tracheæ running into them as a glycerine mount of the caudal portion of a fresh specimen clearly demonstrates. They function, when the larva is out of the water, by protruding themselves through the T-shaped anus, in which state they are filled with blood. A detailed account of their structure will be found elsewhere in this paper.

Limnophilus indivisus Walker,* Plate XV, Figs. 1, 2, 3 and 5. In this form the œsophagus passes from the buccal cavity into the head region where it is a small tube and continues through the prothorax. The crop is absent in this form and the œsophagus passes immediately into the proventriculus. Here the chitinized "teeth" upon the lining such as we find in *H. analis* are lacking. They are not needed, as the form is strictly herbivorous and *H. analis* is semi-carnivorous. The œsophagus begins to enlarge at the posterior edge of the prothorax to form the proventriculus, which lies in the mesothorax. It is silvery in appearance and dark colored, but not resistant to the needle owing to the lack of chitinized teeth within. The proventriculus possesses the six pairs of longitudinal muscles and the circular layer, but these are not as heavy as in *H. analis*. At the posterior margin of the mesothorax the proventriculus constricts slightly and passes over into the mesenteron. This position is contrary to the usual division level for these two portions of the alimentary canal, but the œsophageal valve occurs here and the character of the wall changes to a light pale color, is thicker in cell depth and the six pairs of muscles from the proventriculus form the characteristic layer around the new division. From these characteristic markings there can be no doubt as to this transition. The œsophageal valve is normal, Plate XV, Figs. 2 and 3 show it as a complete invagination of the wall, in a fold of eight projections

The mesenteron takes its beginning in the mesothorax and increases in diameter as it passes through the metathorax. It may be slightly constricted in the first abdominal segment although it frequently passes without any change of contour. It passes through the abdomen at its diameter of one-third that of the abdomen and extends to the sixth segment. Here the transition into the intestine occurs and the juncture is marked by the presence of the six Malpighian tubules, in the same arrangement as in *H. analis*. The tubes are longer, however, and the first pair does not extend into the thorax, but turns backward in the first abdominal segment and returns to the seventh. The second pair frequently extends as far as segment three and then returns to segment eight. The third pair may continue forward through segment six before turning backward. The junction between mesenteron and intestine is marked by a decided valve not found in *H. analis* and similar to the œsophageal valve. A section showing this structure is on Plate XV, Fig. 10. The intestine at its forward end is also cup-shaped and, at the constriction between small and large intestine, possesses a valve formed by the invagination of the intestinal wall. (Plate XV, Fig. 5). Along the intestine are six muscle bundles which seem to control the initial position of the Malpighian tubules Marchal, 1892, considers the tubules as being capable of motion and perhaps these muscles have some part in that action. These muscles likewise support the front edge of the rectum into which the large intestine telescopes.

* This species is selected for a comparison with *H. analis*, as the two represent widely divergent forms.

Phryganea interrupta Say* Plate XV, Fig. 11.

In *P. interrupta*, the œsophagus passes through the head as a narrow tube and enlarges toward the posterior margin of the prothorax to form a crop of small dimension which is marked from the proventriculus by a slight constriction. The proventriculus occupies the meso and metathorax in length and practically fills the whole of the body cavity in this region, it presents the silvery surface as in the other forms and the longitudinal and circular muscles are evident. The posterior end of the proventriculus extends over into the first abdominal segment and here is constricted suddenly and passes through this segment as a small tube about one-fourth the diameter of the proventriculus in the mesothorax. This constriction is so long that the longitudinal muscles of the proventriculus do not follow the tube but span the distance from the beginning of the constriction to the surface of the mesenteron and can be seen as threads across the open space.†

The mesenteron is the same as in the other forms and passes over into the intestine of the proctodeum in the sixth segment where the Malpighian tubules arise. These do not always assume the same positions, which is further evidence of Marchal's theory on their mobility. Marchal, 1892. The intestine extends through segments six and seven and at the anterior margin of the eighth there is a constriction as the intestine passes over into the rectum. The rectum gradually grows smaller as it nears the anus. The anterior portion of the intestine has a heavy musculature and the lower part is ridged longitudinally and these ridges become more prominent in the rectum and form four longitudinal columns which continue to the anus.

HISTOLOGY OF THE ALIMENTARY CANAL.‡

In this work the writer has divided the material into two parts: that dealing with cellular structure and that relating to the musculature of the canal. The condition in *H. analis* is taken as a basis of comparison and where *L. indivisus* differs from the above the condition is noted and illustrated in the figures.

Buccal cavity: The cells are flat and small with small nuclei The cavity is heavily lined with chitin

* This third species is selected on account of its larger size.

† A normal œsophageal valve occurs at the division between proventriculus and mesenteron.

‡ In the histological work, both hot Gilson's and hot Bouin's were used with equal advantage if the material was to be used at once. If more than a month were to elapse before the material would be used, Bouin's was by far the better fixative, as those in Gilson's softened rapidly.

Much better results were attained by clearing in xylol than in cedar oil. An infiltration of not longer than nine hours, including the time in xylol and paraffin, equal parts, at 52 degrees F., produced the material most easily cut.

Staining in Delafield's haemotoxylin and counterstaining in aqueous ½% eosin produced excellent results as a general stain. For muscles and epithelial cells, iron haemotoxylin made clearer slides than the above. Paracarmine with a counter stain of orange G. was especially adapted to digestive epithelial tissue in *L. indivisus*.

Oesophagus: The cells of the epithelium are cubical and the whole epithelium is lined with a chitinous intima. The basement membrane is distinct between the epithelium and the muscles surrounding the œsophagus.

Crop: Conditions the same as in the œsophagus.

Proventriculus: The cells of the epithelium do not vary from those of the œsophagus but the wall itself is thrown into folds and the intima becomes thick and dense and forms the stomachic teeth, the number of which is about thirty-six. A cross section of this region shows them surrounding the cavity. At the posterior margin of the proventriculus is the œsophageal valve which in this form is of peculiar plan. It is practically double with a strongly chitinized invagination into the proventriculus and an extremely deep but narrow invagination into the mesenteron This valve does not completely surround the constriction between the two divisions. For further details see Noyes 1915. This valve in *L. indivisus* is normal and complete. It extends into the mesenteron in a fold, the upper part of which is composed of cubical cells with an extremely heavy intima, while the under portion of the fold although the cells are cubical become somewhat flattened and the intima reduced to a thin membrane. The wall changes suddenly into the columnar structure of the mesenteron with its striated border. At the point where the intima ceases the peritrophic membrane arises. This is separated from the epithelial wall of the mesenteron and surrounds the food in the canal, Plate XV, Fig. 6.

Mesenteron: The epithelium here is similar to that at the posterior end of the œsophageal valve except that the cells become more columnar. The conditions in function accord with those described in the dragonfly nymph, Needham, 1907, and need no further discussion here The wall of the mesenteron is folded as mentioned in the discussion of the gross anatomy of the canal to produce more assimilative surface and this condition prevails the entire length of the mesenteron to the sixth segment. In this same segment the Malpighian tubules show upon the surface and the mesenteron passes over into the intestine, Plate XV, Fig. 10 at dep.

Malpighian tubules: At the posterior end of the mesenteron where the cells are still columnar, the ventral pair of Malpighian tubules may be seen breaking through the epithelial wall on their way to the surface, Plate XVI, Fig. 7. Patten, 1884, in his embryological investigation of the Trichoptera shows that these tubules are evaginations of the proctodeum before the wall of the forming mesenteron is joined with that of the proctodeum. Further evidence of this is seen in sections of the intestine further back where the tubules may be seen forming within the epithelial tissue of the intestinal walls. The cells are still columnar but the presence of intima and the loss of the striated border indicate that this is no longer mesenteron, Plate XVI, Fig. 6. The Malpighian tubules are composed of large cells, glandular in appearance, with a large nucleus in the center of the cell. The pigment so noticeable in gross structure now becomes more evident and stains darker than the nucleus and is not confined to a given region of the cell. There are three

distinct layers; upon the inside is the lining or the intima, then the large celled wall and the covering which is muscular, Plate XVIII, Figs. 7 and 8. The dorso-lateral and lateral tubules reach the surface posterior to the ventral pair.

Intestine: The transition to intestine in *H. analis* is accomplished with a mere constriction and change in cellular structure, but in *L. indivisus* there is a valve formed as the œsophageal valve is formed, but reversed in its components, the upper part of the fold is slightly columnar in its cellular structure but covered with intima in a thin coat, the intima becomes thicker and the cells cubical as the folds turn toward the intestinal wall, Plate XV, Fig. 10. At the posterior edge of segment seven the cubical wall changes and becomes large celled with large nuclei, Plate XVI, Fig. 2. In *H. analis* this continues to the anterior margin of the ninth segment, Plate XVI, Fig. A at 2. At the beginning of the ninth segment the epithelial wall changes to a cubical condition which changes only as the wall becomes differentiated into the blood gills and returns to the cubical condition when this function ceases. The whole length of the intestine is thrown into six longitudinal folds which begin in the sixth segment, Plate XVI, Fig. 6, and is traceable through all the sections to the rectum where the semi-valve occurs and the four blood gills arise. The folds do not continue into the rectum. In *L. indivisus* transition in the eighth segment from the cubical celled condition to the large celled, which marks the end of the intestine in this form, is a distinct rectal valve not different in character or formation from the one into the intestine from the mesenteron; the cells of the wall of the rectum are large with large nuclei and this condition continues to within .5 mm. of the anus. It is possible to consider the rectum of *H. analis* as beginning at this level and the semi-valve as only the transition into the blood gills but the gross anatomical structure seems to bear the former interpretation.

Musculature: The œsophagus is surrounded with bundles of longitudinal muscles, outside of which is a layer of banded circular muscles and outside of these six pairs of longitudinal muscles so noticeable in gross structure. At the anterior end of the proventriculus the inside layer of longitudinal muscles cease and the proventriculus is immediately surrounded by circular muscles, (see Noyes 1915), which continue as a sheath of varying thickness for the full length of the alimentary canal as far as the rectum.

Mesenteron: The six pairs of longitudinal muscles break up into a layer of longitudinal muscles, this layer is composed of large bundles upon the outside and small ones upon the inside next to the thin circular muscles. See Plate XVI, Fig. 7.

Intestine: At the anterior end of this division where the cells of the epithelium are columnar but covered with intima, a heavy circular muscle arises pushing some of the longitudinal muscles outside and enclosing the smaller ones, Plate XVI, Fig. 6. In a very few sections of .008 mm. in thickness this muscular wall is complete, Plate XVI, Fig. 5. The inner layer of circular muscles becomes thicker as we advance toward the posterior end of the canal and the inner longitudinal

muscles have formed themselves into the characteristic six pairs and those pushed to the outside of the outer circular muscles have ceased, Plate XVI, Fig. 4. This heavy outer circular muscle comes to an end in the seventh segment, leaving the six longitudinal pairs as the exterior layer, Plate XVI, Fig. 3. This condition prevails throughout segment eight, Plate XVI, Fig. 2, and past the semi-valve into the gill chamber of the rectum, Plate XVI, Fig. 1. For a diagram of this musculature, see Plate XVI, Fig. A, the levels drawn are numbered as the figures which are taken in cross section at these same levels. The musculature of *L. indivisus* does not vary from this description based upon *H. analis*, with the exception that in the mesenteron the longitudinal muscles are of a single layer, Plate XVI, Fig. S. The blood gills of *H. analis* rightfully belong to the discussion of the histology of the alimentary canal, but their structure is sufficient to claim for them a separate division of this paper.

Blood Gills of *Hydropsychodes analis* Banks.

Protruding from the T-shaped anus, Plate XV, Figs. 8 and 9, Plate XVII, Fig. 1, are often seen four transparent, greenish, finger-like appendages, Plate XIV, Fig. 3. These are protruded beyond the limits of the anus when the larva is out of the water crawling upon the rocks, or may be artificially protruded by pressure upon the abdomen in the caudal region. Pictet, 1834, states that these appendages contain tracheæ. There are muscles leading into the gills which might be mistaken for tracheæ if the microscope were not of high magnification. Dufour, 1847, figures these gills as appendages from the rectum into the body cavity, but without tracheæ. This error of Dufour is easily understood when the larva is dissected, for it is almost, if not quite, impossible to open a larva from the dorsal side and not cut into the rectum so that these gills float out as though appendages from it. It is only when a lateral opening is made that the true internal position is observed. Fritz Muller, 1888, does not show any tracheæ in the gills and Thienman, 1903, and Lubben, 1907, represent these as non-tracheæ bearing structures. In the glycerine mounts of the caudal end of the abdomen with the gills protruding from the anus, the tracheal tubes are seen to pass down the sides of the body sending branches to the alimentary canal and surrounding tissues. Long branches or continuations of the main tracheal trunks extend into the anal pro-legs or drag hooks, but in no instance does a single tracheole extend to a gill. In neither the transverse sections or the longitudinal ones does tracheal structure appear. Muscles and blood make up the content of the gill. These gills are in direct communication with the body cavity and it is possible that, when occasion renders the supply of oxygen insufficient, the blood rushes from the blood sinuses into these "pockets" and comes with sufficient force and quantity to extend the gill and push it to the exterior and an exchange of gases takes place through the wall of the gill. This action, combined with the lack of tracheæ, seems sufficient evidence upon which to claim the term of *true blood gills* for these structures.

When retracted these gills lie within the rectum, which serves a double function, with their distal ends or tips close to the anus and just barely within the aperture. They may function slightly at this time.

In surface view the gills present a cylindrical form which tapers as it extends distally. Upon the surface are transverse ridges which are bounded by thread-like depressions. These depressions are as deep as the ridges are wide, for these ridges are made up of rings of cells one cell deep and one cell wide. At rest these cells are cubical, being as deep as they are wide, and the depressions are the expansion spaces between the cells. In expansion this ring of cells becomes narrower in diameter and the cells themselves wider and more shallow. Compare Plate XVII, Fig. 6, where the gill is at rest, and Fig. 7, where it is in extended condition. The tips of the gills are more dense and of a darker color than the rest of the gill. This condition is due, no doubt, to their close proximity to the anal aperture and to the fact that they must at times push their way through waste material in their extension.

To get a clear conception of the formation of these gills, it is necessary to start with their origin in the wall of the intestine in the ninth segment. Here the glandular large celled condition of the intestinal wall ceases and becomes cubical. The wall is thin and the six longitudinal folds extend inward so as to form a semi-valve at the head of the rectum, Plate XVII, Fig. 4. Gradually these folds merge into four and form the four gills. Plate XVII, Fig. 5, shows these longitudinal folds merging into the gills and being continuous with them. After the formation of the gill the rectal wall does not again fold, but passes directly to the anus.

At rest the width of the gill is about one-third its length, which normally is slightly less than the width of the ninth segment. The gill is capable of extension to about three times its normal length, and at this time the wall becomes thin and the cells much longer than deep. Not all of this extension length is made by the gill itself, as the folds at the head of the rectum extend and the caudal wall of the rectum itself is carried down with the gills, Plate XVII, Fig. 7.

The deep cells of the walls of the gills are possessed of large nuclei and are glandular in appearance. These cells take up about four-fifths of the diameter of the gill when at rest, leaving the other fifth for the muscle which extends from the conjunctiva of the lateral and ventral walls between segments eight and nine. Each gill possesses a muscle which arises at a corresponding place upon the conjunctiva and extends to the tip of the gill. Each gill muscle is three branched, Plate XVII, Fig. 8, and when at rest lines the gill. The gills are covered with a very thin intima, which is continuous with that of the rectum and intestine.

GLANDS.

Not all the glands in the body of the trichopterous larvæ are considered here. The writer has confined her attention to the silk glands, the thoracic glands and the glands in the head, in this last only those in *L. indivisus* have been studied.

The Silk Glands: Of all the glands of the trichopterous larvæ these are the most prominent. They practically fill the part of the body cavity not occupied by the alimentary canal and extend from the labial spinneret into the seventh segment. They are opaquely white, having a pinkish cast in a fresh specimen. Their content is sticky and if the glands of a fresh specimen be broken in dissection the secretion will so glue the organs and tissues together as to make further dissection impossible. This difficulty is remedied by applying Gilson's preservative to the freshly opened specimen and allowing it to remain for fifteen or twenty minutes.

Upon the floor and in the center of the anterior edge of the labium is a spinneret, Plate XVIII, Fig. 3, at sp. This is connected to a single tube of .2 mm. in length. In this region is the silk press composed of muscles which control the flow of secretion. This structure does not differ from the structure of the forms studied by Gilson, 1894, and needs no further discussion in this paper. At the posterior margin of the labium this single, slender tube becomes divided into two and passes ventrad of the nerves extending from the sub-œsophageal ganglion to the mouth parts. On reaching the ganglion each member of the pair of tubes passes laterad of the ganglion, Plate XVIII, Fig 4, and then approaches its mate and passes with it underneath the œsophagus. At the posterior margin of the sub-œsophageal ganglion the tubes change their character from that of a duct to a true gland. In the duct the cells are small with simple nuclei. Externally the change is marked with a depression as though a thread were fastened tightly around the tube. Back of this depression is the gland proper, composed of an outer wall with an irregularly shaped nucleus in a flattened cell. This outer wall is two cells in circumference, the cells are hexagonal with the lateral face in a triangle. The front face of the triangle meets the posterior face of the triangular side of the other cell, see Plate XVIII, Fig. 5. Inside of this wall, which is frequently very loosely applied, is the inner tube consisting of a firm cylindrical wall, where the secretion is formed and inside of this heavy wall is a narrow tube through which the secretion passes to the duct, Plate XVIII, Figs. 6 and 6a.

These silk glands lie ventrad of the alimentary canal throughout the thorax and frequently as far as the second abdominal segment. Finally they make their appearance at the sides of the alimentary canal and increase in size. They extend to the sixth segment where they turn forward again and extend to the second and third abdominal segment, turning backward they reach to the seventh segment where the distal ends are frequently folded under the intestine or float free among the various folds of the Malpighian tubules, Plate XV, Fig. 1. For a detailed description of these glands see Vorhies, 1908.

Thoracic glands: Gilson, 1896, shows *Phryganea grandis* as possessing three glands or pairs of glands in the thorax, one pair to each of the segments. These glands are formed of small tubes which come together to form a small reservoir from which a single tube extends. This tube meets its fellow and together as one tube they open to the exterior in a small pore. Henseval, 1895–6, did not find the three pairs in all of the

forms studied but found a compound gland in the prothorax. This is the condition of *L. indivisus* and *P. interrupta*, although the structure of the two glands is not the same. In *P. interrupta* it resembles the glands found by Gilson in *P. grandis* and is much branched, Plate XVIII, Fig. 9, and Plate XIV, Fig. 2, ggl. The gland in *L. indivisus* is single and lies above the prothoracic ganglion, its opening is between the connectives of this ganglion to the sub-œsophageal and connects with a spinneret which lies at the extreme anterior margin of the prothorax and extends forward under the head, Plate XV, Fig. 1, at ggl, Plate XVIII, Fig. 1, ggl, and Fig. 10. In *H. analis* a gland, corresponding to this gland of Gilson, has not been found.

Glands in the Head of *Limnophilus indivisus* Walker.

In the head are six pairs of glands exclusive of the silk glands. Lucas, 1893, Henseval, 1895, and Russ, 1907, mention two pairs and term them mandibular and maxillary glands. *L. indivisus* possesses these two pairs and others. The mandibular gland is situated on the outer angle of the mandibular sclerite and is composed of a number of single celled glands or "pockets" which open into a common duct. This common duct leads to the base of the sclerite, the name of which it bears, Plate XVIII, Fig. 14. The maxillary gland, as Lucas so terms the second of the head glands, is similar to the mandibular but is composed of many more of the small single celled glands. The two glands lie underneath the œsophagus with their several small lobes folded upon each other and their ducts extending almost at right angles from each other. These ducts open into the buccal cavity at the inner margin of the mandibular sclerite, Plate XVIII, Fig. 13. Patten, 1884, states that they are an invagination of the inner margin of the mandibular sclerite in the embryo and Patten terms them salivary glands. Further ventrad in the lead lies a multicellular gland in the maxillary sclerite with an opening into the distal end of this sclerite, Plate XVII, Fig. 12. In the labium we find a pair of similar glands, Plate XVIII, Fig. 11. With these glands hitherto undescribed, and which we must, from their position at least, term maxillary and labial glands, the so-called maxillary glands of Lucas present a problem for nomenclature. Lucas ventures the theory that the glands of the head are coxal glands and the homologs of the parapodal glands of the annelid. If this theory be accepted then the maxillary sclerites may not be possessed of two pairs of glands nor may the mandibular sclerites. The writer prefers to use Patten's name of salivary gland, for the maxillary gland of Lucas.

Glands also exist at the base of the antennæ and below the visual area, but these are not figured.

Circulatory system of *L. indivisus:* This is simple as in all insects and consists of the dorsal vessel which extends from the ninth segment of the abdomen to the head, where it spreads out upon the supra-œsophageal ganglia. There are nine pairs of alary muscles beginning between the metathoracic and first abdominal segments and continuing to lie between the segments as far back as between the eighth and ninth. The first four are slender but the remaining five are heavy and connect with the one in front and behind it. In front of each pair of muscles, a valve exists in the dorsal vessel, Plate XIV, Fig. 8.

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EXPLANATION OF PLATES.

Plate XIV.

Fig. 1. Central nervous system of *Limnophilus indivisus* and larval reproductive organs.

Fig. 2. Central nervous system of *Phryganea interrupta* and larval reproductive organs gd1=gonad from the ental lateral aspect. gd2=gonad frequently found and assumed to be the ovarian gonad.

Fig. 3. Central nervous system of *Hydropsychodes analis* and anal region with blood gills protruding from anus.

Fig. 4. Dorsal aspect of the supraœsophageal ganglia of *Limnophilus indivisus*.

Fig. 5. Lateral aspect of the supraœsophageal and subœsophageal ganglia of *Limnophilus indivisus*.

Fig. 6. Ventral aspect of subœsophageal ganglion of *Limnophilus indivisus*.

Fig. 7. Transverse section through the ovary of *H. analis*.

Fig. 8. Ventral aspect of the circulatory system of *L. indivisus*.

Plate XV.

Fig. 1. Lateral aspect of the alimentary canal of *Limnophilus indivisus*.

Fig. 2. Œsophageal valve of *Limnophilus indivisus*. The portion of the canal containing the valve has been slit longitudinally and the valve laid open.

Fig. 3. A transverse cut back of the œsophageal valve.

Fig. 4. Diagram to show the relative position of the Malpighian tubules at the division between mesenteron and hind intestine.

Fig. 5. Transverse cut through the rectal valve at a level with 5 in Fig. 1.

Fig. 6. Lateral section through the œsophageal valve. The cephalic end of the valve is toward the bottom of the page.

Fig. 7. Lateral aspect of the alimentary canal of *Hydropsychodes analis*.

Fig. 8. Caudal aspect of anus of *Hydropsychodes analis*.

Fig. 9. Dorsal aspect of the anus of *Hydropsychodes analis*.

Fig. 10. Longitudinal section through the division point between mesenteron and hind intestine showing a valve, caudad of the Malpighian tubules; and the folded digestive epithelium of the mesenteron.

Fig. 11. Ventral aspect of the alimentary canal of *Phryganea interrupta*, only the ventral pair of tubules are figured.

Plate XVI.

Fig. A. Diagram of the hind intestine of *Hydropsychodes analis*, with the levels at which the figures 1–6 are taken, indicated.

Fig. 1. Cross-section through the hind intestine at a point where a semi-rectal valve is formed by the invaginated folds of the intestinal wall.

Fig. 2. Cross section taken at level No. 2, showing the glandular structure of the large intestine.

Fig. 3. Cross section at level No. 3, showing the six folds of the small intestine with the cubical cell in the wall and the ental layer of circular muscles with the six pairs of longitudinal muscles.

Fig. 4. Cross section at level No. 4, showing the ectal row of circular muscles in addition to the condition in Fig. 3.

Fig. 5. Cross section at level No. 5, showing the beginning of the columnar epithelial cells and the breaking up of the six pairs of longitudinal muscles into a layer of smaller longitudinal muscles.

Fig. 6. Cross section at level No. 6, showing the Malpighian tubules forming in the hind intestine; also the breaking up of the ectal circular muscles. Note the presence of intima which indicates the structure as being a part of the hind intestine.

Fig. 7. A cross section slightly cephalad of the level of Fig. 6, showing the digestive epithelium in diagram and the heavy layer of longitudinal muscles characteristic of the mesenteron. The ventral pair of Malpighian tubules are seen here just coming to the surface.

Fig. 8. A portion of a cross section of the mesenteron of *Limnophilus indivisus*, which shows the normal two rows of muscles.

Plate XVII.

Blood Gills of *Hydropsychodes analis*.

Fig. 1. Cross section of anal region to show the T-shaped anus. × 70.

Fig. 2. Cross section through the anus with a gill lying in the aperture. × 70.

Fig. 3. Cross section through the rectum showing all four gills. × 70.

Fig. 4. Cross section through the "so-called rectal valve." × 140.

Fig. 5. Sagittal section of the gill region showing the intestinal wall invaginations that make the valve as at Fig. 4, and later make the gill wall itself and are continuous with the rectal wall caudad of the gills.

Fig. 6. Sagittal section of the gill region to show the retractile muscle of the gill and the relation to the body wall.

Fig. 7. Sagittal section of the gill region with the blood gills extended in function. × 125.

Fig. 8. Cross section of a functioning gill showing the three muscle branches.

Fig. 9. The blood which fills the gills when in function. × 320.

Plate XVIII.

Fig. 1. Dorsal view of the silk glands and Gilson's gland of *L. indivisus*.

Fig. 2. Ventral view of the mouth parts of *L. indivisus* with the silk glands located.

Fig. 3. Lateral aspect of the mouth parts of *L. indivisus*.

Fig. 4. Dorsal aspect of the silk glands in relation to the subœsophageal ganglion.

Fig. 5. Lateral aspect of a portion of the silk gland.

Fig. 6. Cross section of the gland proper of the silk gland of *H. analis*.

Fig. 6a. Cross section of the gland proper of the silk gland of *L. indivisus*.

Fig. 7. Longitudinal section of a Malpighian tubule.

Fig. 8. Cross section of a Malpighian tubule.

Fig. 9. Dorsal aspect of the Gilson's gland of *P. interrupta* in relation to the prothoracic ganglion.

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Fig. 11. Ventral aspect of the glands in the labial sclerite of *L. indivisus*. X 120.

Fig. 12. Ventral aspect of the gland in a maxillary sclerite of *L. indivisus*. X 120.

Fig. 13. Ventral aspect of the maxillary gland of Henseval and Lucas. × 30.

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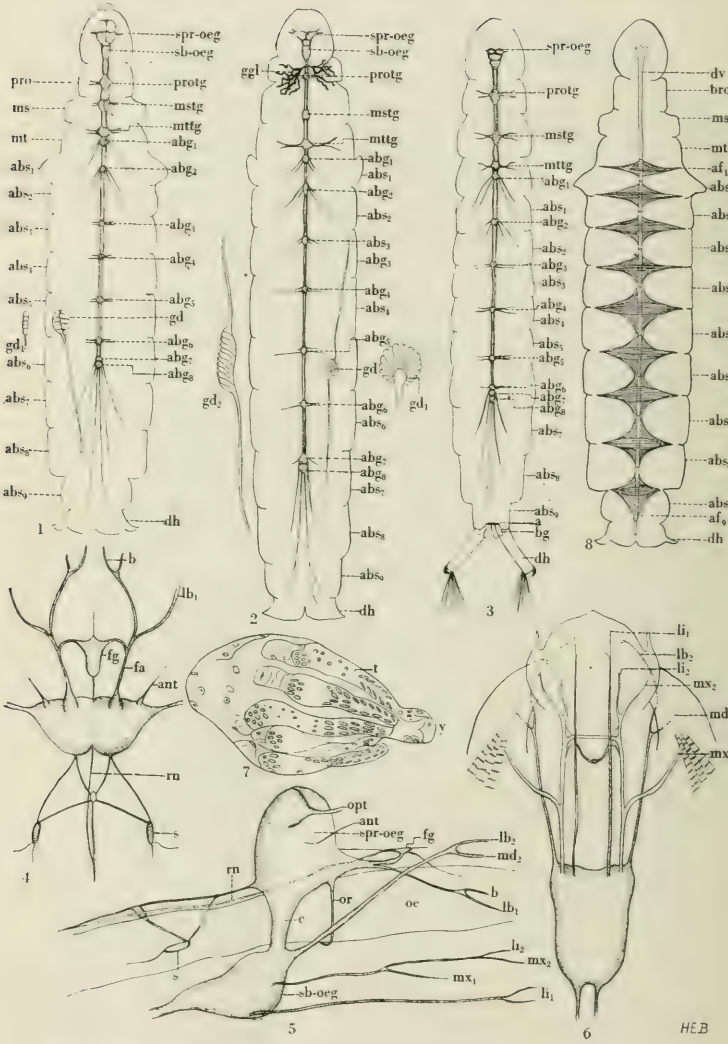
Fig. 15. Cross section of several of the unicellular portions of the maxillary gland of Henseval and Lucas. × 30.

INDEX TO FIGURES.

a = anus.
abg = abdominal ganglia 1 to 8.
abs = abdominal segment 1 to 9.
ant = antennal nerve.
af = alary muscle 1 to 9.
b = nerve to front of head.
bc = buccal cavity.
bg = blood gills.
bm = basement membrane.
c = crura cerebri.
cr = crop.
cm = circular muscles.
cp = corpuscle.
ct = conducting tubule.
dep = digestive epithelium.
dh = drag hooks.
dv = dorsal vessel.
ep = epithelium.
ex = expansion area.
excm = exterior circular muscle.
fa = frontal arm.
fg = frontal ganglion.
gd = gonad.
gd1 = gonad in inner aspect.
gd2 = probable ovary of *P. interrupta*.
ggl = Gilson's gland.
glep = glandular epithelium.
gsp = spinneret of Gilson's gland.
in = intima.
l = Lumen.
lb1 = labral nerve.
lb2 = labral nerve.
lb-s = labral sclerite.
li1 = labial nerve.
li2 = labial nerve.
li-s = labial sclerite.
l-int = large intestine.
lm = longitudinal muscle.
md2 = mandibular nerve.
md-s = mandibular sclerite.
me = mesenteron.
mp = Malpighian tubule.
mp1 = dorso-lateral pair.
mp2 = lateral pair.
mp3 = ventral pair.
ms = mesothorax.
mstg = mesothoracic ganglion.
mt = metathorax.
mttg = metathoracic ganglion.
n = nucleus.
oe = œsophagus.
og = opening of gland.
opt = optic nerve.
oev = œsophageal valve.
or = œsophageal ring.
p = pigment.
pm = gills press muscles.
pr = proventriculus.
pro = prothorax.
protg = prothoracic ganglion.
ptm = perotrophic membrane.
r = rectum.
rm = retractile muscle.
rn = recurrent nerve.
rv = rectal valve.
rw = rectal wall.
s = sympathetic ganglion.
sb-oeg = sub-oesophageal ganglion.
spr-oeg = supra-oesophageal ganglion.
skc = silk gland duct.
skp = silk gland proper.
sb = striated border.
sm-int = small intestine.
sp = spinneret.
t = tubule.
tr = trachea.
y = ventral end of ovary.



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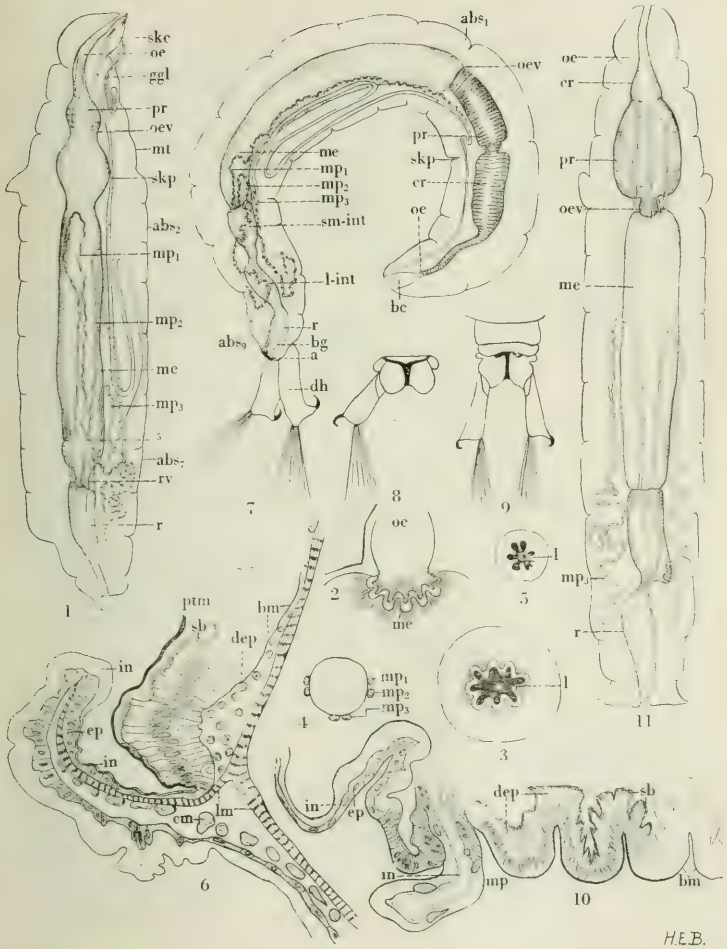

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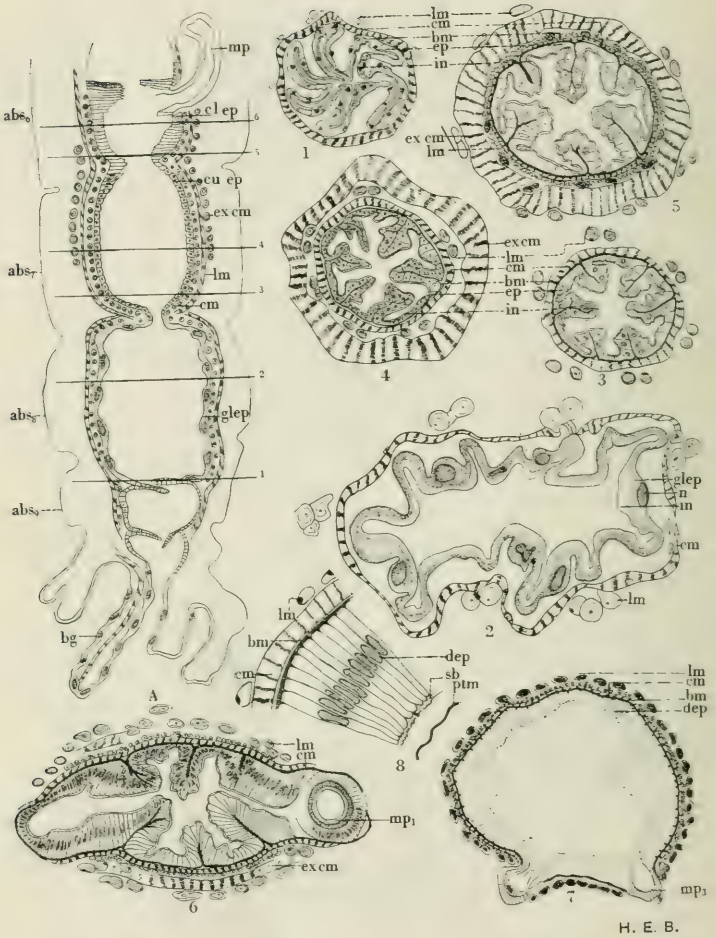

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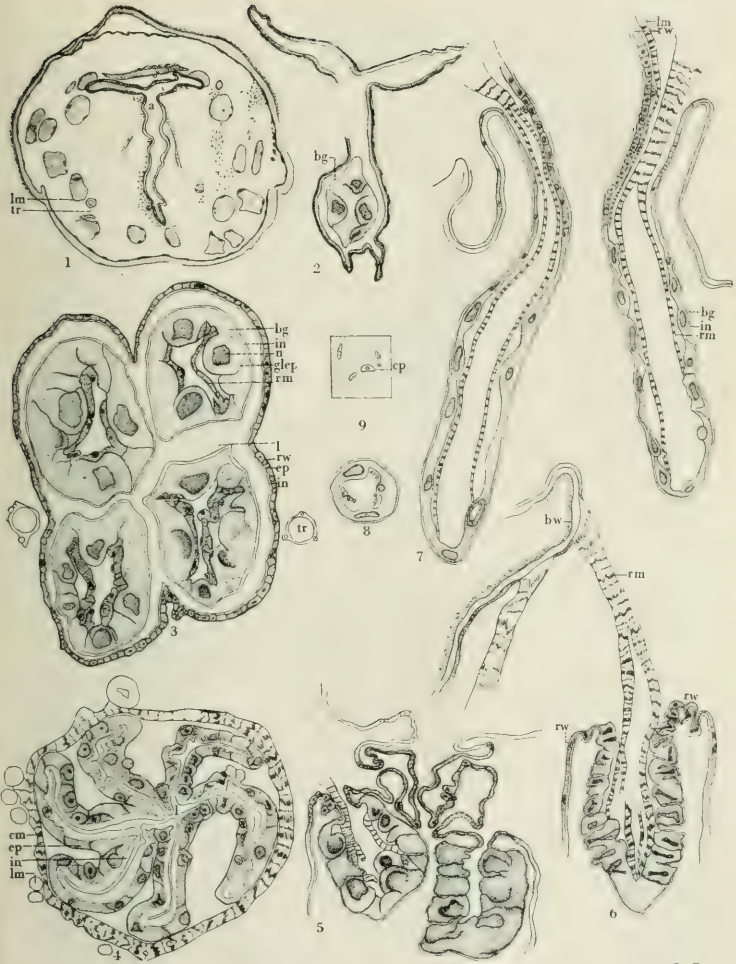

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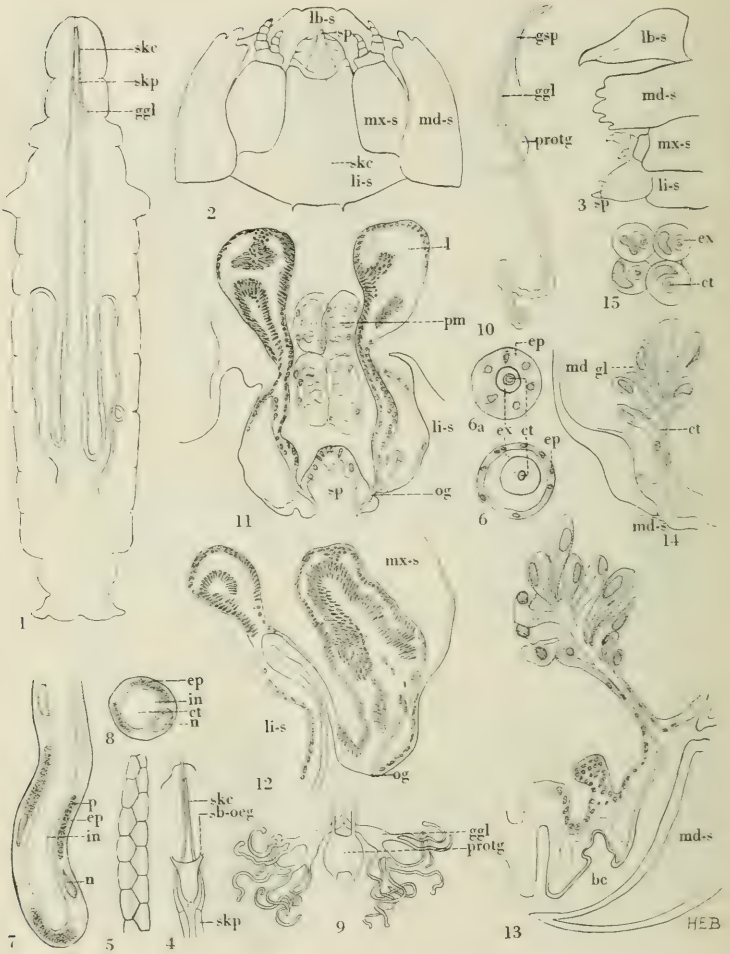

Hazel Elisabeth Branch.

ANNALS

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NOTES ON FEMALE PARAIULIDS

(Myriapods), with Description of a New Species.

Henry W. Brolemann,
Pau (France).

The material submitted to examination is composed of two species of *Paeromopus* and of six representatives of the genus *Paraiulus*. Of the two *Paeromopus*, one is the well known *P. lysiopetalinus* Karsch, while the other, being new to science, will be spoken of as *Paeromopus Chamberlini* and will be described hereafter. The *Paraiulus* species are *P. tiganus* Chamb., *P. pennsylvanicus* (Brandt) Wood, *P. immaculatus* Wood, *P. impressus* Say, *P. venustus* Wood, and the species recorded by the author (1895) as *P. ellipticus* Bollman. Most of the *Paraiulus* specimens have been obtained through the kindness of Ralph V. Chamberlin, of the Museum of Comparative Zoology, in Cambridge, to whom the writer wishes to express herewith his indebtedness.

It may safely be stated that, on the whole, the study of female Diplopods, and particularly of their sexual organs, has been completely neglected, attention having been almost exclusively devoted to the male copulatory apparatus. H. C. Wood (1865, Trans. Amer. Phil. Soc., XIII) is probably the first author having made use of the vulvæ in identifying Paraiulid species.

The distrust in which the females have been held is probably due to the fact that the male structures happened to be so multifarious and of such constancy as to afford the easiest

and most reliable means of identification of the species, while on the other hand the vulvæ appeared less manifold and did not supply equally favorable criteria. Another reason lies in this that the vulvæ have long remained a mystery.

Since 1909 (Sitzb. Ges. naturf. Freunde Berlin, 1909, No. 4), Verhoeff claimed to have settled the matter by holding that the vulvæ—as well as the penis— had to be identified with pairs of limbs. These were supposed to be the posterior limbs of the third segment, which the author admitted to be

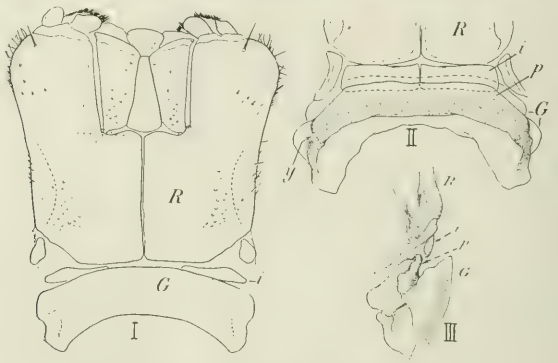

Fig. I. *Paeromopus lysiopetalinus;* gnathochilarium, ventral aspect.
Fig. II. *Paraiulus tiganus.* Base of gnathochilarium of adult female, dorsal aspect. The postmentum, *p*, is fastened to the gula, *G*, along the line left blank, *y*.
Fig. III. *Paraiulus venustus.* Base of gnathochilarium of adult female seen obliquely from the side.

double, as the abdominal segments. It was in fact but a mere personal view, supported by no convincing reasons, and has been contradicted by Brolemann & Lichtenstein (1919, Arch. Zool. exper. gen., LVIII, fasc. 4, mars, 1919), who admit that the so-called vulvæ are not the equivalent of limbs, but are merely superficial differentiations of the membrane surrounding the aperture of the oviduct.

It is not deemed appropriate to recall in this paper the reasons which have prompted the opinions here recorded. Yet it will not be useless, in order to render the task easier

to readers of the following descriptions, to draw an elementary sketch of a vulva and to make them acquainted with the terms which have been applied to the different parts of these puzzling organs.

The two branches of the oviduct are known to end behind the legs of the second pair and to be capped with vulvæ. In most of the Diplopod groups (*Colobognatha* and *Oniscomorpha* excepted), the vulvæ are concealed in a deep depression of the intersegmental membrane, which will be known as the vulvar "vestibulum." In some cases the vulvæ stand side by side in the vestibulum, while in some others they are sunk into independent, lateral invaginations of the vestibulum, apart from each other, (Fig. 3). The position of the vulvæ is therefore very different, according to the various cases; but whatever it may be, in order to make things obvious, a vulva is always considered isolated and standing with its free end upwards (as represented in Figs. 26 and 27, *Paraiulus pennsylvanicus*, for instance).

In condition of rest, the terminal region of the oviduct may be compared to a funnel which has been pressed flat, causing the aperture to be linear and perpendicular to the main axis of the body. Immediately behind the aperture the neighboring surface is raised into a more or less projecting and rounded, always very conspicuous jutting, called the "mound." Its lateral slopes are protected by chitinised plates, reminding one of the shells of a Lamellibranch, and consequently termed the (inner and outer) "valves," (*iv*, Fig. 26). An apical space, the "ridge," (*r*, Fig. 27), is left between the valves, made of colorless chitine, below which is to be seen a longitudinal chitinous, gutter-shaped thickening, the "apodema," (*a*), extending perpendicularly to the aperture of the oviduct. The apodematic gutter communicates with the exterior by means of a longitudinal "slit," which divides the ridge into more or less regular halves.

In some cases the posterior ends of the valves remain free, the ridge being open backwards; in the case of Iulids, the valves are generally connected by, and often fused with a posterior-median plate, the anterior margin of which is emarginate and thickened in shape of a horse-shoe ("horse-shoe plate"). The latter bounds the ridge caudad. (*h*, Fig. 27).

Further backwards, behind the mound, a plate of very variable size and form may be observed, which is known as the "shield." It is not unusually found amongst Polydesmids, Chordeumoids or Spirostreptoids, but has only been met with in a single Iuloid Diplopod, *Mesoblaniulus serrula*, and its existence in *Paeromopus* is highly interesting, (*s*, Figs. 4, 8, 9).

Cephalad the mound is fenced in by the posterior wall of the oviductal funnel; its anterior end is therefore flattened and may be spoken of as the "anterior truncation."

In front of the oviductal aperture is a more or less thickly chitinised, erected plate (*o*, Fig. 5, 26, etc.), the posterior surface of which is lined by the anterior wall of the funnel. Its outline is variable and made to fit the anterior truncation of the mound, whence the name "operculum" used for it.

As a matter of fact, the vulvæ are by no means as simple as could be inferred from the above rough sketch; but the latter will, perhaps, be sufficient from a morphological point of view, and readers interested in further details will kindly refer to Brolemann & Lichtenstein's paper of 1919. Yet a few more words have to be devoted to a structure exceptionally met with in some American species.

When the vestibulum is deep enough to conceal the vulvæ and to allow the third segment to meet the second above them, the operculum has very little importance as a protective plate (see *P. tiganus*). But when the summit of the vulva is on a level with the ventral surface, the operculum is made to shelter the mound from external contacts. For instance, in contradiction with what has been so far observed in other groups, the operculum of some of the species hereafter recorded is by far the largest plate of the vulva, the most interesting cases being those of the *Paraiuli* of the *impressus* group. In these species the vulvæ are coupled, the opercula of both vulvæ having become coalesced into an uncommonly large, tectiform plate, erected perpendicularly to the main axis of the body (*y*, Figs. 39, 46, etc.), the only trace of fusion left being a notch in the apical ridge; consequently this plate will be spoken of as a "synoperculum." The mounds are located laterally in distinct, symmetrical dimples bounded distally and inwardly by diagonal edges of the operculum, delineating between them and the apical ridge a raised, triangular or heart-shaped space,

projecting caudad ("heart-shaped projection").* The outline of the synoperculum, the depth of its apical notch, the size of the heart-shaped projection are different in each species and supply good criteria for the identification of adult females.

Before entering into further details as to each particular case, some of the general features of the species under consideration may be mentioned. In *Paeromopus* the ventral duplicature of the mandibular stipe is short and more or less angular, while in *Paraiulus* it is produced into a rounded lobe, reaching about half the length of the cardo. Ralph V. Chamberlin has published a drawing of the gnathochilarium of a male *Paeromopus lysiopetalinus* (Ann. Entom. Soc. Amer., III, No. 4, 1910, Pl. XLIII) which agrees almost entirely with our own, except that no plates are represented between the gula† and the base of the stipes. In Californian ♂ and ♀, *P. Chamberlini*, as well as in ♀ *P. lysiopetalinus* (Fig. 1), two symmetrical narrow stripes are found, considered to represent the intermentum. However, a sexual dimorphism might account for this discrepancy and the matter has therefore to be investigated anew. The postmentum is constantly missing.

It has already been stated, 1902, that an intermentum and a postmentum exist in both sexes of *Paraiulus*. However, a detail was at that time left unmentioned, i. e., that the postmentum, which is independent in males, is fastened to the gula in females, the caudal margin of the former being fused with the dorsal concavity of the latter, as shown in Fig. II and III. In the *Blaniulidæ*, which are European representatives of the *Paraiulidi* phylum, the intermentum and the postmentum are both present, the latter always remaining independent, but being entire (*Blaniulinæ*) or divided into two plates (*Isobatinæ*). The female *P. pennsylvanicus* examined combines the two structures, as the postmentum is divided, as in *Iso-*

*The origin of the "heart-shaped projection" will probably have to be sought for in the "hood" of *Paeromopus*. While in the latter it has become an almost independent plate through the effects of long lasting rectigradation, in *Paraiulus*, it has not reached the same grade of achievement owing to reasons still to be ascertained, but likely to be connected with Neotenia.

† Since his paper, 1902—Ann. Soc. Entom. France, LXXI—the author has been induced to accept the terms proposed by Verhoeff for the parts of the gnathochilarium. Consequently what was named mentum, hypostoma and ventral plate I in said paper, is now the intermentum, the postmentum and the gula.

batinæ, and yet is attached to the gula, as in other species of *Paraiulus*.

In female *Paraiuli*, the second segment and the third are more or less swollen in accordance with the size of the vulvæ. The second segment is generally produced ventrad, the ventral margins of the tergo-pleural arch being twisted (Fig. 12, a) and bearing the so-called ventral lobes (*l*). On the surface of the twisted part occurs a transverse "ventral ridge" (n), surrounding cephalad a large and shallow dimple (*u*). According to species the ventral ridge is more or less irregularly curved, the dimple resulting broader or longer. The third segment shows a still more irregular structure, as it sometimes tapers ventrally (*tiganus*), and sometimes grows longer (*impressus–venustus*); the ventral lobes may likewise be very different or much reduced.

In *Paeromopus* (♂ and ♀), the ventral region of the three anterior, thoracic segments present a more simple structure, deemed to be archaic. The duplicatures of the collar lobes are more narrow and their angles are evenly rounded (not notched). No ventral lobes are found on the two following segments, the margins of which are diagonally converging backwards, the posterior angles being acute. Under contraction (Fig. 54), the three segments are forced into one another, their ventral margins uniting to build an oval frame, which is closed backwards by the sternal plate of the fourth segment, and in which fit the head with the mouth-parts, the limbs of the first and second pairs and the sexual apertures (vulvæ or penis) closely packed together. An exceptional case is likewise found in *Paeromopus*, as the sternite of the third pair of legs is not fused with the fourth tergo-pleural arch, as usual, but freely articulates with it, a condition realized in the Japanese genera *Karteroiulus* and *Kopidoiulus*.

In all cases the limbs of the first pair remain independent and show no striking particulars; the sternite is usually missing (Fig. 2). The limbs of the second pair are preserved in *Paeromopus* (Fig. 3), and are not coalesced; the sternal plate is scarcely chitinised and only between the stigmata, which are membranous dimples; the tracheal stalks are very long and slender, ribbon-shaped, bent backwards and outwards. The coxæ are represented by their basal expansions only, the cylindrical part missing altogether and the telopodites articu-

lating on the inner angles of the basal expansions. The following joints show the normal structure of the ambulatory legs. The vulvar vestibulum is a wide depression closed by five folds made of tough membrane; of these, two anterior symmetrical folds (1, 2) run parallel with the basal expansions of the coxæ, while two lateral symmetrical folds (3, 4) connected by a fifth median odd fold (5) surround the aperture backwards. On each side of the vestibulum are deep invaginations (*i*) in which the vulvæ are concealed.

In *Paraiulus* the conditions change according to the groups, *tiganus* namely being strikingly different from the other species in respect of vulvæ, and until more material has been examined, no general diagram can be proposed. It seems, however, that the vulvar vestibulum is less developed, that the vulvæ are never hidden in independent invaginations and stand side by side on the middle line, and that the limbs of the second pair have always undergone a more or less advanced reduction, disappearing even entirely in some cases (*immaculatus–pennsylvanicus*).

In a larval stage of *Paraiulus*, supposed to be the last, the second pair of legs constantly has been found to exist, (Figs. 19, 20), but it differs from the ambulatory legs in that the basal coxal expansion is narrower and the cylindrical part is longer than usual.

Genus **Paeromopus** Karsch, 1881.

Paeromopus lysiopetalinus Karsch, 1881.

(Fig. I and 1–5).

♀. Length 133 mm.; diameter 7.25 mm.; 75 segments, of which 1 apodous; 143 pairs of legs.—Adult.

♀. Length 142 mm.; diameter 7.96 mm.; 73 segments, of which 1 apodous; 139 pairs of legs.—Adult.

♀. Length 144 mm.; diameter 6.80 mm ; 73 segments, of which 2 apodous; 137 pairs of legs.—Adult.

Sonoma County, California.

These specimens do not entirely agree with Karsch's description; the fact that the type is a large male, measuring 150 mm. with 80 body segments, may account for the discrepancies.

Color a very dark brown, with brownish limbs; clypeus fulvous; metazonites adorned between the pores with orange transverse bands. Body narrowed anteriorly, the diameter of the seventh segment being 5.20 mm., that of the 24th segment 6.80 mm. Yet the second and third are more swollen than the neighboring segments.

Clypeus transversely wrinkled or rugose. Antennæ reaching as far back as the fifth segment; comparative measures of the joints as follows:

1st joint, length	0.559 mm.;	
2d joint, length	1.978 mm.; diameter	0.752 mm.
3d joint, length	2.193 mm.; diameter	0.709 mm.
4th joint, length	1.935 mm.; diameter	0.623 mm.
5th joint, length	1.763 mm.; diameter	0.645 mm.
6th joint, length	1.333 mm.; diameter	0.645 mm.
7th–8th joints, length	0.301 mm.	
Total length	10.062 mm.	

Mandibular stipe short, scarcely longer than the cardo (Fig. 1); mandibula much higher than broad, with numerous pectinate lamellæ (12 to 14). Intermentum present, divided; postmentum wanting, the gula showing a single ventral ridge, (Fig. 1).

First segment coarsely punctured dorsally; lateral lobes small, acute, with some 8 or 10 thin, shortened sulci closely packed together in the angle of the lobe. Second segment showing coarse punctures intermingled with faint longitudinal sulci dorsally, the punctures disappearing laterally, while the sulci grow deeper. Following segments distinctly sulcate even dorsally, with only few punctures along the posterior margin, the latter disappearing gradually backwards. First pore on the sixth segment, opening in front of, but close to the suture; further caudad the pores open behind the suture in the center of a small, smooth, indistinctly raised area. Segments without marginal fringe. Karsch devotes a special mention to some depressions to be seen on the segments behind the 18th, which have not been observed.

Legs of the first and second pairs comparatively short. First sternal plate membranous; coxæ of first pair expanded laterally with a slightly sinuous outer margin, and without a cylindrical apical part (Fig. 2). Second sternal plate scarcely chitinised between the stigmatic membranous dimples; tracheal stalks very long and slender, ribbon-shaped; coxæ of second pair similar to those of the first, but somewhat shorter.

Vulvæ concealed in lateral, broad and moderately elongate, invaginations, their summit being on a level with the bottom of the vestibulum (Fig. 3). The operculum, in its anterior aspect, appears as a triangular plate strewn with short setæ, the lateral margins of which are bent back perpendicularly, the outer more than the inner. It is tipped with a peculiar, hood-like appendage (*c*, Figs. 4, 5), laterally compressed, overlapping the mound and bearing few setæ.

The mound is protected laterally by oval valves moderately pilose, standing vertically (*ov*). Their upper angles are connected by what appears to be (in posterior aspect) a thick, strongly chitinised, quadrangular pad (*h*), which is the basal end of the horseshoe plate. The upper forks of the latter, as well as the ridge lying between them, are bent forwards so as to face the concavity of the operculum, thus assuming the position of the anterior truncation. The ridge is wide,

lobed cephalad, and divided by a slit which is narrow anteriorly, but abruptly widens backwards. The apodematic gutter (*a*) is moderately elongate and bears numerous loops and two apical, small, globular diverticula (*d*).

The space left free between the valves and behind the horseshoe plate is filled by a plain, subquadrangular plate (*s*) somewhat broader than long and slightly convex, equivalent to the shield of some *Polydesmus;* its upper margin slightly encroaches on the posterior margin of the horseshoe plate, but does not seem fit to cover completely the plate.

Paeromopus chamberlini, n. sp.

(Fig. 6—9).

♀. Length about 84 mm.; diameter 5.10 mm.; 68 segments of which 2 apodous; 127 pairs of legs.—Adult.
Mt. Shasta, California.

Resembles the preceding species in many features such as relative length of the clypeus and of the antennæ, structure of the gnathochilarium, of the anterior body segments, of the first pair of legs, etc.*

The mandibular stipe is not much longer than the cardo (Fig. 6); it is gradually narrowed anteriorly, the apical angle being slightly produced and acute.

Lateral expansions of the coxæ of second pair much developed (Fig. 7), strongly and evenly arched. The cylindrical part entirely missing. The posterior surface is unusually callous paramesally (*y*) and strongly projects backwards, hanging over the aperture of the vestibulum. The vulvæ appear spindle-shaped on the whole (Fig. 8), being more restricted proximally than in *lysiopetalinus*. The main body of the operculum show no special structure, but the hood (*b*) is larger and broader, more sharpened apically and more expanded caudad, made to cover entirely the mound. The latter (Fig. 9) is longer than high, the valves are lower and more rounded, the horseshoe plate and the ridge are less bent forwards, more horizontal and only partly encroach upon the anterior truncation. The horseshoe plate (*h*) being angularly excised, the ridge is triangular; the slit is not broadened caudad. The apodematic gutter is rather short, depressed in the middle, provided with two short diverticula (*d*); the anterior diverticulum is irregularly swollen and sitting, while the posterior is globular and borne on a short, slender stalk.

The shield (*s*) is as broad as the mound, strongly convex, with rounded base and straight distal margin. The membranous connection between the shield and the horseshoe plate being wide, the shield is admitted to glide over the mound and join the hood of the operculum, the ridge thus becoming entirely hidden from view.

* Further details to be found in the description of the male given "*in fine.*"

Genus **Paraiulus** Humbert & Saussure, 1869.

Paraiulus tiganus Chamberlin, 1910.

(Figs. II and 10–21).

♀. Length 37 mm.; diameter 2.44 mm.; 56 segments, of which 2 apodous; 102 pairs of legs.—Adult.

♀. Length (?); diameter 2.48 mm.; 55 segments, of which 2 apodous; 100 pairs of legs.—Adult.

♀. Length (?); diameter 2.44 mm.; 55 segments, of which 2 apodous; 100 pairs of legs.—Adult.

♀. Length 39 mm.; diameter 2.38 mm.; 54 segments, of which 2 apodous; 98 pairs of legs.—Adult.

♀. Length 29 mm.; diameter 2.05 mm.; 52 segments, of which 2 apodous; 94 pairs of legs.*—Immature.

Adult Female.—Interocular sulcus deeply impressed. Antennæ moderately elongate; comparative measures of joints as follows:

1st joint, length	0.192 mm.;		
2d joint, length	0.608 mm.;	diameter	0.224 mm.
3rd joint, length	0.544 mm.;	diameter	0.240 mm.
4th joint, length	0.512 mm.;	diameter	0.240 mm.
5th joint, length	0.480 mm.;	diameter	0.288 mm.
6th joint, length	0.448 mm.;	diameter	0.272 mm.
7th–8th joint, length	0.192 mm.		
Total length	2.976 mm.		

Mandibular cardo (Fig. 13) equal to two-thirds of the stipe. Mandibular stipe short and broad (ratio: l. 6 x b. 5), rounded anteriorly. Promentum entirely dividing the laminæ linguales; the latter bear six setæ in a longitudinal row, besides the usual premarginal bristle.

Second and third segments (Figs. 10, 11) conspicuously swollen. Profile of second segment angular; ventral ridges low (Fig. 13), almost regularly curved; dimples oval, broader than long; ventral lobes large, over-lapping each other. Third segment tapering ventrally, with profile scarcely convex. Anterior aspect as in Fig. 13, B.

Legs of second pair much reduced (Fig. 14). The sternite (*S*) is a short but broad stripe, with posterior margin straight and outer angles unusually produced. Tracheal stalks more or less developed. The six joints of the limbs are preserved, all except the two distal joints being shorter than broad; first joint almost completely fused with the sternal plate; last joint oval, tipped with a spine-like claw.

Vulvar vestibulum moderately deep, with a wide aperture not constricted by symmetrical folds, fastened to the duplicatures of the third segment and to the anterior margin of the fourth. The vulvæ sit at the bottom of the vestibulum side by side, the operculum facing externally and somewhat forwards.

The mound is a very low, semi-cylindrical body, the walls of which represent the horseshoe plate probably fused with the valves (Figs. 15, 18). The inner region of the wall is more raised and more convex than the outer, causing the mound to be asymmetrical, with the ridge

*The last leg-bearing segment has but a single pair of limbs.

gently sloping outwardly. An abbreviated sulcus is seen on each side of the wall, running close to, and parallel with the anterior truncation, which is rather broad. The apodema (*a*) does not exceed the second third of the ridge; it is deeper in the middle than at both ends and sends forth a median, club-shaped, and an apical, strangely hooked diverticulum (*d*, Fig. 15, 18). The operculum (*O*) is a quite unimportant plate, the form of which is not even definite, as in one of the specimens examined it was scarcely chitinised, while in another no trace of chitinisation could be observed, the operculum being represented by a soft membranous fold.

Immature Female.—In an immature female (Fig. 19, 21), the sternal plate of the second pair of legs is three times broader than long in the middle, slightly arched, with the median angle scarcely produced. The immature vulvæ (*V*, Fig. 19) sit on a membrane stretched behind the second pair of limbs, on a level with the laterally reflexed ends of the sternite. Each vulva is formed of three rounded swellings disposed diagonally, the anterior-outer swelling (*O*, Fig. 21) being the operculum, the anterior-inner (*in*) representing the inner half of the mound, and the posterior (*ov*) the outer half. A rudimentary conic apodema (*a*) is to be observed between the two last mentioned swellings.

It is well worth insisting upon the features of the vulvæ of *P. tiganus*, as not only the condition of the operculum is decidedly exceptional, having never been met with before, but the aspect of the whole organ is so different from what will be found in the following species, that the relationship between the latter and *tiganus* appear very distant, as far as vulvæ are concerned.

Paraiulus pennsylvanicus (Brandt, 1840), Wood, 1865.

(Fig. 22–27).

♀. Length 39 mm.; diameter 2.25 mm.; 64 segments, of which 2 apodous; 118 pairs of legs.—Adult.

♀. Length 34 mm.; diameter 2.15 mm.; 60 segments, of which 2 apodous; 110 pairs of legs.—Adult.

Interocular sulcus moderately impressed. Mandibular cardo (Fig. 24), shorter than in *P. tiganus*, about two-fifths of the length of the stipe. Breadth of the stipe equal to two-thirds of its length; anterior and ventral edges unite in an evenly curved line without any trace of an anterior angle. The promentum thins out apically, the laminæ linguales being almost in contact; the latter bear a row of three to four short setæ and two premarginal long bristles.

Anterior body segments almost cylindrical, the diameter of the second segment is only a little larger than that of the head (Fig. 22, 23). Profile of the second segment rounded; ventral ridges raised; dimples more or less angular and subquadrate (Fig. 25, 1); ventral lobes broad, encroaching on each other. The third segment is not shortened

ventrally; the inner pleural margins are thickened; to their posterior angles are attached flattened lobes, twisted perpendicularly, which overlap each other; the anterior angles are produced into strongly chitinised hooks bent dorsally (Fig. 25, *B*). The upper ends of the hooks are connected by a tough membrane, stretched perpendicularly, in the middle of which are found the relics of the atrophied sternite of the second pair of legs (*P2*). These relics consist of a subreniform, irregularly chitinised, transverse plate, with no definite outline, showing traces of stigmata and of tracheal stalks; the limbs have disappeared altogether.

The space left between the membrane and the ventral lobes is filled with vulvæ. The vestibulum could not be observed, being probably shallow. The vulvæ stand side by side, connected by soft membrane, with the operculum facing cephalad. The general appearance of a vulva is that of a truncate spindle or of a tiny cask. The operculum is flattened, oval in outline, and bears macrochaetæ disposed in four longitudinal rows, two lateral and two paramedian rows, the latter converging proximally. The valves (*iv*, Fig. 26), are almond-shaped, with a median row of bristles, and stand erect. The central part of the mound, i. e., the horseshoe plate and the ridge framed by its branches, are strictly comparable to the mound of *tiganus*, which would have undergone a caudal rotation of 45°, causing the ridge to face fully backwards (Fig. 27). Ridge oval. The slit divides the summit of the mound and part of the ridge into fairly symmetrical halves. The apodema is short, but ends in an extremely long, slightly sinuous, tubular diverticulum.

Paraiulus immaculatus Wood, 1864.

(Fig. 28-34).

♀. Length 36 mm.; diameter 2.65 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

♀. Length 31 mm.; diameter 2.10 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

Interocular sulcus not impressed. Antennæ moderately long, not exceeding the fourth segment; comparative measures of joints as below:

1st joint, length	0.160 mm.;		
2d joint, length	0.544 mm.;		
3d joint, length	0.480 mm.;		
4th joint, length	0.448 mm.;		
5th joint, length	0.416 mm.;	diameter	0.208 mm.
6th joint, length	0.352 mm.;	diameter	0.224 mm.
7th-8th joint, length	0.128 mm.		
Total length	2.528 mm.		

Mandibular cardo (Fig. 30) about equal to three-fourths of the stipe, the latter being longer than usual, and rounded anteriorly. Mandibula furnished with 8 to 9 pectinate lamellæ. Promentum

narrow, shorter than the laminæ linguales, the inner angles of which are almost in contact. Each lamina bears two setæ and two pre-marginal bristles.

Anterior segments not obviously swollen (Figs. 28, 29). Ventral region of second and third segments produced far beyond the collum. Second segment with posterior margin raised and abruptly excised, and with short, triangular ventral lobes. Ventral ridge strong, almost angularly bent; the dimples are broader than long and stretched diagonally (Fig. 31, *A*). The third segment is not narrowed ventrally; its pleural margins are excised, the posterior angles ending into short, ventral lobes, the apex of which remain separated by a wide gap (Fig. 29). The anterior angles send forth rounded processes which are connected by a chitinous bridge (*P2*), homologous with the sternite of the second pair of legs. The sternal bridge shows traces of the stigmata and of the tracheal stalks, the limbs being completely atrophied.

The sternal bridge, the pleural excision and the ventral lobes of the second segment circumscribe an oval space through which the summit of the vulvæ is seen to protrude. Wood (1865, p. 200, Fig. 33) has given a drawing of the vulvæ of *immaculatus*, which gives a correct idea of their general aspect. The vulvæ stand side by side and cling together, although no fusion seems to intervene (Fig. 32). The operculum is a thick, subquadrangular plate, more than twice as high as broad, with blunt angles; the bristles of the anterior surface are rare and only to be found near the apical margin. On its posterior surface a thickening is seen adjacent to the inner distal angle and projecting above the ridge of the mound (*H*, Figs. 32, 33). The latter is extremely asymmetrical. Seen in posterior aspect, the outer valve (*ov*) appears as a triangular plate gradually narrowed proximally and truncate distally, the distal margin being about half the length of the plate; it leans inwardly so as to cover most of the posterior surface of the organ. The inner valve (*iv*) is more like a subcylindrical pillar, much lower than the outer valve; yet its base being on a level with the center of the outer valve, its summit considerably exceeds the apical truncation of the latter and almost reaches the top of the operculum. No horse-shoe plate is present, unless an apical thickening of the outer valve, which connects it with the inner valve, be considered to be its homologue. The ridge is hidden to view, being bent cephalad and dipping obliquely towards the base of the organ (Fig. 34). The apodema is very short and sends forth a comparatively small, pear-shaped diverticulum.

The sternal plate of the third pair of legs has a special shape, different from that of the other segments in having the anterior angles produced laterally and the sides sinuous.

It is noteworthy that, in *immaculatus*, conditions are similar to those met with in *tiganus*, in so far as the vulvar chamber has a rigid aperture supplied by the third segment. However, the comparison cannot be carried on any further as the vulvæ

widely differ in both species, *immaculatus* more approaching those hereafter dealt with. In spite of the special form of its mound, the relationship can be traced in the structure of the operculum, the subapical thickening of which is undoubtedly a preliminary stage of the heart-shaped projection of the synoperculum of *impressus*.

Paraiulus impressus Say, 1821.

(Fig. 35–42).

♀. Length 33 mm.; diameter 2.20 mm.; 53 segments, of which 2 apodous; 96 pairs of legs.—Adult.

♀. Length 26 mm.; diameter 1.77 mm.; 53 segments, of which 3 apodous; 95 pairs of legs.—Immature.

♀. Length 25 mm.; diameter 1.78 mm.; 53 segments, of which 3 apodous; 95 pairs of legs.—Immature.

Adult Female.—Interocular sulcus slightly depressed. Antennæ about the same length as in *immaculatus*, but comparative measures of joints somewhat different:

1st joint, length	0.160 mm.;		
2d joint, length	0.576 mm.;		
3d joint, length	0.512 mm.;	diameter	0.208 mm.
4th joint, length	0.448 mm.;	diameter	0 208 mm.
5th joint, length	0.480 mm.;	diameter	0.240 mm.
6th joint, length	0.416 mm.;	diameter	0.256 mm.
7th-8th joint, length	0.128 mm.		
Total length	2.720 mm.		

Gnathochilarium as in *tiganus*, but less narrowed proximally (Fig. 38); laminæ linguales bearing three setæ besides the premarginal pair. Mandibular cardo about two-thirds of the stipe; breadth of mandibular stipe about four-fifths of its length; anterior margin truncate, with lower angle obvious (Fig. 35).

Second and third segments much swollen (Figs. 35, 36), their ventral surface protruding far beyond the angles of the collum and appearing rounded in profile. Ventral ridge of second segment less sinuous than in the preceding species; dimples as high as broad, almost triangular; the ventral lobes remain disjoined (Fig. 37, *A*). Third segment growing longer ventrally; inner margins almost straight, converging backwards, with rounded anterior angles and short ventral lobes, reflexed and prominent. Ventral aperture wide, filled by the vulvæ, which are never completely concealed (except in contracted condition of the animal).

A rough sketch has already been given in the preceding chapter. The synoperculum sits on a broad base and is narrowed distally, its apical margin being equal to about half its base (Figs. 39, 40). The dwarfed legs of the second pair (*P2*) are attached to its anterior surface, no sternal plate being recognizable; the legs are composed of six joints

shorter than broad, their apex not overreaching the distal margin of the synoperculum. The latter is interrupted mesad, the notch being comparatively narrow and shallow. The heart-shaped projection (*H*, Fig. 40) is slightly impressed longitudinally in connection with the notch; its lateral edges are attenuate and unite proximally with a low, flattened, perpendicular keel, dividing the basal excavations.

The mound (Figs. 40, 41) is a globular, asymmetrical body, entirely clad with the valves, which are fused with the horse-shoe plate and only connected caudad by a narrow, not particularly chitinised bridge. The inner valve is the longest; it is inflated caudad, its upper margin being feebly lobed; cephalad is a low, sharpened, diagonal crest (*c*). The outer valve is divided anteriorly by a wide perpendicular furrow (*w*), the bottom of which is membranous, the valve being conspicuously gibbous immediately backwards of the furrow. The upper margins of the valves are pressed together, concealing the ridge. The apodematic gutter (*a*, Fig. 41) is located in the anterior half of the mound; it appears distorted by numerous loops and terminates in a long and comparatively thick, gradually tapering diverticulum.

Ventral region of the fourth segment, as in Fig. 37, *B*.

Immature Female. — In a larva of the last stage, the mandibular stipe is gently narrowed anteriorly and rounded apically. The second and third segments are neither swollen nor produced ventrad; the third is very different from what it is in adult and more approaches the condition of the second segment, being even shorter than the latter. The main points of the structure of the second pair of legs have already been recorded.

The immature vulvæ (Fig. 42) are considerably more developed than in the *tiganus* larva, being broader than the second sternite, and several details being noticeable. The opercula have already coalesced, their evenly arched upper margins uniting mesad and giving rise to a wide angular notch; on each side of the notch the posterior surface of the synoperculum shows the raised area which, in the adult organ, will be fused in a heart-shaped projection. The mounds are broader than high and of comparatively much larger size than in the adult; yet no other detail of their structure is obvious but a rudimentary apodematic thickening.

Paraiulus venustus Wood, 1864.

(Fig. 43–50).

♀. Length 33 mm.; diameter 2.45 mm.; 51 segments, of which 2 apodous; 92 pairs of legs.—Adult.

♀. Length 33 mm.; diameter 2.42 mm.; 50 segments, of which 2 apodous; 90 pairs of legs.—Adult.

♀. Length 25 mm.; diameter 2.05 mm.; 51 segments, of which 2 apodous; 93 pairs of legs.—Immature.

Adult Female.—Resembles *impressus* in most of its features. Antennæ as below:

1st joint, length	0.224 mm.;		
2d joint, length	0.544 mm.;	diameter	0.208 mm.
3d joint, length	0.512 mm.;	diameter	0.208 mm.
4th joint, length	0.448 mm.;	diameter	0.208 mm.
5th joint, length	0.448 mm.;	diameter	0.240 mm.
6th joint, length	0.432 mm.;	diameter	0.256 mm.
7th-8th joint, length	0.096 mm.		
Total length	2.704 mm.		

Mandibular stipe truncate, but scarcely angular below. Lateral lobes of first segment not evenly rounded, a posterior angle being obvious. The second and third segments are appreciably more swollen, in relation with the larger size of the vulvæ (Figs. 43, 44). The posterior ventral margin of the second segment is raised and rounded, causing the ventral dimple to be almost as long as broad, trapeziform (Fig. 45, *A*). The third segment is much longer ventrally than dorsally; the inner pleural margins are parallel and nearly straight; but the ventral lobes are so small and so widely separated that the vulvar aperture is practically open backwards and reaches as far back as the fourth segment, (Fig. 44).

The vulvæ are uncommonly large (Fig. 46, 47). H. C. Wood (1865, p. 197, Fig. 29) has issued a description and a drawing of these organs which, though reduced are perfectly appropriate; yet he fails to mention that the "flattened cylinders" are coalesced. Compared with the similar organ of *impressus*, the synoperculum is more quadrate, its outer margins being perpendicular (slightly emarginate) and its breadth hardly different distally and proximally. The median notch is larger, with rounded bottom. The edges of the heart-shaped projection (*H*, Fig. 47) are considerably expanded into broad, flattened triangular lobes, reaching laterally the outer margins of the synoperculum and overlapping the distal half of the excavations in which the mounds are sheltered; the outer margins of the lobes converge towards the base of the synoperculum without meeting, entirely disjoining the mounds.

The "pair of very slender, almost filiform, feet-like bodies" mentioned by Wood in connection with the synoperculum, are the atrophied limbs of the second pair which are fastened to its anterior surface. As in *impressus* the six joints are preserved, being broader than long and of irregular size. In addition a small sternal plate was present in the specimen examined.

The lateral outline of the mound reminds of a crescent, the lower, rounded end of which is abruptly bent inwardly below the mound (Fig. 48). A narrow cleft divides the organ into two subequal halves, which are only connected caudad by the reflexed end of the crescent (*h*, Fig. 49), this being equivalent to the horse-shoe. No dividing sulcus exist between the latter and the valves. Cephalad each valve bears a sharp diagonal crest, both crests meeting at the anterior end of the crescent. The anterior region of the inner valve which faces

the synoperculum is poorly chitinized, but lacks the furrow observed in *impressus*. The apodematic gutter (*a*) is by one-third shorter than the mound; it appears distorted by numerous, densely packed loops and terminates caudad with a long, rod-like diverticulum, bent at right angles near its base and clavately enlarged apically (*d*).

The sternite of the third pair of legs is unusually widened cephalad, its breadth largely exceeding half the diameter of the segment (Fig. 45, *B*).

Immature Female.—In a larva admitted to belong to the last stage, the mandibular stipe is rounded in front, no trace of inferior angle being obvious. The second segment has its ventral margins less produced. The third is quite different from the corresponding mature segment, as it is gradually narrowed ventrally, the inner margins running obliquely in the lobes, very much as in the second segment. The second pair of limbs is unmodified, i. e., it shows the structure of the ambulatory legs, except that the coxæ are longer, as is the case with larvæ of other species.

The immature vulvæ (Fig. 50) remind of those of *impressus*, as the opercula are low, transverse plates, with distal margin gently arched, but not fused mesad. The mounds appear as half-moon-shaped bodies, divided by a shallow depression, with a linear slit and rudiments of the horse-shoe and of a digitiform diverticulum.

Paraiulus ellipticus Bollman, 1887.

(Brolemann, 1896-1902).* (Figs. 51, 52).

Gnathochilarium as in *pennsylvanicus*. The twisted ventral lobes of the third segment are very prominent ventrad. A rough outline of the anterior aspect of same and of one of the limbs of the second pair has been published in 1902. Traces of the second sternite are preserved.

Synoperculum very deeply split mesad (Fig. 51); on each side the distal margin is slightly curved and sloping laterally, being in addition strewn with tiny setæ. Lateral margins sinuate, prominent at a short distance from the base. Heart-shaped projection (*H*) somewhat as in *venustus*, its edges being likewise expanded into flattened lobes, but the latter remaining far apart from the outer margins of the synoperculum; the lobes converge abruptly, uniting in a ploughshare-like process (*x*) bent cephalad and driven between the summit of the mounds (*M*), the bases of which remain in contact. The valves of the mound are very dissimilar, the outer (*ov*, Fig. 52) being somewhat higher and appreciably shorter than the inner, causing the ridge to face obliquely backwards and externally. The ridge (*r*) is wide and divided by a conspicuous slit. The apodematic gutter is comparatively short, dipping perpendicularly, provided with some rounded loops and with a fairly long diverticulum, much as in *venustus*.

* This specimen being no longer in the author's collection, the secondary structures had to be omitted.

Description of a New Species.

Paeromopus chamberlini n. sp.

(Figs. 53–57).

♂. Length about 111 mm.; diameter 4.60 mm.; 79 segments, of which 1 apodous; 149 pairs of legs.—Adult.

♂. Length about 93 mm.; diameter 5.12 mm.; 71 segments, of which 2 apodous; 131 pairs of legs.—Adult.

Mount Shasta, California.

Pleural regions black, or at least very dark brown; a broad lively orange band runs dorsally from the first tergite to the last, almost entirely filling the space between the pores; the band thins out anteriorly; posteriorly it covers the margins of the anal valves. Clypeus fulvous, with yellow margin. Limbs brownish.

Labral plate very obvious, the anterior margin of the clypeus being somewhat swollen; mesal notch deep. Clypeus elongate, almost three times the length of the epicranium; surface rather flattened, leathery, with but few setiferous punctures, of which a pair stands in a line with the antennæ. Epicranium unusually short, longitudinally rugose, divided by a distinct sulcus. A less marked transverse sulcus connects the inner angles of the eyes; behind, and in contact with it is the usual pair of setiferous dimples which is formed by coupled punctures. Antennæ long, yet not extending over the fourth segment; measures of joints as below:

1st joint, length	0.256 mm.;		
2d joint, length	1.344 mm.;	diameter	0.544 mm.
3d joint, length	1.728 mm.;	diameter	0.544 mm.
4th joint, length	1.440 mm.;	diameter	0.448 mm.
5th joint, length	1.374 mm.;	diameter	0.480 mm.
6th joint, length	1.184 mm.;	diameter	0.480 mm.
7th–8th joint, length	0.192 mm.		
Total length	7.518 mm.		

Ocelli distinct, numbering about 22 (7, 6, 5, 4), collected on a subtriangular field. Mandibular stipe (Fig. 53) almost quadrate, not longer than high, produced ventrally and with its anterior angle somewhat angular. Gnathochilarium as in female *lysiopetalinus*, i. e., with intermentum and without postmentum.

Collum strewn dorsally with numerous, moderately coarse punctures. Lobes small, angular, marked with four or five short and thin sulci. Following segments very much as in *lysiopetalinus*, the metazonites bearing sulci intermingled with punctures; sulci strongly impressed anteriorly, less deep but more numerous backwards. First pore on the sixth segment; the five or six anterior pores are located behind, and in contact with the suture, which is slightly sinuous; further caudad the pores and more and more removed from the suture, so as to open in the first and third of the metazonite. Last tergite very short; its posterior margin is thick and scarcely produced, leaving uncovered the

dorsal angles of the anal valves. The latter are moderately prominent, much higher than long, scarcely rugose, with a tiny irregular sulcus close to the inner margin. Anal sternite with apex truncate. Sternites with a transverse groove behind the middle. Legs elongate; the ventral surface of the second joint is fleshy, appearing generally excavated, and the fifth joint is provided with an angularly produced pad, both structures being found on almost all the legs.

The legs of the first pair are not unlike those of *lysiopetalinus* (Fig. 55). The basal joint is a very short ring, curiously excised posteriorly (*C*), provided with a short tracheal stalk; outwardly a small rounded plate is seen (*S*), admitted to be all that is left of the sternite, the first joint thus being a coxa. The second joint is still shorter and open externally. The remaining joints of the limb are fused into a short and stout cone, tipped with a hook coiled cephalad and divided on its posterior surface by two superficial transverse sulci, which do not extend on the opposite surface. Legs of the second pair with almost completely atrophied sternite; coxal joint subcylindrical, destitute of basal expansion. The following joints show no particular structures, the telopodite being merely shorter than in the ambulatory legs. Penis small, parallel sided on most of its length, apically divided into a pair of abruptly sharpened cones.

Peltogonopods (i. e., anterior pair of gonopods, Fig. 56) resembling those of *lysiopetalinus*. The very short sternal band (*S*) is fused with the long and flattened tracheal stalks (*t*). Coxal joint very long (*C*), gently tapering distally, its apex being pear-shaped and provided with two small hooks directed cephalad. The basal half of its inner edge bears an inconspicuous, short and blunt, retroflexed projection. Apical joint (*T*) as long as the coxa, fastened to the lateral edge of the latter in a manner that its basal, narrowed end almost reaches the sternal plate, while its distal end exceeds the summit of the coxa by less than one-fourth of its own length. The distal end is shallowly depressed cephalad, with acute outer angle, and is provided with two conspicuous processes, an anterior very long and slender, stake-like process, the sharpened end of which is directed proximally, and an inner erected, slightly curved spine, expanded and toothed in the middle of its length.

Sternite of gonopods (*S*, Fig. 57) crescent-shaped, with a narrow median, erected rod thrust between the limbs. The latter are rectangular lamellæ, three times as long as broad. Above the very thick base, the anterior surface is abruptly and deeply excavated, and the outer margin is slightly notched, owing to the fact that the distal part of the margin lies over the proximal part instead of standing in a line with it. Such structures bearing evidence to the former existence of a joint, the proximal thickened region (*C*) has to be looked upon as a coxal ring, while the upper flattened region (*T*) is equivalent to a telopodite. The latter end with a shallow depression, the outer angle being rounded and the inner bearing two short, erected processes, an anterior hooked and an inner spined process. The presence of a seminal groove could not be ascertained.

The female structures have been described above. The larval stages are unknown.

The systematic position of the genus *Pæromopus* has long remained doubtful. Its features are so special that Bollman has been led to create for it the family *Pæromopidæ*, in which Karsch's genus stood alone. But the question of its affinities was not solved thereby. Silvestri, after having left the point undecided, 1896[1], finally, 1898, admits Bollman's family *Pæromopidæ* amongst his *Iuloidea*. So likewise does Pocock[2] who denies it a relationship with the *Blaniulidæ* and the *Isobatidæ*. Attems, in his arrangement of the so-called "*Protoiulidæ*," does not mention Karsch's genus[3].

That *Pæromopus* has to take place in the *Paraiulidi* phylum, will certainly not be contested; yet it has still to be decided if it has to stand with the *Paraiulidæ* or with the *Blaniulidæ*[4].

If considered separately, the male genitalia supply no positive criterium. However, since the vulvæ are somewhat better known, it seems that a clue may be obtained from their structure. It has been mentioned that the vulvæ of *Pæromopus*, provided as they are with a shield, are of a type not usually met with amongst *Iuloidea*. In fact the only species in which a similar structure has been as yet observed, is *Mesoblaniulus serrula* (Brol.), a tiny cave-dweller of the French Mediterranean coast, originally ascribed to *Blaniulus*. In a paper actually submitted to press[5], an abstract of which[6] appeared recently, the author has altered his first opinion mostly on account of the conditions of the vulvæ; consequently it has been brought to rank amongst the *Isobatinæ*. An identical reason will therefore justify an attempt to enclose *Pæromopus* in the same group, in which a new Tribe—*Pæremopini*—will have to be created for its reception. No objection against such a conclusion can be derived from the male genitalia of *Pæromopus*, as these show the structure constantly found existing in *Isobatinæ*, i. e., the preservation in the gonopods of a distinct coxal region, which is missing in *Blaniulinæ*.

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[1]Silvestri, 1896, Ann. Mus. Civ. Stor. Nat. Genova, (ser. 2) XVI, 26, III, 1896, and 1898, Ibid, (ser. 2) XVIII, 29 XII, 1897.

[2]Pocock, Ann. Mag. Nat. Hist., (7) XII, No. 71, Nov. 1903, p. 527.

[3]Attems, Arkiv. for Zool., Stockholm, 1909, V, No. 3.

[4]According to the author's system, the *Blaniulidæ* are divided into two subfamilies, *Blaniulinæ* and *Isobatinæ*.

[5]This paper was ended during the spring, 1921, but could not be issued owing to the adverse conditions.

[6]Arch. Zool. exper. gen., LX, Notes et Revue, No. 1, 1921.

Of course the point under discussion will have to be re-examined when the American *Isobatinæ* and the Asiatic fauna will have become better known. Amongst the Japanese Diplopods already recorded is Attems' genus *Karteroiulus*, the male of which has the fourth segment open, whereas it is fused with the corresponding sternite in the female. But judging from the rough outline published by Attems (l. c., Pl. 2, Fig. 34), the vulvæ seem more closely related to those of the *impressus* group, as the "auf der Oralseite aufgeschlitzen Chitinring" probably answers halves of the synoperculum described in the preceding pages. Nothing is known of the female *Kopidoiulus* Att., the male of which is said to have the fourth segment open, as in *Karteroiulus*.

EXPLANATION OF ABBREVIATIONS USED

a=Apodematic gutter of Mound.
b=Hood of operculum.
C=Coxite.
d=Diverticulum of Vulvæ.
G=Gula.
H=Heart-shaped projection of operculum or synoperculum.
h=Horse-shoe plate or thickening of Mound.
i=Intermentum.
iv=Inner valve of Mound.
l=Ventral lobes of segments.
M=Mound of vulvæ.
O=Operculum of vulvæ.
o=oviduct.
ov=outer valve of Mound.
P2, P3=Second, third pairs of limbs.
p=Postmentum.
R=Stipes of gnathochilarium.
r=Ridge of Mound.
S=Sternite.
s=Shield of Vulvæ.
T=Telopodite of limbs.
T=Tracheal stalks.
u=Ventral dimples of segments.
v=Valves of Mound.
W=Vulvæ.
Y=Synoperculum of Vulvæ.

EXPLANATION OF PLATES.*

PLATE XIX.

Fig. 1. *Paeromopus lysiopetalinus.* Right mandibula, ventral aspect.
Fig. 2. *Paeromopus lysiopetalinus.* First pair of limbs, cephalic aspect.
Fig. 3. *Paeromopus lysiopetalinus.* Second pair of legs, vestibulum (*V*), and right vulvar invagination (*I*), caudal aspect. 1–5=Folds of aperture of vestibulum.
Fig. 4. *Paeromopus lysiopetalinus.* Left vulva, caudal aspect.
Fig. 5. *Paeromopus lysiopetalinus.* Left vulva, outer profile.
Fig. 6. *Paeromopus Chamberlini.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 7. *Paeromopus Chamberlini.* Coxæ of second pair of legs of adult female, caudal aspect. *y*=paramesal projection of coxæ; 1–5= folds of aperture of vestibulum.
Fig. 8. *Paeromopus Chamberlini.* Right adult vulva, caudal aspect.
Fig. 9. *Paeromopus Chamberlini.* Mound and shield of right adult vulva, oblique caudal aspect.

PLATE XX.

Fig. 10. *Paraiulus tiganus.* Anterior end of adult female.
Fig. 11. *Paraiulus tiganus.* Ventral aspect of segments 1–3 of same.
Fig. 12. *Paraiulus tiganus.* Cephalic aspect of second segment (A) and ventral region of third (B). *n*=ventral ridge, and *u*=ventral dimple of 2d segment.
Fig. 13. *Paraiulus tiganus.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 14. *Paraiulus tiganus.* Legs of second pair of adult female, cephalic aspect.
Fig. 15. *Paraiulus tiganus.* Mound of left adult vulva, outer aspect. *O*=membranous fold replacing the operculum.
Fig. 16. *Paraiulus tiganus.* Left vulva from above. *O*=membranous fold replacing the operculum.
Fig. 17. *Paraiulus tiganus.* Anterior truncation of left vulva, the opercular fold of which has been removed.
Fig. 18. *Paraiulus tiganus.* Left vulva of another adult female, outer aspect, showing individual variations in the diverticulum, *d*.

PLATE XXI.

Fig. 19. *Paraiulus tiganus.* Legs of second pair of larva and immature vulvæ, caudal aspect.
Fig. 20. *Paraiulus tiganus.* Base of legs of second pair of larva, cephalic aspect.
Fig. 21. *Paraiulus tiganus.* Immature vuivæ of Fig. 19, enlarged.
Fig. 22. *Paraiulus pennsylvanicus.* Anterior end of adult female.
Fig. 23. *Paraiulus pennsylvanicus.* Ventral aspect of segments 1–3 of same.
Fig. 24. *Paraiulus pennsylvanicus.* Cardo and stipe of left mandibula, ventral aspect.
Fig. 25. *Paraiulus pennsylvanicus.* Cephalic aspect of ventral region of second segment (A) and of third (B). *x*=membrane connecting the ventral margins of 3d segment and bearing the atrophied sternite of 2d legs, *P2*.
Fig. 26. *Paraiulus pennsylvanicus.* Right adult vulva, inner profile.
Fig. 27. *Paraiulus pennsylvanicus.* Right adult vulva, caudal aspect.
Fig. 28. *Paraiulus immaculatus.* Anterior end of adult female.
Fig. 29. *Paraiulus immaculatus.* Ventral aspect of segments 1–3 of same. *P2*=chitinised bridge with symmetrical thickenings homologous to sternite of second pair of legs.

*Camera drawings from the author.

PLATE XXII.

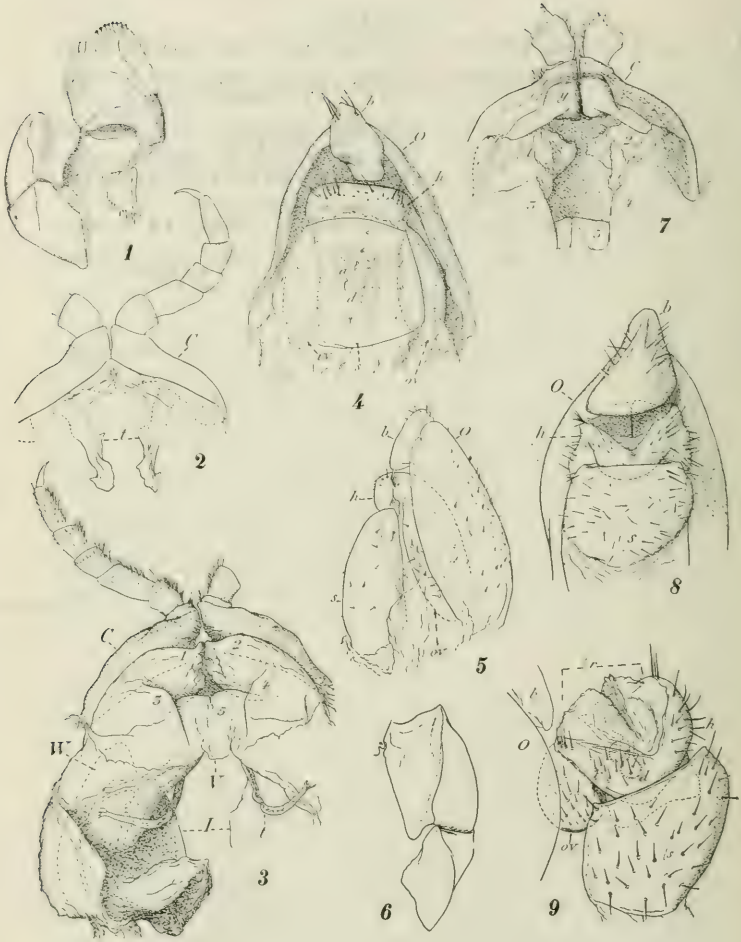
Fig. 30. *Paraiulus immaculatus.* Cardo and stipe of right mandibula, ventral aspect.
Fig. 31. *Paraiulus immaculatus.* Cephalic aspect of ventral region of second segment (A) and of third (B). *P2*=atrophied sternite of second legs.
Fig. 32. *Paraiulus immaculatus.* Adult vulvæ, caudal aspect.
Fig. 33. *Paraiulus immaculatus.* Right vulva, outer profile
Fig. 34. *Paraiulus immaculatus.* Inner oblique view on the anterior truncation of left vulva, the operculum of which has been partly detached and turned aside.
Fig. 35. *Paraiulus impressus.* Anterior end of adult female.
Fig. 36. *Paraiulus impressus.* Ventral aspect of segments 1–3 of same. *S4*=sternite of 4th segment.
Fig. 37. *Paraiulus impressus.* Cephalic aspect of ventral region of second segment (A) and of fourth (B). *S4*=sternite of 4th segment.
Fig. 38. *Paraiulus impressus.* Gnathochilarium of adult female.

PLATE XXIII.

Fig. 39. *Paraiulus impressus.* Synoperculum and dwarfed legs of second pair, cephalic aspect.
Fig. 40. *Paraiulus impressus.* Both vulvæ, caudal aspect. The left mound is bent backwards and is seen from above. *c*=crest of the inner valve of the mound, and *w*=furrow of the outer valve. *e*=basal excavation of the synoperculum.
Fig. 41. *Paraiulus impressus.* Mound of left vulva, inner profile. *c*=crest of the inner valve.
Fig. 42. *Paraiulus impressus.* Base of legs of second pair of larva with immature vulvæ, caudal aspect.
Fig. 43. *Paraiulus venustus.* Anterior end of adult female.
Fig. 44. *Paraiulus venustus.* Ventral aspect of segments 1–3. *S4*=sternite of fourth segment.
Fig. 45. *Paraiulus venustus.* Cephalic aspect of ventral region of second segment (A) and of fourth (B). *S4*=sternite of fourth segment.
Fig. 46. *Paraiulus venustus.* Synoperculum and dwarfed legs of second pair, cephalic aspect. *O*=oviduct.
Fig. 47. *Paraiulus venustus.* Both vulvæ, caudal aspect. *x*=hardened area in the membrane of the vestibulum.

PLATE XXIV.

Fig. 48. *Paraiulus venustus.* Mound of the right vulva, outer profile.
Fig. 49. *Paraiulus venustus.* Mound of the right vulva, anterior truncation (cephalic aspect).
Fig. 50. *Paraiulus venustus.* Base of legs of second pair of larva with immature vulvæ, caudal aspect.
Fig. 51. *Paraiulus ellipticus.* Synoperculum and right mound (*M*), oblique caudal aspect. The left mound has been removed to show the plowshare-like process of the synoperculum, *x*.
Fig. 52. *Paraiulus ellipticus.* The left mound, outer profile.
Fig. 53. *Paeromopus Chamberlini.* Cardo and stipe of male left mandibula, ventral aspect.
Fig. 54. *Paeromopus Chamberlini.* Ventral aspect of segments 1–3 (under contraction).
Fig. 55. *Paeromopus Chamberlini.* Left leg of first pair of male. *A*=cephalic aspect; *B*=caudal aspect.
Fig. 56. *Paeromopus Chamberlini.* Right half of peltogonopods, cephalic aspect.
Fig. 57. *Paeromopus Chamberlini.* Left half of gonopods, cephalic aspect.



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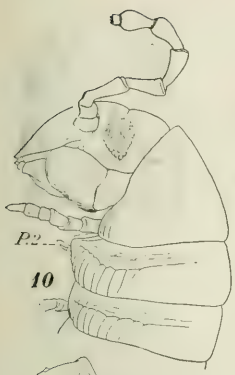

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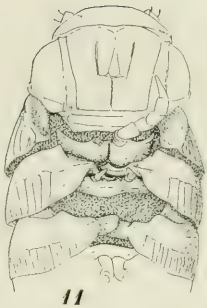

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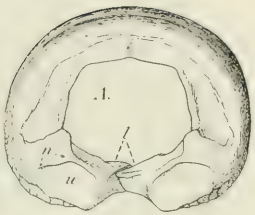

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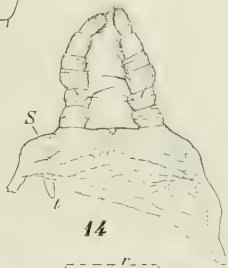

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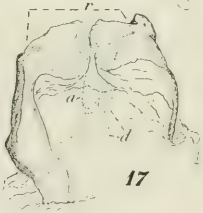

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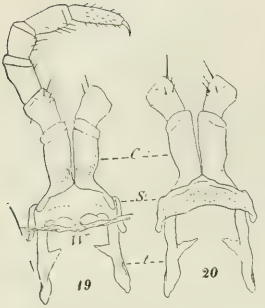
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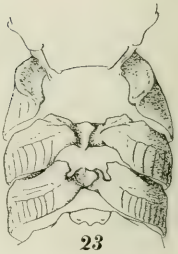
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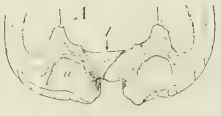
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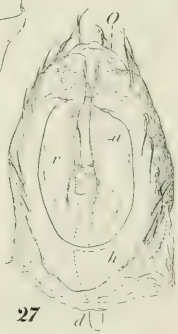
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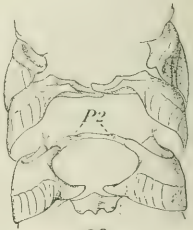
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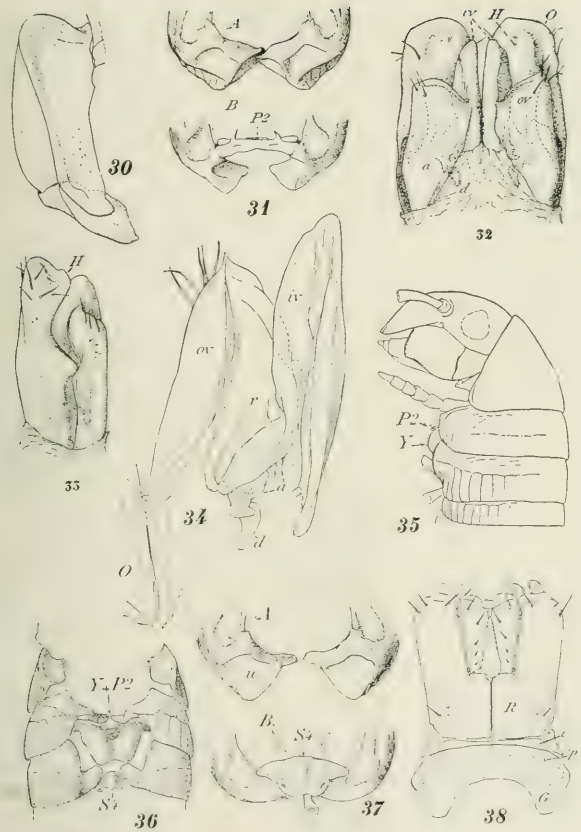

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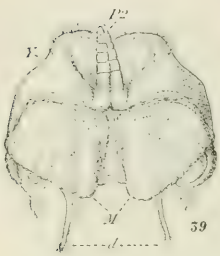
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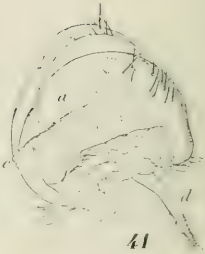
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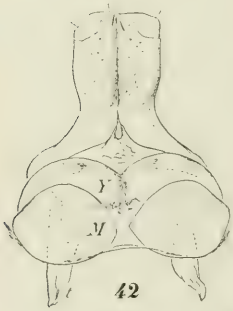
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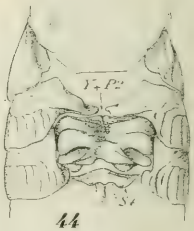
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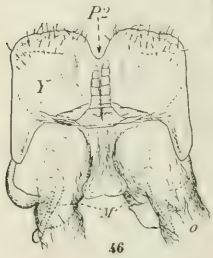
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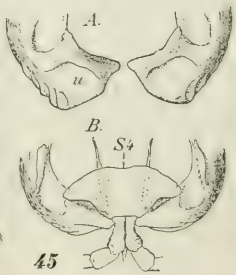
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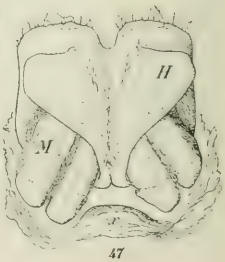
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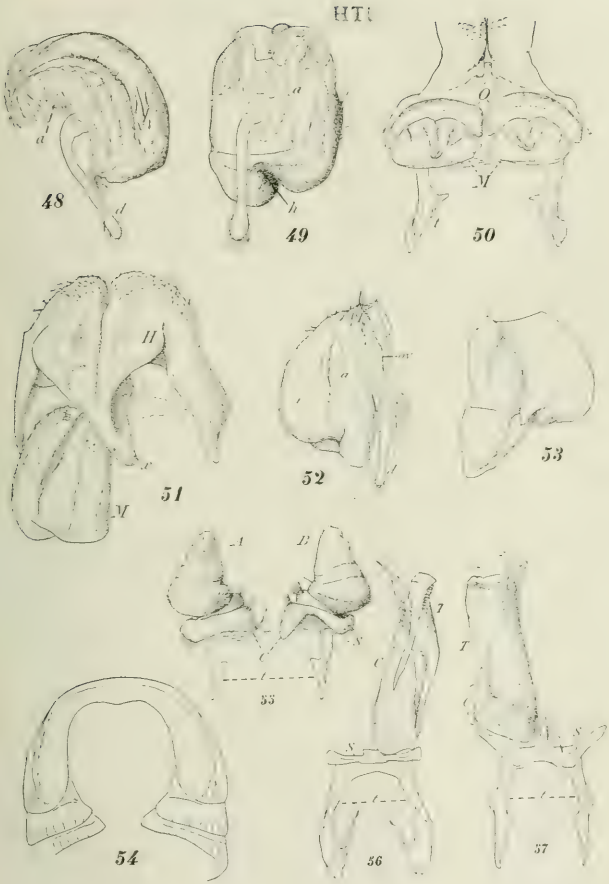

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HEAD AND MOUTH-PARTS OF MECOPTERA.

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Bureau of Agriculture, Manila, Philippine Islands.

INTRODUCTION.

Our knowledge of the head and mouth-parts of the Mecoptera is fragmentary. Nothing comprehensive has been published dealing with the study of a collection of genera and species representative of the entire order. It was with the object of contributing to our knowledge of the morphology of the head and mouth-parts of the Mecoptera and to invite further investigation on the subject that this study was undertaken.

In order to make the work as comprehensive as possible, an attempt was made to study as many species as could be obtained, representing the different genera. Comstock, in his Manual for the Study of Insects, recognizes only one family of Mecoptera, the family Panorpidæ. In his paper on the Panorpidæ of America North of Mexico, Hine (1901) listed five genera, namely: *Merope*, *Boreus*, *Panorpodes*, *Panorpa* and *Bittacus*, dividing these into two groups, those with ocelli in one group and those without in the other. *Merope* and *Boreus* were placed in the first group and *Panorpodes*, *Panorpa* and *Bittacus* in the second. In a recent monograph of the Mecoptera, Esben-Petersen (1921) lists five families, namely: Bittacidæ, Boreidæ, Panorpidæ, Natiothaumidæ and Meropidæ. I have been able to study all of the genera listed by Hine. This comprises all of the families in Petersen's monograph with the exception of one, the family Natiothaumidæ, which like the family Meropidæ, includes only one species (*Natiothauma reedi* MacLachlan) and this is known to exist only in Chile and is very rare.

This study was carried on under the direction of Dr. Alex. D. MacGillivray, of the University of Illinois, and to him I am indebted for his constant encouragement and valuable suggestions and criticisms throughout the progress of this work. I am also indebted to Dr. MacGillivray for his efforts in securing

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specimens not obtainable locally, and I also wish to express my thanks to the following gentlemen who very kindly donated specimens: Dr. J. Chester Brodley, of Cornell University, for *Boreus nivoriundus;* Professor Arthur L. Lovett, of the Oregon Agricultural College, for *Panorpodes oregonensis;* Professor Franklin Sherman, Jr., of Raleigh, North Carolina, for *Panorpodes carolinensis;* and Mr. Nathan Banks, of the Museum of Comparative Zoology, for specimens of *Apterobittacus apterus* and *Merope tuber.* My thanks are also due to Professor S. A. Forbes and Dr. C. P. Alexander for specimens of *Bittacus strigosus* from the collections of the Illinois State Natural History Survey and lastly to Dr. J. W. Folsom, for specimens of *Boreus nivoriundus,* sent to him by Mr. Chas. Macnamara, of Arnprior, Ontario, Canada, and for certain references. I wish also to acknowledge the permission given by Dr. MacGillivray to use his terminology, which will be embodied in a book on insect morphology soon to be published.

METHODS.

The specimens of the head of the different species were treated for a few minutes with a five per cent solution of hot potassium hydroxide. Before being examined they were washed with distilled water and then transferred to 70% alcohol. All dissections and examination were made in alcohol under a binocular microscope. Parts with minute details were mounted temporatily on slides and studied under a compound microscope. An ocular eyepiece micrometer ruled in squares proved helpful in getting the proportions for the drawings.

FIXED PARTS OF THE HEAD.

The order Mecoptera is referred to by taxonomists as having the head prolonged into a trunk-like beak at the end of which are located the biting mouth-parts. An examination of the head of the various species studied shows that *Panorpodes* (Figs. 1, 17, 27) does not conform to this characterization of the order. It is very much orthopteran in form and is the most generalized of all the genera studied and has been taken as the type. *Panorpa* (Figs. 10, 24, 31) and *Boreus* (Figs. 14, 26, 32) are the only genera that possess a trunk-like beak and are the most specialized, *Boreus* being more so than *Panorpa. Bittacus* (Figs. 3, 19, 28), *Aptero-bittacus* (Figs. 5, 23, 29) and *Merope* (Figs. 7, 25, 30) are intermediate in form. It should be mentioned, however, that specialization is not monopolized by either *Boreus* or *Panorpa. Merope,* for example, is without ocelli and in this respect is more highly specialized than either *Boreus* or *Panorpa.*

The epicranial suture is undoubtedly the most important landmark on the head capsule of insects. In a discussion of the sclerites of the head, therefore, it is logical to begin with this suture. This suture is the inverted Y-shaped median stricture found in nymphs, larvæ and generalized adult insects. It marks the line of closure of the head during embryonic development. Originating at the occipital foramen, it extends along the dorso-meson for some distance and gives rise to two branches known as the epicranial arms. Each arm extends toward a compound eye in generalized adult insects and to the cephalic margin of the head in the case of larvæ. The stem of the epicranial suture, designated as the epicranial stem, is obsolete in all the species of Mecoptera studied. In a hypothetical type of the mecopterous head, the epicranial stem, as in generalized insects, originates from the occipital foramen and extends cephalad and ventrad along the meson and is interrupted at some point by the median ocellus. Emerging, still as a single suture from the ventral margin of the median ocellus, the epicranial stem extends ventrad of the antennariæ, where it divides into the epicranial arms, each arm extending laterad to a pretentorina and then ventrad, terminating in a precoila. In *Panorpodes* (Fig. 1), the epicranial arms (ea) are only partially present and the portion of each arm extending from a pretentorina (pn) to a precoila (pr) is obsolete. In *Bittacus* (Fig. 3), the entire epicranial arms are present and in this respect *Bittacus* is more generalized than *Panorpodes*. In *Apterobittacus* (Fig. 5), the transverse portion of the arms connecting the pretentorinæ has disappeared. In *Merope* (Fig. 7), the entire epicranial suture is obsolete. In *Panorpa* (Fig. 10), on the other hand, a portion of the arms is present and is, therefore, in this particular more generalized than *Merope*. In *Boreus* (Fig. 14), the same condition as in *Merope* obtains, the complete obsolescence of the epicranial suture.

The vertex (V, Figs. 1, 6, 14, 16, 19, 27, 28) extends from near the occipital foramen (of. Figs. 16, 19, 22) and ventrad to the sutures marking the boundary of the sclerites of the ventral portion of the head. In generalized insects, as the cockroach, the vertex is a paired sclerite, being divided along the meson by the epicranial stem. The vertex in the Mecoptera is a solid piece, not a paired sclerite, on account of the obsolescence of the epicranial stem. It bears, besides the compound eyes, the ocelli and the antennæ (a). Each lateral portion of the vertex is greatly prolonged ventrad in *Boreus* and *Panorpa*. There is a tooth-like lateral projection of the vertex in *Bittacus*, *Apterobittacus*, *Merope* and *Panorpodes* which is especially prominent in the species of the last named genus. This projection seems to be wanting in *Panorpa* and *Boreus*, but its homologue can be identified in these last two genera.

The fronto-clypeus (fc), formed by a fusion of the front and clypeus through the obsolescence of the fronto-clypeal suture, is, roughly speaking, subquadrate in *Panorpodes* (Fig. 1), *Bittacus* (Fig. 3), *Apterobittacus* (Fig. 5), and *Merope* (Fig. 6), and rectangular and greatly elongated in *Panorpa* (Fig. 10) and *Boreus* (Fig. 14). It is in general

setiferous and is fused with the labrum (l) in all the species studied. Its ventral extent, however, is marked by the position of the precoilæ (pr). In *Merope* and *Boreus*, the fronto-clypeus has completely merged with the vertex owing to the obsolescence of the entire epicranial suture; in *Bittacus*, the fronto-clypeus is wholly separated from the vertex by the epicranial arms, and in *Apterobittacus*, the fronto-clypeus is fused with the vertex along its dorsal margin owing to the obsolescence of the transverse portion of the epicranial arms, whereas in *Panorpodes* it is fused with the vertex along its lateral margins, brought about by the disappearance of the lateral parts of the epicranial arms.

There is a pair of membranous areas dorsad of the fronto-clypeus which connect the antennæ and the head (Fig. 1). These are the antacoriæ (an) and are located on the vertex in the Mecoptera. The size of the antacoriæ in the Mecoptera varies considerably, being smallest in *Bittacus* and most pronounced in *Panorpodes*. Surrounding each antacoria is a narrow, ring-like sclerite known as the antennaria (ar). There is a cuticular projection into the antacoria from the ventro-lateral portion of the antennaria, which is somewhat prominent in *Panorpa* (Fig. 31) and *Boreus* (Figs. 14, 32), designated as the antacoila (aa). Yuasa (1920) referred to the antacoila as being the "chitinized pin" in the cockroach, as described by Miall and Denny.

The compound eyes (ce), regarded as the appendages of the first, ocular or protocerebral segment are of considerable size in the Mecoptera and are especially prominent in *Bittacus* (Figs. 3, 28) in proportion to the size of the head. Viewed from the lateral aspect, the compound eyes are oval except in *Merope* (Figs. 7, 30), where they are oblong and emarginate on the cephalic margin, giving them a distinctly reniform shape, thus resembling the eyes of some Hymenoptera, as *Vespa maculata*. In *Bittacus* the eyes are slightly emarginate on the caudal margin, the reverse of *Merope*, giving the eyes also a kidney-shaped appearance. Each compound eye is surrounded by a narrow ring-like area, which is prolonged cutad as an annular strongly chitinized plate. This area is called the oculata (ol) and was designated by Comstock and Kochi (1902) as an "ocular sclerite." These authors considered the oculata as the proximal segment of an ocular appendage. Crampton (1921), however, is not inclined to consider the oculata as a sclerite, stating that this area is not marked off by a true suture and objects to the consideration of the oculata by Comstock and Kochi as being the basal segment of an ocular appendage. Yuasa (1920) observed the oculata as being always present in all the species of Orthoptera which he studied and as well developed in the species having large compound eyes, as *Mantis religiosa* and *Melanoplus differentialis*. Peterson (1916) likewise recognized the oculata in Diptera and calls it the ocular sclerite, using the term proposed by Comstock and Kochi.

The normal number of ocelli is present in all of the genera studied, with the exception of *Merope*. They are more or less circular in outline and are most prominent in *Bittacus* and in *Apterobittacus*. They are located on the vertex as is true in all Entoptera. In *Bittacus* (Figs.

3, 28) and in *Apterobittacus* (Figs. 5, 29), the lateral ocelli (lo) are situated distinctly dorsad of the compound eyes, whereas they are mesad of the latter in the other genera where they are present. The ocelli are located on convex areas in *Panorpodes* (Fig. 1) and *Panorpa* (Fig. 10) and are close to each other in *Panorpa*. The median ocellus (mo) in all cases is slightly smaller than either of the lateral ocelli.

As stated previously, Hine (1901) divided the genera of the Panorpidæ into two groups, those with ocelli in one group and those without in another. *Merope* and *Boreus* were placed in the first group and *Bittacus*, *Panorpa* and *Panorpodes* in the other. In his monograph, as already referred to, Esben-Petersen (1921) divides the Mecoptera into five families, giving as one of the characteristics of the family Boreidæ to which *Boreus* belongs, the absence of ocelli. I found the normal number of ocelli present in the species of *Boreus* that I studied. The ocelli, however, were small and overshadowed by the black color and shiny appearance of the head, black with a bluish tinge. This is probably the reason why the ocelli in *Boreus* have been overlooked by previous workers. A few minutes' treatment of the head with a five per cent solution of potassium hydroxide will reveal the ocelli as circular, white opaque bodies. Each lateral ocellus is located near the dorso-mesal margin of a compound eye and the median ocellus between the antacoriæ (an). Judged from the location of the ocelli, *Boreus* is more specialized than any of the other genera.

There is a pair of depressions on the cephalic aspect of the head ventro-mesad of the compound eyes. These depressions are known as the pretentorinæ (pn), which mark the point of invagination of the pretentoria (pt, Figs. 37, 38, 39, 40). In *Panorpodes*, *Panorpa* and *Boreus*, the pretentorinæ are situated directly ventrad of the antacoriæ (an), while they are distant from the latter in *Bittacus*, *Apterobittacus* and *Merope;* they are, in these last three genera, near the ventro-mesal margin of the compound eyes and distinctly more so in *Bittacus* where they nearly touch the margin of the eyes.

In specialized insects, the pretentorinæ are not fixed in location. They may migrate away from the precoilæ (pr) but are usually located on or near the epicranial arms. In the Orthoptera, the pretentorinæ are located immediately dorsad of each precoilæ and are apparently distant from the epicranial arms. In the Mecoptera, they are isolated from the precoilæ and are markedly so in *Panorpa* and *Boreus*, owing to the great elongation of the fronto-clypeus.

The precoilæ (pr) in which the mandibles are articulated on the cephalic aspect are distinct in the Mecoptera. Each precoila is located at the ventro-lateral angle of the fronto-clypeus. In generalized insects, each precoila is situated at the caudo-lateral or dorso-lateral angle of the clypeus, depending upon the direction of the mouth-parts. In the honey-bee and other Hymenoptera, the precoilæ are similarly situated as in the Mecoptera. The clypeo-labral suture is obsolete in the Mecoptera studied.

The labrum (l) of *Panorpodes* (Fig. 1) is of considerable size, setiferous, narrower at tip, and each lateral margin is slightly emarginate.

The ventral margin is distinctly emarginate. That of *Bittacus* (Fig. 3) is elongated, narrows gradually ventrad and is slightly rounded at the apex. Its ventral half is fringed along the lateral margin with setæ, those toward the apex being rather prominent. The dorsal half of the lateral margin is thin and folded mesad (Fig. 52). The ventral portion of each lateral fold is also fringed with rather small setæ. The labrum of *Apterobittacus* (Fig. 5) is very similar to that of *Bittacus*. That of *Panorpa* (Fig. 10) is reduced on account of the great elongation of the fronto-clypeus. It is chordate in shape and its apical margin is emarginate. Each lateral margin is fringed with setæ, which are more prominent and are present in larger numbers than in *Bittacus*. *Boreus* (Fig. 14) has likewise a reduced labrum, which is rounded, fleshy and densely setiferous at the apical margin. The setæ of the distal margin are minute. The labrum of *Merope* (Fig. 7) has a bluntly pointed apex and its free margins are densely fringed with rather long setæ. The cephalic surface is also clothed with short setæ, an oblique row of such setæ being recognizable along each side of the meson.

In all the genera studied, the occipital foramen (of, Figs. 17, 19, 22), 24, 25, 26) is of considerable size and is divided into two parts by a strongly chitinized bridge designated as the corpotentorium (et), or body of the tentorium. The dorsal or upper portion of the occipital foramen is larger than the ventral, with the exception of *Bittacus*, where they are almost of the same size. At each ventro-lateral margin of the dorsal portion of the occipital foramen is a strongly chitinized triangular projection known as an odontoidea (od), which serves as a point of articulation for a cervepisternum (ccs), a chitinized lateral sclerite of the cervix or neck which connects the head and the thorax. The membrane connecting the neck and the head is the cervicoria (cc). The odontoideæ are more prominent in *Panorpa* and *Panorpodes* than in *Bittacus*, *Apterobittacus* and *Boreus*. They can hardly be identified in *Merope*.

That part of the head adjacent to the occipital foramen and dorsad of the odontoideæ is known as the occiput (oc). In some insects, as in the grasshopper (*Melanoplus differentialis*) the occiput can be differentiated because of the partial presence of the occipital suture. It is divided along the meson by the epicranial stem. In all the mecopterous insects studied, the occiput is merged with the vertex owing to the obsolescence of the occipital suture.

In the Orthoptera, as in the grasshopper, there are two distinct sclerites, known as the postgenæ (pa), ventrad of the occiput, one on each side of the occipital foramen. In the same insect, there is a transverse suture which separates the occiput and a postgena. The suture in question is designated as the occipito-postgenal suture. In the mecopterous heads studied, the postgenæ are continuous with the vertex and occiput. In the absence of the occipito-postgenal suture, the odontoideæ may be used as landmarks in determining the point of division between the occiput and each postgena. In all the species treated in this paper, the postgenæ are of considerable size and in *Boreus* and *Panorpa*, they are prolonged ventrad as a narrow area.

At the apical margin of each postgena is a distinct acetabulum, a coila, known as a postcoila (ptl) in which the caudo-proximal portion of each mandible is articulated. The postgenæ in all the species of Mecoptera studied extend mesad and fuse on the meson, forming a bridge, known as the genaponta (gn), which limits the ventral extent of the occipital foramen. The genaponta in *Boreus* (Fig. 26) is a large area, whereas it is very narrow in the other genera.

In *Blatta* and other Orthoptera, the tentorium consists of the following parts: metatentoria, carpotentorium, pretentoria, laminatentorium and supratentoria. The tentorium in the Mecoptera (Figs. 37, 38, 39, 40) is not as well developed as in the Orthoptera. All of the typical parts of the tentorium mentioned above, except the laminatentorium, are present in the Mecoptera. The metatentoria (mt) support the lateral margins of the occipital foramen and are prolonged mesad, fusing into a strongly chitinized bridge known as the carpotentorium (ct) or body of the tentorium, and which, as has been stated previously, divides the occipital foramen into two portions. The points where the metatentoria are invaginated are the metatentorinæ (mn); as a rule they are not very distinct in the species of Mecoptera studied. The pretentoria (pt) or anterior arms of the tentorium connect the caudal and the cephalic aspects of the head. The places of invagination of the pretentoria are the pretentorinæ (pn), which have been described elsewhere. Arising from each pretentorium and connecting the latter with the ental portion of each lateral margin of an antennaria is a supratentorium (st). The supratentorium are best developed in *Bittacus* and *Apterobittacus* and are hardly distinguishable in *Panorpa* and *Panorpodes* where they are thread-like.

MOVABLE PARTS OF THE HEAD.

The antennæ are usually long, setiferous and multiarticulated in the Mecoptera. The antenna of *Boreus* (Fig. 35) is filiform and consists of twenty-three segments. Those of *Panorpodes* and *Panorpa*, like those of *Boreus*, are filiform and consist of a larger number of segments. *Bittacus* (Fig. 33) has a setaceous antenna consisting of about twenty segments. The antennæ of *Merope* (Fig. 34) are very different, moniliform, there being twenty-nine segments.

The mandibles of all the species studied are decussating. Those of *Panorpodes oregonensis* (Figs. 20, 21) are triangular and are provided with two distadentes (dd), the distal one being more prominent. The mesal margin is irregularly serrated. The mandibles of *Panorpodes carolinensis* (Figs. 15, 23) differ somewhat in shape and the distadentes are not as prominent. The mesal serration is more regular than that of *oregonensis*. Those of *Merope* (Figs. 9, 18), *Panorpa* (Figs. 11, 12), and *Boreus* (Figs. 4, 11) do not differ very much in shape from those of the two species of *Panorpodes*. Unlike those of *Panorpodes*, they are not serrated along the mesal margins. The mandibles of *Merope* and *Panorpa* are each provided with three distadentes, the lateral one being the most prominent and is especially well developed in *Merope*, and the mesal tooth the smallest. Hine (1901) gave as one of the characteristics

of the genus *Panorpa* the two-toothed condition of the mandibles. Examination of the mandibles of *Panorpa americana* and *Panorpa lugubris* shows that they are distinctly three-toothed. The mandibles of *Merope* are slightly emarginate at the middle of the mesal margin. Those of *Boreus* are six-toothed, the teeth decreasing in size toward the proximal portion of the mandible. *Bittacus* (Figs. 2, 8) has a distinctly different type of mandibles. They are greatly elongated, sword-shaped, and end in a prominent distadentis. There is also a rudimentary mesal tooth. At the meso-proximal portion of each mandible, there is present a conical projection, the function of which is not clear. Hine (1898), in his paper on the genus *Bittacus* failed to notice this, as may be judged from his descriptions and figures. The mandibles of *Apterobittacus* (Figs. 6, 16) are very much like those of *Bittacus*. In all the mandibles of the Mecoptera here considered, there is a prominent swelling on the caudo-proximal portion, a condyle, known as the postartis (ptc), which articulates in a distinct acetabulum of the postgena, the postcoila (ptl, Figs. 50, 52, 59). Each mandible articulates on its cephalic aspect to the precoila of the clypeus by means of another condyle known as the preartis (py). The tendons, to which the muscles of the head are attached, controlling the movement of the mandibles, are well developed. The lateral tendon, which is the smaller of the two, and to which the extensor muscles are attached, is known as the extensotendon (et), and the mesal tendon, to which the retractor muscles are attached, is called the rectotendon (rt).

The maxillæ are well developed in the Mecoptera. The maxillæ of *Panorpodes oregonensis* (Fig. 49) and *P. carolenesis* (Fig. 45) are very similar and they represent the most generalized condition of all the species examined. The maxillæ of *Boreus* are the most specialized owing to the fact that they are completely fused with the labium. The cardo (ca) in all the species is undivided and is strongly chitinized. In both species of *Panorpodes*, the cardo is triangular and with a few prominent setæ at ventro-lateral angle. It is also triangular in *Panorpa* and is provided with a few small setæ, whereas it is subquadrate in *Bittacus* (Fig. 41) and *Apterobittacus* (Fig. 44) and the setæ, as in *Panorpodes*, are prominent. The two cardines in *Merope* (Fig. 46) are club-like in outline and there is in each cardo a prominent projection on its ventro-mesal margin. The cardines in *Boreus* (Fig. 36) are fused and together with a part of the submentum form a somewhat elliptical plate. The stipes (s) is also strongly chitinized, generally club-shaped; in *Panorpodes*, *Bittacus*, *Apterobittacus* and *Panorpa* and with prominent setæ. As has been already stated, the maxillæ of *Boreus* are fused with the labium so that it is impossible to ascertain the mesal extent of the stipes. The stipes (s) in Merope (Figs. 46, 47) are broad and fused at the proximal end. There are two prominent lobes distad of the stipes in all the species. The outer or lateral lobe has been designated by other workers, among whom are Hine, Miyake and Crampton, as the galea and the inner or mesal lobe as the lacinia. In nearly all the species studied, the so-called lacinia is always the larger and the better developed of the two lobes, which is an anomaly,

considering the condition existing in other specialized insects. By virtue of the position of the lobes, these designations are logical, the part adjacent to the maxillary palpus is always the galea. In highly specialized insects, as the Diptera, the lacinia is in nearly all cases wanting and where it is present, as in *Simulium* and *Tabanus*, as Peterson has shown, it is greatly reduced and the question may be raised as to whether this is even the lacinia. In most Hymenoptera, the lacinia is greatly reduced and in certain cases, as MacGillivray has shown, the lacinia may be absent. He has also shown that in many species of Hymenoptera, as *Macroxyela infuscata*, *Dolerus unicolor*, *Ophion bilineatum* and *Vespa maculata*, the galea is divided into two lobes. This divided condition of the galea is what probably obtains in the Mecoptera; the two lobes represent subdivisions of the galea while the lacinia has completely disappeared. The lobes of the galea (gl) in *Panorpodes oregonensis* (Figs. 49, 58) are finger-like and setiferous and they are of about the same length. In *Panorpodes carolinensis* (Fig. 45) the outer lobe of the galea is distinctly shorter. In *Bittacus* (Figs. 41, 43) and *Apterobittacus* (Figs. 44, 53), the two lobes are greatly elongated, and the inner lobe is even longer than the stipes. In *Merope* (Figs. 46, 54), the two lobes have assumed the form of strongly chitinized triangular plates with dense brushes of rather long setæ. The mesal margins of the lobes are thick, somewhat fleshy and with numerous minute setæ. Figure 55 shows the lateral aspect of the two lobes in *Merope*. The brush presents a U-shaped appearance. In *Panorpa* (Figs. 42, 47) and *Boreus* (Figs. 36, 60), the lobes have been reduced in length owing to the greatly elongated stipes. In *Panorpa* they are of about the same size and are setiferous. In *Boreus* the inner lobe is fleshy, setiferous and provided with two rows of strong conical spines arranged diagonally at the proximal end. The outer lobe in *Boreus* is a triangular plate curved mesad.

The maxillary palpus (mp) is five-segmented and setiferous in all the species. The palpifer (pf) is chitinous in *Panorpa*, membranous in *Bittacus* and *Apterobittacus* and slightly so in *Boreus* and continuous with the first or proximal segment of the maxillary palpus. In *Panorpodes*, the palpifer cannot be differentiated; it is probably merged with the stipes. The maxillary palpi of *Boreus* differ markedly from those of the other species studied in that the segments increase in diameter distad, the distal segment being not only the broadest but also the longest.

The maxillæ in general are not articulated to the paracoila of the head by a parartis. They are merely connected with the head by means of the maxacoriæ (mc) which are distinct in all the species.

The labium (li) consists typically of the following parts in generalized insects: submentum, mentum, and ligula, the latter of which consists of the stipulæ, glossæ, paraglossæ, palpigers and labial palpi. The mentum is in most cases small, completely fused with the stipulæ and cannot be identified as a separate sclerite. In both species of *Panorpodes* (Figs. 45, 49), the area between the stipes and cardines is entirely membranous. This area comprises the submentum (sm)

and the labicoriæ (lc), the membranes which connect the maxillæ and the labium in all generalized insects where the submentum is a distinct sclerite. In *Panorpa americana* (Fig. 48), the submentum is membranous except the ventral portion, which is distinctly chitinized. This chitinized portion of the submentum was designated as the mentum by Crampton (1921) in his figure for *Panorpa lugubris*, not indicating, however, the submentum. I have also examined specimens of the labium, as well as other parts of the head, of *Panorpa lugubris* and have not found marked morphological differences between it and that of *Panorpa americana*. The labicoriæ of *Panorpa americana*, as in *Panorpodes*, are continuous with the submentum. In *Bittacus* (Fig. 19) and *Apterobittacus* (Fig. 44), the chitinized portion of the submentum (sm) is an elongate area, vase-like in outline and bears long, prominent setæ. The ventral portion of this area was likewise designated by Crampton (1921) in his figure for *Bittacus* (species not indicated), as the mentum, labeling the dorsal portion of it as the submentum. Hine (1898) in his figure of the labium of *Bittacus strigosus*, showed the area between the stipes and cardines, considered as the submentum and labicoria in this paper, as if it were wholly setiferous and failed to indicate the chitinized area, which is rather distinct. Hine further considered the ligula as being absent. In *Merope* (Fig. 46), the submentum (sm) and labicoriæ have become strongly chitinized, except the portion between the cardines. In *Boreus* (Fig. 36), the area has become completely chitinized and fused with the stipes. We have thus in the Mecoptera a modification of this area from a wholly membranous to a wholly chitinized condition and also a condition where the maxillæ are distinctly differentiated from the labium in one case and another where they are distinctly continuous with it.

There is a subquadrate area distad or ventrad of the submentum which consists of the fused stipulæ, palpigers, glossæ and paraglossæ. This area is here designated as the mecaglossa, because it is typical of the Mecoptera. The palpigers (pp) are represented in all the figures as occupying the distal portion of the mecaglossa and include the somewhat membranous areas at the proximal ends of the labial palpi. Crampton (1921) calls the mecaglossa in *Panorpa lugubris* the palpigers, although, he says, they may represent the basal segments of the labial palpi. In his figure of the labium of the same species, he shows a distinct suture between what he calls the palpigers. Besides *Panorpa americana*, I have also examined numerous specimens of the labium of *Panorpa lugubris* and I was unable to find a suture dividing what he terms the palpigers. What appears to be a suture is a thickening formed by the fusion of the tendons which control the movement of the labial palpi. There is a depression along the region he indicates, but it is such a broad depression that it can not be called a suture.

The mecaglossa is very different from the stipulæ, glossæ and paraglossæ of generalized insects where there is a palpiger attached to the lateral margin of each stipula. It is a greatly reduced area in the Mecoptera and the palpigers are distal in position. The obsolescence of the sutures separating the glossæ and paraglossæ from the stipulæ and

the marked reduction of the mecaglossa as a whole has misled most authors in considering the mecaglossa as the palpigers.

The labial palpus (lp) in all of the species is two-segmented. The first segment in most cases is broad and fleshy, especially in the case of *Panorpa* (Fig. 48). At the base of the first segment of the labial palpus of *Panorpa* there is a chitinized plate which Miyake called the "basal piece." In his figure of *Bittacus*, and it is unfortunate that he did not indicate the species, Crampton (1921) shows, besides emphasizing it in the text, that each labial palpus is three-segmented. He makes some use of this condition in attempting to establish close relationship between the Neuroptera, Diptera and the Mecoptera. I have examined many specimens of the labium of *Bittacus strigosus* and found only two segments in the labial palpus. The distal segment is never divided as far as observed. Miyake figures two segments in *Bittacus nipponicus* and states for the Japanese Mecoptera as a whole: "The labial palpus is very conspicuous, consisting of two joints." Can it be that within the same genus the number of segments in the labial palpus varies to this extent or has Crampton made an error? Even in widely different genera of Orthoptera, the number of segments in the labial palpus is constant; it is always three. My specimen of *Apterobittacus* also shows a two-segmented condition of the labial palpus and this was formerly placed within the genus *Bittacus*.

The pharynx is defined as the portion of the alimentary canal extending from the occipital foramen to the mouth, the mouth being the opening surrounded by the mouth-parts. The pharynx has two main parts, a cephalic or ventral portion, depending on the position of the head, called the prepharynx, and a caudal or dorsal portion called the postpharynx (pox) which is always tubular. The prepharynx includes the epipharynx, hypopharynx and other parts. The size of the epipharynx (ex) varies with the size of the labrum, which in turn varies with the size and shape of the head. It is greatly reduced in *Panorpa* (Fig. 61) and *Boreus*, owing to the greatly elongated frontoclypeus. The epipharynx (ex) in general has minute circular areas, which are most numerous in *Panorpodes* (Fig. 50). These circular areas are probably portions of taste organs, which Packard (1889) designated as the taste cups. They are also found on the labium and the maxillæ. In *Panorpa* (Fig. 61), there is an oblique row of minute setæ on each side of the meson and along each side of this row of setæ there is a group of the circular areas that have been referred to previously. The epipharynx in *Merope* (Fig. 59) is densely clothed with very minute setæ.

The hypopharynx (hx) in the Mecoptera is well developed, except in *Boreus*, where it is somewhat reduced. In general it is tongue-like in appearance and is setiferous. At the base of the hypopharynx, where it joins the labium, is located the opening of the salivary duct, called the salivos (so). The salivary duct can be easily identified in many of the species. It is very well developed in *Apterobittacus* (Fig. 53) and its striated condition is very apparent.

SUMMARY.

Of all the genera represented in this study, namely: *Panorpodes*, *Bittacus*, *Apterobittacus*, *Merope*, *Panorpa* and *Boreus*, the first one, *Panorpodes*, is the most generalized. The head is orthopteran in form and does not have a trunk-like beak. *Boreus* and *Panorpa* are the most specialized, *Boreus* being markedly more so than *Panorpa*. These genera are the only two that possess a distinctly trunk-like beak.

The order Mecoptera is commonly characterized as having the head prolonged into a trunk-like beak at the end of which are located the biting mouth-parts. This characterization of the order is inaccurate and somewhat misleading. The term "trunk-like beak" does not fit most of the genera and moreover, the only mouth-parts located at the end of the beak are the mandibles.

Certain sclerites of the head and mouth-parts are given new interpretations. The portions of the labium which have been regarded as the palpigers by some authors are designated as the mecaglossa, because it is typical of the Mecoptera. It comprises the fused stipulæ, palpigers, glossæ and paraglossæ. The labial palpus is always two-segmented. The two lobes, commonly regarded as a galea and a lacinia, are here considered as subdivisions of the galea.

The American species of Mecoptera offer no evidence confirmatory of the opinion of Crampton and Tillyard that the glossæ and paraglossæ of Peterson in the Diptera are homologous with the labial palpi.

The normal number of ocelli present is three. They are ordinarily large and subadjacent. The ocelli are wanting in *Merope*. Authors hitherto have described the ocelli as wanting in *Boreus*. I have found three small, distant inconspicuous ocelli in this genus.

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LIST OF ABBREVIATIONS.

a—antenna.
aa—antacolla.
af—antafossa.
an—antacoria.
ar—antennaria.
ca—cardo.
cc—cervicoria.
ccs—cervepisternum.
ce—compound eye.
ct—corpotentorium.
dd—distadentes.
ea—epicranial arm.
et—extensotendon.
ex—epipharynx.
fc—fronto-clypeus.
fl—flagellum.
hx—hypopharynx.
gl—galea.
gn—genaponta.
l—labrum.
lc—labicoria.
li—labium.
lo—lateral ocellus.
lp—labial palpus.
mc—maxacoria.
md—mandible.
mg—mecaglossa.
mn—metatentorina.
mo—median ocellus.
mp—maxillary palpus.
mt—metatentorium.
oc—occiput.
od—odontoidea.
of—occipital foramen.
ol—oculata.
p—pedicel.
pa—postgena.
pf—palpifer.
pn—pretentorina.
pox—postpharynx.
pp—palpiger.
pr—precoila.
pt—pretentorium.
ptc—postartis.
ptl—postcoila.
py—preartis.
rt—rectotendon.
s—stipes.
sc—scape.
sld—salivary duct.
sm—submentum.
so—salivos.
st—supratentorium.
v—vertex.

EXPLANATION OF PLATES.

PLATE XXV.

Fig. 1. *Panorpodes oregonensis*, cephalic aspect of head.
Fig. 2. *Bittacus strigosus*, cephalic aspect of sinistral mandible.
Fig. 3. *Bittacus strigosus*, cephalic aspect of head.
Fig. 4. *Boreus nivoriundus*, caudal aspect of sinistral mandible.
Fig. 5. *Apterobittacus apterus*, cephalic aspect of head.
Fig. 6. *Apterobittacus apterus*, cephalic aspect of sinistral mandible.
Fig. 7. *Merope tuber*, cephalic aspect of head.
Fig. 8. *Bittacus strigosus*, caudal aspect of sinistral mandible.
Fig. 9. *Merope tuber*, cephalic aspect of sinistral mandible.

Fig. 10. *Panorpa americana*, cephalic aspect of head.
Fig. 11. *Boreus nivoriundus*, cephalic aspect of sinistral mandible.
Fig. 12. *Panorpa americana*, caudal aspect of sinistral mandible.
Fig. 13. *Panorpa americana*, cephalic aspect of sinistral mandible.
Fig. 14. *Boreus nivoriundus*, cephalic aspect of head.
Fig. 15. *Panorpodes carolinensis*, cephalic aspect of sinistral mandible.
Fig. 16. *Apterobittacus apterus*, caudal aspect of sinistral mandible.
Fig. 17. *Panorpodes oregonensis*, caudal aspect of head.
Fig. 18. *Merope tuber*, caudal aspect of sinistral mandible.
Fig. 19. *Bittacus strigosus*, caudal aspect of head.
Fig. 20. *Panorpodes oregonensis*, caudal aspect of sinistral mandible.
Fig. 21. *Panorpodes oregonensis*, cephalic aspect of sinistral mandible.
Fig. 22. *Apterobittacus apterus*, caudal aspect of head.
Fig. 23. *Panorpodes carolinensis*, caudal aspect of sinistral mandible.

PLATE XXVI.

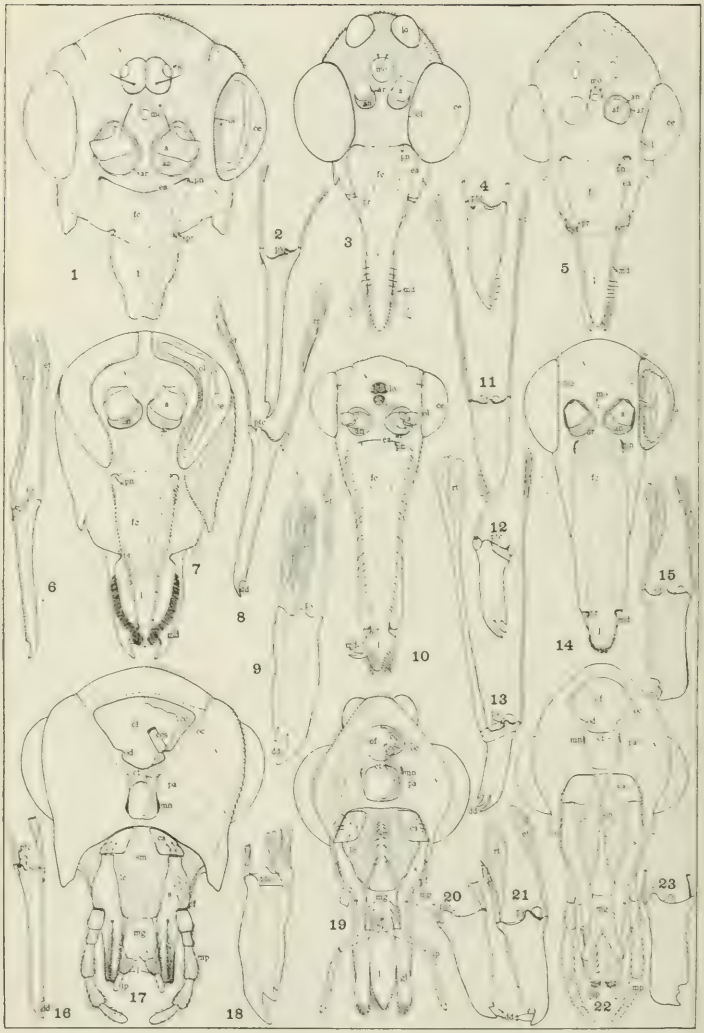
Fig. 24. *Panorpa americana*, caudal aspect of head.
Fig. 25. *Merope tuber*, caudal aspect of head.
Fig. 26. *Boreus nivoriundus*, caudal aspect of head.
Fig. 27. *Panorpodes oregonensis*, lateral aspect of head.
Fig. 28. *Bittacus strigosus*, lateral aspect of head.
Fig. 29. *Apterobittacus apterus*, lateral aspect of head.
Fig. 30. *Merope tuber*, lateral aspect of head.
Fig. 31. *Panorpa americana*, lateral aspect of head.
Fig. 32. *Boreus nivoriundus*, lateral aspect of head.

PLATE XXVII.

Fig. 33. *Bittacus strigosus*, antenna
Fig. 34. *Merope tuber*, antenna.
Fig. 35. *Boreus nivoriundus*, antenna.
Fig. 36. *Boreus nivoriundus*, labium and maxillæ.
Fig. 37. *Panorpodes oregonensis*, ental portion of tentorium.
Fig. 38. *Panorpodes oregonensis*, lateral view of tentorium.
Fig. 39. *Panorpodes oregonensis*, caudal aspect of tentorium.
Fig. 40. *Bittacus strigosus*, lateral view of tentorium.
Fig. 41. *Bittacus strigosus*, maxilla.
Fig. 42 *Panorpa americana*, cephalic aspect of galea.
Fig. 43. *Bittacus strigosus*, cephalic aspect of galea.
Fig. 44. *Apterobittacus apterus*, labium and maxillæ.
Fig. 45. *Panorpodes carolinensis*, labium and maxillæ.
Fig. 46. *Merope tuber*, labium and maxillæ.
Fig. 47. *Panorpa americana*, maxilla.
Fig. 48. *Panorpa americana*, labium and maxillæ.
Fig. 49. *Panorpodes oregonensis*, labium and maxillæ.

PLATE XXVIII.

Fig. 50. *Panorpodes oregonensis*, epipharynx.
Fig. 51. *Panorpa americana*, diagrammatic section to show hypopharynx, salivos and salivary duct.
Fig. 52. *Bittacus strigosus*, epipharynx, hypopharynx and mandible.
Fig. 53. *Apterobittacus apterus*, hypopharynx and salivary duct.
Fig. 54. *Merope tuber*, hypopharynx and salivary duct.
Fig. 55. *Merope tuber*, lateral view of galea.
Fig. 56. *Panorpa americana*, caudal aspect of head, to show mandibles, tendons and postpharynx.
Fig. 57. *Bittacus strigosus*, mecaglossa and palpi folded back to show hypopharynx and salivos.
Fig. 58. *Panorpodes oregonensis*, hypopharynx and salivary duct.
Fig. 59. *Merope tuber*, epipharynx and mandible.
Fig. 60. *Boreus nivoriundus*, hypopharynx.
Fig. 61. *Panorpa americana*, epipharynx, hypopharynx, salivos.



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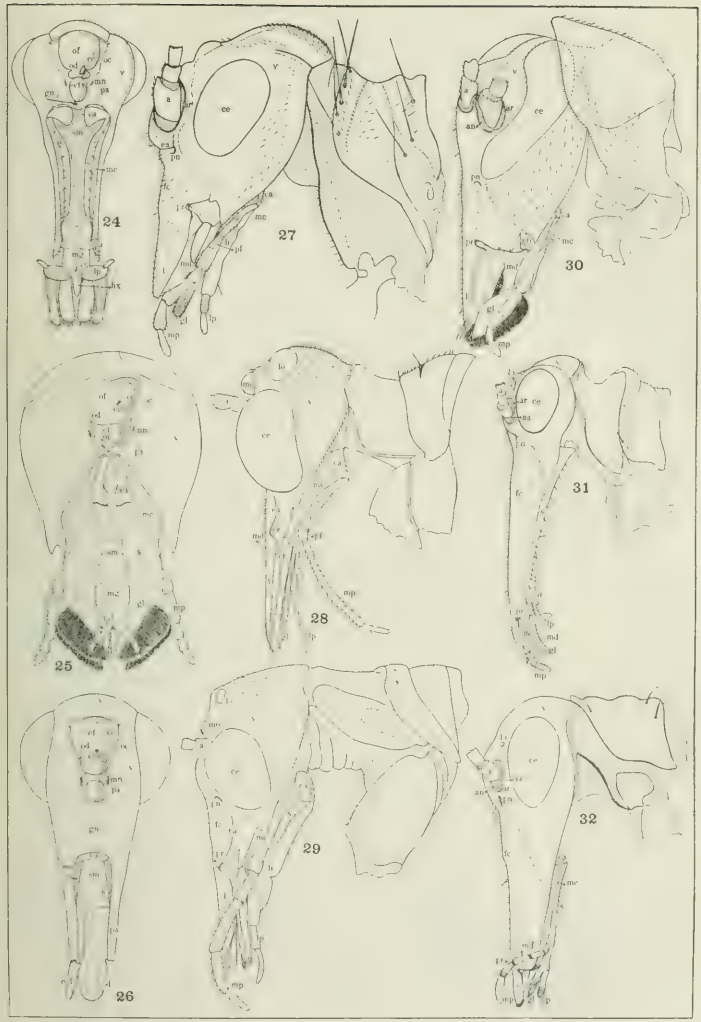

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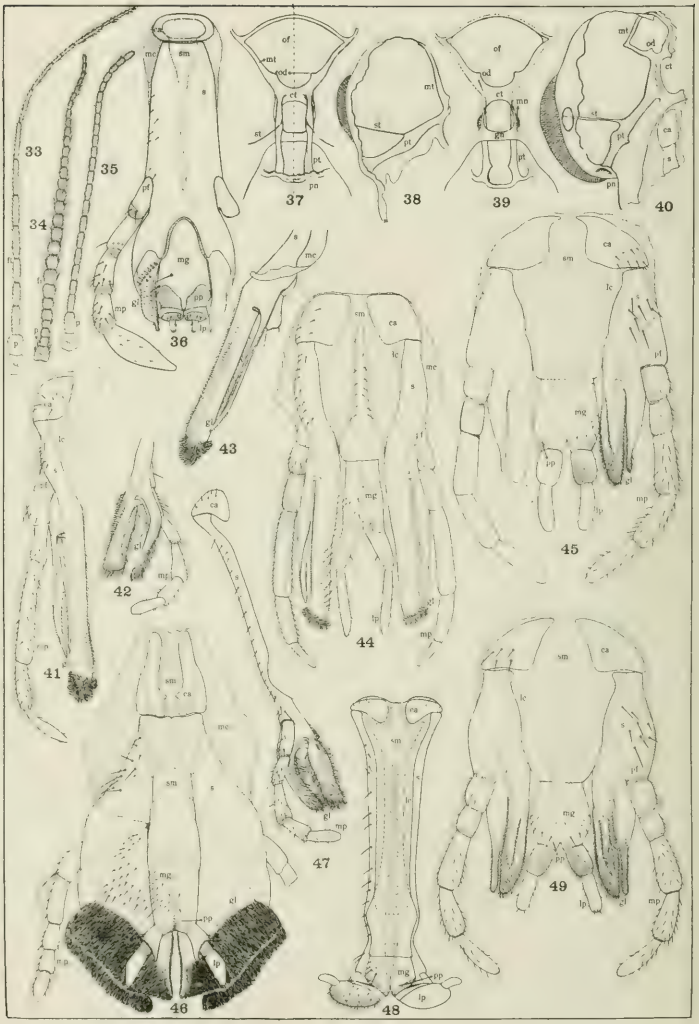
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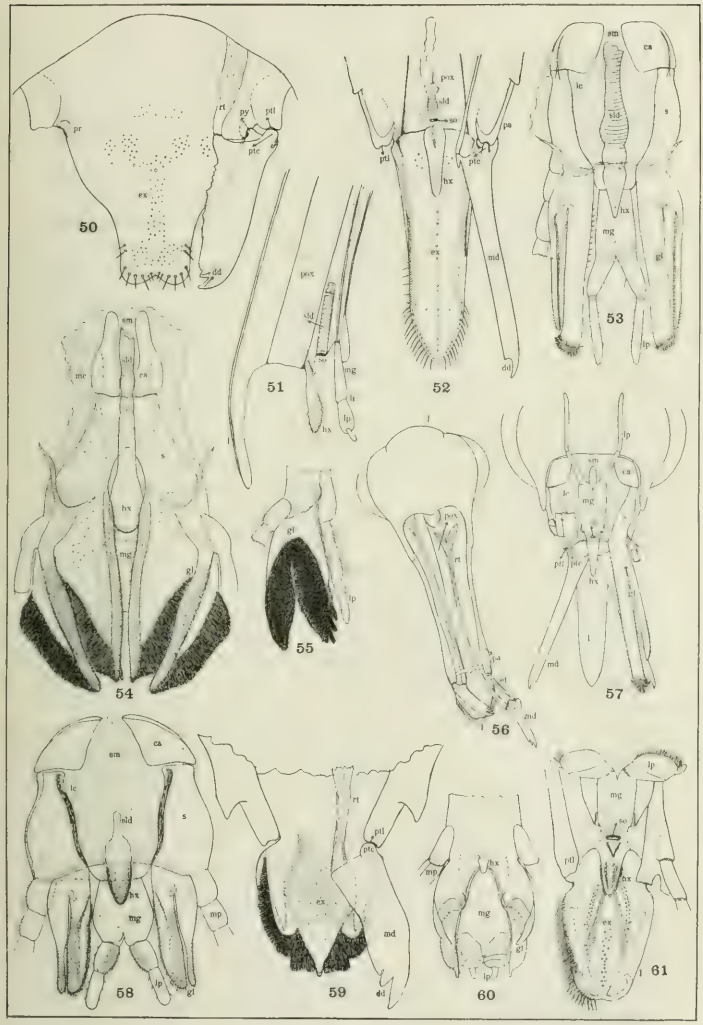
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F. Q. Otanes

THE WING-VENATION OF THE COLEOPTERA.*

Wm. T. M. Forbes,
Ithaca, N. Y.

In the course of the last two generations, since the first attempts by Adolph (Nova Acta der Leop.-Carol. deutschen Akad. d. Naturf. 41(2), 213, 1880.) and Redtenbacher (Ann. d. k. k. naturhist. Hofmuseums I, 153, 1886) the comparative study of the wing-veins of the various groups of insects, supplemented by that of their larval tracheæ, has shown that all insect wings have a venation based on a common plan, whose modifications in the various orders are for the most part, well understood. In the Coleoptera, alone, of the larger orders, there is nothing approaching agreement in interpretation, for several reasons. In the first place the venation is sufficiently unique, and complicated, to make such a superficial study as brought even Adolph and Redtenbacher close to the truth in the Lepidoptera, for instance, almost completely futile. The complicated foldings also interrupt the veins and cause distortions in their courses. Further, the first forms studied for their pupal tracheation were specialized Cerambycidæ, a family in which the tracheation is degenerate and no longer fully corresponds to the veins. Several workers, notably Kempers (Tijd. voor Entom. 42 to 45) and Kolbe (Archiv fur Naturges. 67: Beiheft 89, 1901) have been thrown off by Adolph's or Woodworth's theories of an alternate system of convex and concave veins, which in the manner applied by them, is deceptive in the higher orders. More recently d'Orchymont has proposed a more carefully studied scheme, but his also ignores the evidence of the tracheation, and to me seems only half correct. Kühne's study of the tracheation (Zeits. wiss. Zool. 112: 692) alone has resulted in essentially the same conclusions which are expanded below. His paper is somewhat diagrammatically illustrated and appears to have been largely ignored by other workers; but I have veritfied his main conclusions, the differences between our results being mainly a matter of interpretation.

* The expense of publishing this paper was borne by a grant from the Hecksher Foundation for the Advancement of Research, established by August Hecksher, at Cornell University.

In the present paper I shall try to identify the main veins of the Coleopterous wing with those recognized in other orders, and will suggest a tentative scheme of their branching. The main identifications, though differing from the several schemes which now hold the field, are supported by a convergence of evidence from the tracheation and basal sclerites, as well as by the character of the veins themselves.

In interpreting the tracheation my first assumption has been that each trachea which is separate in the most generalized form available, represents a single main vein, and that together all the veins are accounted for. In a single particular this assumption has been slightly modified—the identification of the first anal stem, as discussed below.

To take up the main veins in order:

Costa.—In all the orders of insects the costal vein lies along the costal edge of the wing, or is preceded only by a membranous strip, and runs far basad, forming a hook-like articulation with the body. It contains a weak trachea or none. In the Coleoptera studied the base of the costal edge is occupied by a vein, which in Calosoma contains a weak trachea. This is certainly *costa*. In a few forms (Silpha, Fig. 24, and Buprestidæ, for instance) there is a little membrane in front of it, but never another vein.

Subcosta.—In all the known orders of insects subcosta is immediately recognizable as a concave vein, that is, it lies at the foot of a trough in the surface of the wing, and its cavity is mainly below the level of the wing-membrane. The second vein from the costal edge in all the Coleoptera is so formed, and may be safely labelled *subcosta*. It contains a strong trachea in all the forms studied (the one labeled "C" by Comstock and Needham, who overlooked costa).

Radius.—The third vein of the wing is strongly convex, and forms the principal articulation with the thorax, together, that is, with the second axillary sclerite, from which it rises. Its trachea is always strong, and rises from the anterior tracheal trunk (Chapman, in Comstock's "Wings of Insects") running in front of the wing-process in close proximity to C and Sc. In the Coleoptera the third of the three closely crowded veins at the costal margin of the wing articulates in the proper manner, and contains the most posterior of the tracheæ arising from the anterior trunk, in every form studied, from Cicindela to the Cerambycidæ. It then is *radius*.

Media.—With media a more serious problem arises. Media is highly unstable in the various orders of insects and may associate itself as a branch with either radius or cubitus. In the Coleoptera whose tracheation is most complete, however, (Calosoma, Fig. 2, Dytiscus, Fig. 5, for instance, and some specimens of Tenebrio, Fig. 6), there is an independent trachea that can only be media. In Calosoma

and Tenebrio, at least, it arises from the posterior tracheal trunk, as in the majority of specialized insects. The corresponding vein is always weak, fading out at the base, and the trachea shows a strong tendency to weaken, and to lose its terminal portion to the neighboring tracheæ. In Tenebrio it is individually unstable, in some specimens independent, in others arising from the base of Cu. In many forms its basal part is a mere rudiment (labeled R in Comstock's "Wings of Insects," Figs. 309, 310), while its outer part has switched its connection to branches running up from Cu, or more rarely down from R. The weakness of this vein and trachea would characterize it as M, even were there not the further evidence of its position immediately following the unmistakable Sc and R. It is a "concave" vein, like M in the Lepidoptera and Neuroptera, and as in them it has no direct connection to the basal sclerites.

In all those Coleoptera whose basal venation is sufficiently spaced out, there is an arculus-like bar running across from the base of radius to Cu. This evidently represents an *anterior* arculus, being a short sector of vein M (Fig. 6), whose extreme base has fused with R, while it anastomoses immediately after, with Cu. In a few cases, where the medial trachea is independent, it can be plainly seen, passing from the radial to the medial vein-cavity through this bar.

Cubitus.—Cubitus is a strong convex vein. Here is perhaps the best opportunity for disagreement in interpretation. My identification is based, *first*, on the position and independence of the trachea in the Adephaga, which have the fullest tracheation, and in some specimens at least, of various Serricorns; *second*, on its basal connection with the axillary sclerite (though d'Orchymont considers this connection secondary, a result of fusion with the vein I interpret as 1st A); *third*, on the fact that the next vein (1st A) arises out of it near its base, just as the vein so called does in the Lepidoptera, and several other orders, and as the homologous vein (commonly called Cu_2) does in the Neuroptera and Trichoptera.

First anal.—The difficulty as to this vein is rather one of nomenclature than of homology, save only in the Phytophaga and Lamellicorns. In the most primitive orders there is an independent vein lying between Cu and the anal fan (1st A of Comstock's figures 116 to 124). This is in early forms fluctuating in position, and possibly even duplicated in a few cases (Comstock, Fig. 117, hind wing); attaching itself either to Cu or to the anal fan; but in almost all cases lies close beside the anal furrow. In the holometabolous orders it has become definitely associated with the cubital stem and appears like a branch of cubitus near the base. For this reason it is commonly treated as a branch of Cu in certain orders (e. g., the Neuroptera) and has been illogically labeled Cu_2. Of course if counted at all with the cubitals it would be Cu_3, as it would be the third branch of that stem. In other orders (as the Lepidoptera and Diptera) the connection with Cu is inconspicuous, either on account of a secondary splitting back, or through atrophy of the vein itself (butterflies); and the vein has been counted as independent, the true vein Cu_2 being correctly so labeled.

In the Coleoptera, save in the Phytophaga and some Lamellicorns, there is a trachea which splits off from Cu near its base, then frequently runs obliquely through the membrane, and enters a vein in the outer part of the wing, running with it to the margin (Figs. 3, 5, 6). The concave anal furrow lies close below this trachea. In Cupes (Figs. 4, 12) the whole is represented by a vein, and meets all the qualifications of 1st A (that is, Cu_3). In higher phytophaga at least, this trachea is completely absent, as shown by a Comparison of Comstock's figures 308 to 310, with mine of Tenebrio (Figs. 6, 43); and the corresponding vein of the imago is also absent.

Second and following anals.—There remain two branched tracheæ, and a third which is also bifurcated in the Adephaga, but more commonly simple. These may be numbered in order: 2d A, 3d A and 4th A. They doubtless represent the anal fan of lower orders, and also the second and third anals, and supporting vein of the jugum in, the Lepidoptera. The first of these is 3-branched at least, as shown plainly in the Buprestidæ (Figs. 6a, 34); but the anterior branch, both trachea and vein, is lost in many families, including all the Adephaga, Palpicornia and Heteromera; and the posterior branch, save in the Elaters, Lampyrids, and some Buprestidæ and Dermestidæ, fuses at the apex with the anterior branch of 3d A.

In this discussion the anals are treated as four in number on account of the tracheal arrangement, and seem to be homologous with the three recognized anals and the jugal brace of the Lepidoptera; but the condition in the base of the wing is complex, and comparison with Chauliodes (Fig. 71: a form which shows the same number of terminal anal branches) suggests strongly that the second may be a fusion of an original second and third anal; and that the vein here considered a cross-vein between 2d A and 3d A may really be a fourth branch of 2d A; in several forms it has a trachea.

The permanent cross-veins.—Certain cross-veins are so constant in higher insects as to become a part of the hypothetical plan. These are the *humeral*, the *arculus*, and a series near the middle of the wing (known as discocellulars in the Lepidoptera). The humeral cross vein shows plainly in several Coleoptera as a short fusion of C and Sc, which are everywhere closely parallel. Arculus is plain enough, especially in the Serricorns and Heteromera, (Figs. 65 and 66 for instance), and has already been discussed as a sector of media. The discocellulars, if present as such at all, are disguised by the folding, and must be discussed among the more problematical veins.

Stigma.—The stigma or pterostigma is a thickening of the marginal portion of the wing in the neighborhood of the apical part of Sc (Sc_2) and R_1. It shows plainly in a great many beetles belonging to the Adephaga, Palpicornia and Staphylinoidea, and will be used below as a means of identifying the distal sector of R_1.

THE FORKING OF THE VEINS.

Subcosta is so completely fused with costa and radius that a discussion of its outer course can lead to no certain conclusion. I have postulated a forking beyond the hinge, to account for one of the obscure cells at this point in the Carabidæ and the double thickening of the stigma in Hydrous. The fading out of the trachea of R_1 in those forms that have one at all, shows that the terminal portion of R_1 has been captured by Sc_2 (a common occurrence). In the more specialized forms Sc_2 is one of the tracheæ that persists, and with the disappearance of true veins in the apical part of the wing, takes an oblique course toward the apex regardless of what traces of veins remain (Fig. 5, 6a; but compare Fig.6). The tracheæ of M and 2d A in certain forms behave similarly.

Radius.—R_1 is a vein that tends strongly to weaken and disappear, its terminal portion fusing with Sc. In several Coleoptera there is a plain anterior branch of the radial stem which continues in the common cavity of Sc and R beyond the point at which the main radial trachea leaves it (Fig. 2) . There is no reason to doubt that this is R_1, and that the main trachea, beyond the bifurcation, is the stem of R_s.

Beyond this point tracheation fails to give evidence, as the subdivisions of R_s are unstable in all the forms yet studied. The interpretation laid out on the hypothetical plan (Fig. 1) is based on the assumptions, *first*, that the apex of the wing in a low holometabolous insect is to be sought in the neighborhood of R_3, and *second*, on the plain connection of the stub here identified as R_{4+5} across to the stem of R_s in such forms as Tetracha (Fig. 13). The terminal veining here introduced into the hypothetical plan is nowhere so plain as in Hydrous, but well-marked traces survive, not only in the other large Hydrophilidæ, but in the Lamellicorns as well. This group of veins might likewise be interpreted as M_{1+2}, but the strong tendency to reduction in the median and cubital systems of the Neuroptera would suggest a similar interpretation here.

In the Polyphaga the base of R_s is atrophied, leaving the outer part as an apparent backward-projecting spur—the *radial recurrent* (Rr). The second radial cross-vein, on the atrophy of a segment of R_s crossing the main folds, swings into this portion of R_s, and is usually reckoned with it as a portion of the radial recurrent, which would then be designated according to the usual terminology as R_s & 2d r.

Media.—Media has become two-branched in practically all the known Neuroptera, and in many is reduced to a single stem, forking only at a point corresponding to the nearly veinless apical region of the Coleoptera. The presence of but a single medial trachea in all the forms studied, save for unstable terminal branching, would suggest here that no branches need be sought save in the terminal portion of the wing. I have marked as medials those terminal veins that seem to connect most closely with the medial stem. The main trachea in the Adephaga, runs out in the vein here marked M_4 (Fig. 3); in the Polyphaga swinging into the same vein with Cu toward the margin. The two veins that survive in the generality of forms are marked M_1 and

M_4 because they are the extreme members of the complex group shown by Hydrous. They might be considered M_{1+2} and M_{3+4} if the extra veins of Hydrous be considered secondary.

In almost all forms (except a few Adephaga and Cupes) the base of media fades out, leaving the main part of it attached at the apex only. This sector of the vein is known as the *medial recurrent* (Mr).

Cubitus.—There is never but one vein supplied by the cubital trachea (leaving out of account the vein here treated as 1st A). Many Neuroptera also have only a single corresponding cubital, or a single main vein supplemented by some secondaries. To judge by the arrangement of these terminal branches the missing cubital branch has either fused completely with the surviving one, or has atrophied on the posterior side of it. At this point some Lamellicorns have a trachea not represented by any very distinct vein in the imago, which may possibly be the missing Cu_2, but is more likely a last trace of 1st A.

In the Hydrophilidæ and Haliplidæ (Figs. 19 to 23), Cu runs toward the margin as an independent vein. Comparison with these two families shows that in the remaining Adephaga the apex of Cu has disappeared by atrophy, while the double trachea suggests that in the Polyphaga it has fused with M_4.

First anal.—This is simple. With the atrophy of its base the cross-vein cu-a remains to connect it with the stem of cubitus (Hylecœtus, Fig. 40). In some forms, as in the Lampyridæ (Fig. 32) it is not clear whether it is the base of the main vein or the cross-vein, which has disappeared.

Second anal.—The second anal trachea divides, at the maximum, into three branches. The first corresponding vein has been universally considered a branch of the vein here designated 1st A, but if that is the case the extraordinary course of its trachea, which actually has to turn basad in some Buprestidæ, to enter its cavity, and which may run for some distance in a common vein-cavity with the first anal trachea without fusing with it, remains entirely unexplained. This first branch is doubtless the one that has disappeared in the Tenebrionidæ and Adephaga (where there is no corresponding trachea); but in the higher Phytophaga it seems rather to be 1st A that has vanished, as there is no trace of a first anal trachea arising from Cu. The second branch of 2d A has nothing extraordinary, and receives the unbranched second anal trachea in the Tenebrionidæ (in some specimens only of which the third branch also receives a tracheal twig). The third branch has apparently evolved in two distinct ways. In a few forms it is entirely independent (as in Attagenus, Fig. 35, and many Buprestidæ, Fig. 34). The next, and perhaps most primitive condition, is for it to be connected by a cross-vein to the upper fork of 3d A, as plainly shown in *Cebrio* (Fig. 30). It is my belief that the same condition holds in the other Elateridæ (s. l.) and Lampyridæ, where there are three anal twigs below the second anal furrow, and the vein bounding the wedge-cell is transverse and tends to disappear by atrophy (Alaus, Pyrophorus, Calopteron). In most forms, however, the apex of this branch has

obviously fused with the first branch of 3dA, forming a pointed wedge-cell, and leaving only two terminal branches below the second anal furrow (compare Figs. 32 and 37).

On the basal side of the wedge-cell there is a short oblique vein running from the stem of 2d A to the upper branch of 3d A. Whether this is a fourth branch of 2d A, which has permanently joined 3d A_1, or a cross vein, is not clear. Occasionally it contains a trachea arising from 2d A, but tracheæ in other crossveins are not entirely unknown. In the pupa of Tenebrio and Dytiscus it is more definitely transverse than in the imago, a significant point.

Third anal.—The third anal vein forks once near the base of the wing as a rule. Sometimes both branches have a trachea, sometimes only the lower. The upper is connected to 2d A by two transverse veins, enclosing the wedge-cell between them. In a few forms the third anal is simple, presumably by the atrophy of its upper branch, which is broken, for instance, in the Lamellicorns (Fig. 62).

Fourth anal.—The anterior branch of the fourth anal vein is present in all save markedly reduced species, and contains a trachea in all species with fairly complete tracheation. A second branch is present in most Adephaga, running along the inner margin of the wing, and in a few a third, running back and stiffening the alula. This is the superficial interpretation; it is not impossible that a detailed comparison with the Neuropteroids will result in a different interpretation. In particular the vein here considered 3d A_2, may possibly belong in fact to 4th A.

CROSS-VEINS.

It is evident that the Coleoptera are descended from a form with a considerable number of cross-veins, which were tending at least to take definite positions. Assuming that they were not wholly definite, the survival of certain ones was doubtless determined by the folding, which necessitated a more complete cross-bracing than in the Trichoptera and Lepidoptera, for instance. The humeral has already been taken up. Discussion of other cross-veins in the costal region would be useless, as the longitudinal veins are almost completely fused. Comparison with the Neuroptera would prepare one for a large number of such veins, but the few forms in which C and Sc are separate (e. g., Cupes, Fig. 12) show no sign of them.

Between R_1 and R_s there is plain evidence of several cross-veins. For the region basad of the pivot-fold, the Hydrophilidæ, and especially the primitive Elaters, give the best evidence. They plainly show two cross-veins, one variable in position, but well before the fold of the wing, the other stiffening the edge of the first fold, being the outer part of the vein marked R_{s+r} in Fig. 30. The latter is obscurely indicated in several Adephaga, but there is no trace, apparently, of the first, the radial fork coming just before the hinge.

Beyond the hinge the Hydrophilidæ show only faint traces of veins, and most Polyphaga none at all; but the Adephaga have two well-developed cross-veins, which may be called 3d r and 4th r. The

vaguely defined vein which stiffens the fold half way between the last and the apex in the Gyrinidæ, for instance, would then be 5th r.

There would be possible a second explanation of these veins; namely, that the pivot fold of the Adephaga corresponds not to that of the Hydrophilidæ and Tenebrionidæ, etc., but to that of the Coccinellidæ and Malachiidæ. This would reduce the number of radial cross-veins postulated, as it would make the two main cross-veins of the Adephaga homologous with the two of the Polyphaga, but it would involve a reversal in direction of the two principal transverse folds. It would also leave the faint cells of Hydrous unexplained. This interpretation seems to me less probable, but must be taken into account, considering the variable character of the folding in all parts of the wing. There is much room for some one with care and patience to make a study of the wing folding, which shows much more variety of type than Woodworth's account would imply. The forms intermediate between the Adephaga and Polyphaga (Staphylinoidea in the broad sense; Figs. 24 to 28) are all highly modified, and many of them minute, with reduced venation; so that very careful analysis will be necessary to interpret them.

Between radius and media (as interpreted by the tracheæ) the Adephaga have single fully formed cross-vein, marked r-m. In some species of Cupes this has migrated far toward the base of the wing, (Fig. 4), but in other species (Fig. 12), and in Omma, it is normal. In a few Elaters (Fig. 3), it is plainly shown, as a distinct, though faint, vein connecting the base of R_s with M, but as a rule in the Polyphaga it is lost, or incorporated indistinguishably in the radial recurrent. (Compare Hydrocharis, Fig. 22, with Hydrous, Fig. 20).

The obvious cross-vein of the Polyphaga appears to be a second, the surviving element of a complex net-veined area, apparently, which is faintly visible in some Cerambycidæ and Chrysomelidæ, but has been mostly obliterated to form the large and complexly folded central cell. Aside from the Phytophaga a few other forms show aberrant veins or thickenings that may be remnants of this system, notably the Cupedidæ (Figs. 4, 12) and Ostomidæ (Fig. 49). How much is original and how much secondary in the complicated conditions of the Malachiidæ (Fig. 58) and Coccinellidæ (Fig. 56) may sometime appear from more detailed study, or the discovery of transitional forms.

A third radiomedial cross-vein is indicated at the outer boundary of the central cell, connecting the stem or stub of R_{4+5} with M_1. It must be through the survival of this cross-vein that R_{2+3} in the Lamellicorns gets its connection with the medial stem.

There are two medio-cubital cross-veins, enclosing the so-called *Oblong* cell (O) of the Adephaga and Cupedidæ. The more basal of these may receive a trachea from media, but I am inclined to consider this not significant, as the assumption that it is really the stem of M_{3+4} will not work out into any logical interpretation of the marginal veins. In the more specialized Adephaga (Fig. 13) and the Hydrophilidæ there is only one cross-vein. The usual explanation is that one or the other has atrophied. It seems more simple to assume the

two have fused, especially as in several Carabidæ there is a partial fusion. The families in which there is a single cross-vein are the Cicindelidæ (save the genus Pogonostoma, as figured by Horn, Gen. Ins., 82, pl. 5, f. 52), Rhysodidæ and Hydrophilidæ, with a few stray genera of other families. In the remaining Polyphaga the cross-veins are obliterated by the fusion of M_4 with Cu.

The cross-vein cu-1st a is mentioned under the discussion of that vein. In Cupes alone there is a second cubito-anal cross-vein in the outer part of the wing.

A very important cross-vein is the one from the base of 1st A or from the fused root of Cu+1st A to the base of 2d A. It is doubtless homologous to the anal cross-vein of the Trichoptera and lower Lepidoptera. In all forms but the Cupedidæ the extreme base of 1st A is transverse and appears (with the disappearance of a sector of 1st A) as a part of it. I will refer to this combined vein as the anal arculus (a. arc.) as its relation to 1st A is exactly that of the arculus to media in the Odonata and some other orders. This vein appears in all the Adephaga and Staphylinoidea, excluding the Histeridæ, but nowhere else. Another cross-vein 1st-2d a appears in the outer part of the wing in Cupes oculatus (Fig. 12), but in most other Coleoptera it is obliterated by the anastomosis of the anterior branch of 2d A with 1st A.

Two cross-veins may be assumed between 2d A and 3d A, enclosing the wedge-cell (W) between them, but as noted in the discussion of 2d A, it is not quite certain that the inner is a cross-vein, and the outer is preserved only in the Elateridæ, Lampyridæ, and a few related forms.

There is in the Cupedidæ and Adephaga a transverse vein at the extreme base between 3d A and 4th A, but its significance is uncertain.

FOLDING.

I figure folding diagrams of a few typical Coleoptera (Figs. 7, 16, 21, 25, 27, 61). In these the portions of the wing reversed (turned under or over) in the folded wing are shown dark those which remain right side up are white. Convex folds are indicated by a broken or serrate line, concave by an even line. Regions of irregular crumpling, and regions not completely folded under, are striated.

It can be seen that the folding is highly complex, and may differ in details in closely related forms, though of the same fundamental plan (compare especially Harpalus, Fig. 16, with Dytiscus, Fig. 7). The Dytiscid and Hydrophilid foldings are homologized by d'Orchymont differently than by me, with the result that he considers the vein I call media in the Adephaga to be rather the radial recurrent. I have given first weight to the fact it always contains the medial trachea, and have assumed that the area at the hinge that folds under has become more extensive in the Adephaga, and has crossed the medial vein. It should be also noted that the area homologous with the reversed portion in the cell of the Adephaga is not the large reversed portion of the Polyphaga, but the relatively inconspicuous crumpled strip

above cubitus, as shown by the fact that it alone constantly reaches the base of the wing. Hydrocharis (Fig. 22) and other forms with a short radial recurrent, show the condition better than Hydrous (Fig. 21).

DISCUSSION OF CERTAIN FORMS.

It is not the province of one not a Coleopterist to go into the detailed discussion of the relationships of the Coleoptezous groups, but some points come out so clearly that they should be emphasized. First it is strikingly clear that Gahan's system comes far nearer to agreeing with the evidence of the wings than any other known to me.

Adephaga.—(Figs. 2, 3, 5, 7, 10, 11, 13–19). If venation means anything at all this is a homogenous group, and includes the Rhysodidæ as a hardly aberrant member. Whether the Cupedidæ should also be included is a discussed question. They certainly have one point of divergence from all the typical Adephaga in venation, namely, the preservation of the first branch of 2d A as an apparent branch of 1st A. The Haliplidæ alone of the forms examined have preserved the tip of Cu; as have the Pelobiidæ as figured by d'Orchymont. The subfamilies of Carabidæ are not obviously indicated by the venation, even Pseudomorpha being hardly aberrant. Fragments of 2d r appear in a few forms (Harpalus, Fig. 15). R_{4+5} often appears as a strong stub (Fig. 13) but never bears terminal branches. Amphizoa does not differ obviously from Dytiscus, both having a long straight 1st A, with a thickening below it. The Gyrinidæ differ mainly in having a thickening above the outer part of the stem of M, of uncertain significance. It might be interpreted as a trace of M_{1+2}, but this would not lead to any logical working out of the distal part of the wing.

Cupedidæ.—(Figs. 4, 12). The characters of this family have been abundantly discussed. The difference between the superficially almost identical species C. capitatus and C. oculatus is curious. Note espepecially 1st r-m, 2d A_1, the wedge-cell, and the position of the anal cross-veins.

Staphylinoidea.—Silpha (Figs. 24, 25) and Necrophorus are closely related, in fact almost identical in venation as well as wing-folding, and show a marked resemblance to the Staphylinidæ (Fig. 28). Note the preservation of the anal arculus, the principal fold of the wing lying before the thickened stigma, and the simplified anal region without any visible connection between 2d A and 3d A. There is practically nothing to connect this group of families with either the Adephaga or higher forms, and they might well be a survival of some earlier type. The alula of the elytron is preserved, as in the Adephaga and Hydrophilidæ. The folding is unique, but perhaps a little more easily interpreted as Adephagous.

Brathinus, an interesting intermediate form in body characters, is too reduced to have a significant venation.

Necrophilus (Figs. 26, 27) is far more widely separated from Silpha than it from the Staphylinidæ. The folding is unique (Fig. 27), the wing folding over just beyond the stigma. The genus, while perhaps

Silphid, is obviously out of place between Silpha and Necrophorus. I believe the small Silphidæ will go with it; Prionochæta at least shows essentially the same wing.

Palpicornia.—(Figs. 20-23). This group is interesting as alone showing a complex apical venation, as well as being the only one of the Polyphaga to preserve traces of the radial cells beyond the fold. The folding at the costal margin is as in the Adephaga while the remainder of the wing is almost typically Polyphagan. The radial recurrent obviously belongs more to the first r-m than to the base of Rs, in several genera almost connecting with the stem of M. One anal (2d A_1) is always lost. The family is primitive in preserving M_4 and Cu as separate veins, like the lower Adephaga and perhaps the Staphylinoidea, but unlike all the higher forms.

The smaller genera (such as Sphæridium, Fig. 23) show a striking resemblance to the Lamellicorns, that may possibly be significant, as the latter show distinct traces of distal veining.

Buprestidæ.—(Figs. 6a, 34). A student here is working on this family, which as Gahan notes shows no close resemblance to the Elaters. It is evidently a survival, and is one of the very few that has three free branches to 2d A. The lack of folding of the wing is not characteristic of the family as a whole, since Brachys folds normally.

Elateroidea.—(Figs. 30–33). The Elateridæ (Fig. 31) and Lampyridæ (Fig. 32) form a very well defined group in venation, to which all the small families of Sternoxia but the Rhipiceridæ will attach themselves. Cebrio (Fig. 30) is most primitive, and basic for interpreting the anal region. A general characteristic is the transverse outer end of the wedge cell (which fails in several genera by the loss of the cross-vein, and in Tharops alone by its obliquity). Another is the position of 1st r in all but a few aberrant groups markedly basad of the radiomedial. The folding is also uniform, being a double chevron-fold in the apex, rather like that of the Heteromera and lower Buprestidæ, but utterly unlike the Malachiidæ. The Lampyridæ are exactly like the most specialized Elaters, differing from the typical ones only by the loss of the cross vein cu-a. If the venation means anything they are degenerate rather than primitive.

Malachiidæ (*Melyridæ*).—Figs. 57, 58). These so far as the wings show have nothing whatever to do with the Lampyridæ, and may be a survival of a primitive type, especially if the transverse vein from the cell to the inner margin is really an independent Cu. The folding is very complicated and I have not worked it out fully. The nearest thing to it seems to be in the Coccinellidæ (Fig. 56). There are two pivot-folds at the costa, the more posterior of which corresponds in its manner of folding with that of the Adephaga and Hydrophilidæ, the more anterior with that of the Bostrychidæ and Byrrhidæ. The anal region is degenerate and gives no help. A large South American species shows no more veins than Malachius.

Dascylloidea.—(Figs. 37, 38). The Dascyllidæ and Rhipiceridæ are almost identical in venation, and distinguished mainly by the lack of the special characters of the other groups, in this resembling the lower

members of the Clavicornia, and the Macrodactylia. At present several members of this group are considered Buprestidæ and one or two primitive Elateroids are standing as Dascyllidæ. The Helodidæ are not even remotely related, but vaguely suggest the Dryopidæ and the Nitidulidæ.

Macrodactylia.—(Figs. 41, 42). It is an utter mystery to me how Kolbe, with any consideration of the venation, could separate the Parnidæ in three distinct superfamilies. There are differences, but they are mainly of the character of degree of development, and could be matched in almost any family of Coleoptera containing small species. He seems to have particularly emphasized the development of the medial recurrent. In venation the series has no particular characters, unless perhaps the tendency for R_3 to be stronger than M_1. Psephenus has preserved a radial cross-vein, while the European Dryops viennensis (Fig. 41) has preserved the usual five anals in the main group, which are reduced in the others. The folding is based on the Hydrophilid type, but this may not be significant, as this was presumably the original type for the Polyphaga generally; the preservation of 2d A_1 forbids derivation directly from the Hydrophilidæ.

Lymexylonidæ (Fig. 40).—I have only been able to study two forms. Hylecœtus tenebroides has nothing aberrant about it, and could perfectly well belong to the Heteromera, which themselves are not widely unlike many other Serricorns. Atractocerus is so modified as hardly to be significant, and is strangely suggestive of the Meloidæ, but could equally be derived from Hylecœtus.

Cleridæ.—(Fig. 48). This family, which with the Malachiidæ makes up the Trichodermata, shows none of the primitive characters of the Malachiidæ. On the other hand it is not strongly distinguished in venation from the Ostomidæ.

Dermestidæ.—(Figs. 35, 36). The Dermestids show at least three radically different types of venation. Attagenus (Fig. 35) is primitive in having the wedge-cell open by the lack of fusion of 2d A_3 and 3d A_1, as well as in the presence of an ocellus. It resembles nothing else whatever. Dermestes (Fig. 36), represents the ordinary Dermestid type, and while well characterized, it would not be out of place in the Dascylloids so far as venation is concerned. The 2d anal furrow seems however, to have three veins below and two above it, which would suggest a more primitive position for it also. Anthrenus is reduced, but offhand would suggest another family type, nearer the normal clavicorns.

Byrrhidæ (Figs. 51, 52).—These do not suggest the Dermestidæ at all in venation, nor anything else I have studied except possibly Mycetophagus. There are two pivot-folds, as in the Malachiidæ, but otherwise no very close likeness. The Mycetophagidæ (Fig. 53) are more primitive in preserving the wedge-cell, the Byrrhidæ in having cross-vein cu-a. Both show traces of complexity in the vein r-m, but this may be a secondary effect of the folding.

Ostomidæ (*Trogositidæ*) (Figs. 49, 50).—The most distinctive character of this family seems to be a tendency to chitinize the area of the wing crossed by r-m, in the form of an arrowhead-shaped mark,

exactly as in the Cleridæ, and to a rather strong preservation of the tip of M_1. A chitinization beyond the pivot-fold alone gives a slight special likeness to the Hydrophilidæ, with which they agree in type of folding.

Heteromera (Figs. 6, 43–46).—There is nothing about the venation of the Heteromera to separate them in two groups corresponding to those in Leng's Catalogue, and on the whole not much that is distinctive. The folding, as in the Hydrophilidæ, Buprestidæ, Elateroidea, Dascylloidea, Dermestidæ, Macrodactylia, etc., is of what may be called the normal type, dominated by a double pivot fold in the same position as in the Adephaga. The venation of the same region is rather simple, and possibly nearest to the Buprestidæ which fold their wings, and the Ostomidæ. In the anal region 2d A_1 is invariably lost, but the type is that normal in families mentioned, in other points. The *Erotylidæ* have the same venation, and should be re-examined as to homogeneity as a family, as some of them have heteromerous tarsi.

Meloidæ.—The Meloidæ (Fig. 47) at first sight are markedly divergent from the remainder of the Heteromera; but the points of divergence seem merely to be the result of reduction. The radial cell is lost, and the outer ends of the radial and medial recurrents have become nearly transverse, and continuous with the radiomedial crossvein, giving a characteristic appearance to the outer part of the wing. In the anal region there are three simple veins, with a chevron-shaped structure between the second and third, toward the base. At first sight this arrangement seems unique, but is easily derivable from the normal heteromerous type by the loss of the lower side of the wedge-cell and vein 2d A_3+3d A_1. The Trictenotomidæ of Africa seem to be intermediate.

The *Rhipiphoridæ* have so completely lost their veining that they might be interpreted in any way. The few traces of veins left are not specially suggestive of the Meloidæ, but the other characters and habits place the family in this neighborhood. The *Stylopidæ* are also extremely reduced; but the venation, so far as preserved, seems to agree with that of the Meloidæ.

Nitidulidæ (Figs. 54, 55).—Phenolia grossa is a reduced form, but with an extraordinarily complex type of folding, which I have not tried to work out in detail. The recurrents form a deep loop, exactly as in the Histeridæ, but the character is as likely as not to be due to convergence, as the forms have no other special likeness.

Histeridæ (Fig. 29).—Ganglbaur by some extraordinary slip put this family in the Staphyliniformia on venational characters, stating that the medial recurrent is absent. In fact Mr is an exceptionally strong and heavy vein, as well as Rr, and both appear to take part in the folding of the wing, which resembles the Staphylinidæ in no way. Save for the preservation of R_5 as a vein in the outer part of the wing, the form would be easily derivable from the other clavicorns, by an increase of the folded portion. In any case, as there is no trace of the anal arculus, and the recurrents are fully developed, the relationships

of the form are to be sought in the latter families and not in the Staphyliniformia.

Coccinellidæ (Fig. 56), *Endomychidæ*.—These two families agree in the curious anal system formed of two loops, and the curious manner of folding, with two hinge-folds working together. The venation is adjusted to this folding, and reduced, even in species as large as Epilachna, so that except as it emphasizes the isolation of the family the venation is of little use. What likeness there is, is to the Malachiidæ.

Bostrychoidea (Figs. 59–61).—The Bostrychidæ are characteristic, and the Ptinidæ resemble them closely. The folding is very simple (Apate, Fig. 61) and derived from a type with anterior pivot-fold, such as the Melachiidæ. In venation the principal character is the origin of M_1 directly from the cross-vein, whereas it is free in almost all the other Polyphaga. Dinapate is not aberrant in the least.

Lamellicornis (Fig. 62).—All the Lamellicorns have a single type of venation. There is a strong tendency for the central cell to be obvious, and to keep its rounded form, and R_3 frequently switches its attachment from the upper to the lower side of it, as in the figure. The anal region is characterized especially by the reduction of the upper fork of 3d A to a short stub running across toward 2d A, the complete disappearance of the wedge-cell, and the detachment of 1st A and the two upper branches of 2d A, which show as fine chitinous streaks or disappear entirely. I have seen no form in which all three were distinct; in some 1st A is visible close to the junction of M_4 with Cu (Kühne, Fig. 21), in others it is 2d A_1 that is preserved; 2d A_2 is usually present. The radial cross-vein appears always to be absent, but the apical system of veins are more distinct than in any other family save the Hydrophilidæ, R_{4+5} often showing as a distinct stub, connected with R_{2+3}, and Mr showing a decided angle at the point where M_1 is presumably given off.

In general the Trogidæ and Lucanidæ have a larger cell below the base of 2d A, but the families are not well separated in venation.

Phytophaga (Figs. 63–68).—This group tends strongly to simplification of the anal region, but the lower forms are quite typical. There is, with a few exceptions, a spur on the outer side of r-m, and rarely one on the inner side also, or even more complex structures involving the first radiomedial as well. The central cell is apt to be well-outlined, and M_1 usually is strongly developed and attaches to it. Aberrant forms, however, like Distenia undata, figured, violate all the definitions of the group, and make it undefinable on venation. In Prionus the anal region is almost like that of Hydrous. On the other hand the typical venation, with a spur on the second radiomedial cross-vein, is universal in the Chrysomelidæ and Mylabridæ (Bruchidæ) and is carried over into the Anthribidæ of the Rhynchophora, whose position in the group cannot be challenged. The higher Rhynchophora, of course, are highly modified in connection with their peculiar wing folding, though even they show some slight trace at times of the characteristic spurred cross-vein.

The folding is of the Hydrophilid type.

SUMMARY.

The venation of the Coleoptera is based on the same fundamental plan as that of the Neuroptera and other Holometabola, but with a rather large number of cross-veins. Costa is typical, not always marginal; subcosta normal, concave, usually fusing with radius; radius with R_1 obsolescent, fusing with Sc, Rs sharply divergent from R_1 at origin, and usually obsolescent at root, then broken by the principal fold of the wing, R_2 and $_3$ represented by parallel more or less rudimentary veins toward the costa, R_{4+5} bending down sharply on the outer side of a *central cell* where all the folds of the wing tend to converge, then turning out, and when complete ending in one branch near apex and one far below, near M_1. (Hydrophilidæ, Histeridæ), usually reduced to a short stub (Adephaga, Scarabæoidea) or lost. Media oblique from R to Cu near root, then obsolete a distance, then showing as a spur attached at its apex to Cu, in the outer part of the wing with two divergent branches, representing M_1 and M_4; Cu simple, strong to fold, then usually lost beyond or fused with M_4; anals complexly anastomosing, typically with 6 or 7 terminations, of which only one belongs to 1st A.

The Haliplidæ are generalized among the Adephaga, the Amphizoidæ very close to the Dytiscidæ.

The Hydrophilidæ contrast with all the other Polyphaga in the preservation of both M_1 and Cu, and often in a more or less complete apical venation. Sphæridium suggests the Lamellicorns.

The Silphidæ are very near the Staphylinidæ in venation; the Necrophilus group less close. They form an isolated group apparently not nearer the Polyphaga than Adephaga.

The Histeridæ have nothing to do with the Staphyliniformia, but are Clavicorn or isolated.

The Elateridæ and Lampyridæ are closely related, and the venation suggests that the Lampyridæ are degenerate from an early elater type, not primitive.

The Malachiidæ, Coccinellidæ and some other families seem to make a separate group, which certainly has nothing to do with the Lampyridæ or Cleridæ.

The Rhipiceridæ are Dascylloid, not Elateroid, as noted by Gahan.

The Cleridæ are possibly related to the Ostomidæ.

The Lymexylonidæ are not especially generalized, and suggest the point of origin of the Heteromera.

The Heteromera show no sign of double origin where now divided; the Meloidæ on the other hand, contrast strongly with the families associated with them, apparently resembling the Rhipiphoridæ and Stylopidæ.

The Clavicornia are a heterogeneous group, on which light will certainly be thrown by the venation and folding.

EXPLANATION OF PLATES.

ABBREVIATIONS USED.

C—Costa.
Sc—Subcosta.
Sc_1; Sc_2—its branches.
R—Radius.
R_1, R_2, R_3, R_4, R_5—its branches.
Rs—Stem of radial sector.
M—Media.
M_1, M_2, M_3, M_4—its branches.
1st A—First anal vein.
2d A—Second anal vein.
$2dA_1$, $2dA_2$, $2dA_3$—its branches.
3dA—Third anal vein.
$3dA_1$, $3dA_2$—its branches.
$4thA_1$—Fourth anal vein.
$4thA_2$—Presumed second branch of fourth anal.
hum—humeral cross-vein.
arc—arculus.
a. arc—anal arculus (cross-vein 1st-2d and base of 1st A).
r—radial cross-veins.
r-m—radiomedial cross-veins.
m-cu—mediocubital cross-veins.
cu-a—cubitoanal cross-veins.
1st-2d a, 2d-3d a—interanal cross-veins.
O—Oblong cell (2d M).
W—Wedge-cell (2d 2d A).
st—Pterostigma.

PLATE XXIX.

Fig. 1. Hypothetical plan of wing venation of Coleoptera, based mainly on Cupes (base and cell), Cebrio (anal region) and Hydrophilus (apex). The conventional symbols for the veins and cells are used, namely:
Fig. 2. Tracheation of wing of imago of Calosoma species. The tracheæ are shown as solid lines, the veins stippled.
Fig. 3. Tracheation of imago of Dytiscus verticalis.
Fig. 4. Venation of Cupes capitata.

PLATE XXX.

Fig. 5. Tracheation of young pupa of Dytiscus, from a preserved specimen. The tracheæ are shown so far as made out, by solid lines, the vein-cavities stippled. The specimen is imperfect and a fresh wing would probably show more tracheæ and veins.
Fig. 6. Tracheation of young pupa of Tenebrio molitor (about one day after pupation). The tracheæ are all as shown in one mount, the veins restored by comparison with the late pupa and imago.
Fig. 6a. Tracheation of young pupa of Agrilus ruficollis. Slide by Henry Good.
Fig. 7. Diagram of wing-folding of Cybister. The portions of the wing reversed in folding are shown black. Concave folds are indicated by even lines, convex ones by toothed lines. Regions of the wing, which are half folded over, or crumpled, are hatched.
Figs. 8, 9. Folded wing of Apate capucina (Polyphaga, Bostrychidæ); the veins cross-hatched and concealed portions dotted in. Dorsal and ventral views.
Figs. 10, 11. Folded wing of Colymbetes sculptilis (Adephaga, Dytiscidæ); like Figures 8 and 9. Dorsal and ventral views.

PLATE XXXI.

Fig. 12. Cupes oculata (Cupedidæ). Slide by courtesy of C. T. Brues.
Fig. 13. Tetracha virginica (Cicindelidæ).
Fig. 14. Galerita janus (Carabidæ).
Fig. 15. Harpalus caliginosus (Carabidæ).
Fig. 16. Same; folding plan (compare Figure 7).
Fig. 17. Pheropsophus æquinoctialis (Carabidæ; South America).
Fig. 18. Trogus glaucus (Dytiscidæ; South America).
Fig. 19. Cnemidotus edentulus (Haliplidæ).
Fig. 20. Hydrous triangularis (Hydrophilidæ).
Fig. 21. Same, folding plan (compare Figure 7).
Fig. 22. Hydrocharis obtusatus (Hydrophilidæ).
Fig. 23. Sphæridium scarabæoides (Hydrophilidæ).

PLATE XXXII.

Fig. 24. Silpha species (Silphidæ).
Fig. 25. Same. Folding plan (see Figure 7).
Fig. 26. Necrophilus hydrophiloides (Silphidæ?).
Fig. 27. Same. Folding plan (see Figure 7).
Fig. 28. Staphylinus maculosus (Staphylinidæ).
Fig. 29. Hister inæqualis (Histeridæ; Europe).
Fig. 30. Cebrio bicolor (Cebrionidæ).
Fig. 31. Elater discoideus (Elateridæ).
Fig. 32. Photuris pennsylvanicus (Lampyridæ).
Fig. 33. Pactopus hornii (Throscidæ).
Fig. 34. Dicerca lurida (Buprestidæ). Slide by Henry Good.
Fig. 35. Attagenus pellio (Dermestidæ).

PLATE XXXIII.

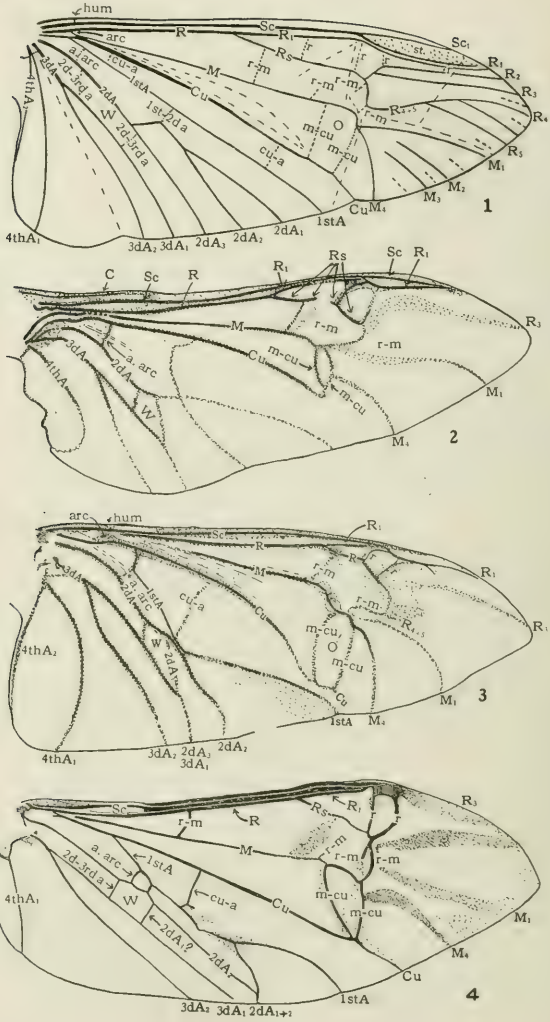
Fig. 36. Dermestes marmoratus (Dermestidæ).
Fig. 37. Sandalus porosus (Rhipiceridæ).
Fig. 38. Dascyllis plumbeus (Dascyllidæ).
Fig. 39. Cucujus clavipes (Cucujidæ).
Fig. 40. Hylecoetes tenebroides (Lymexylidæ; Europe).
Fig. 41. Dryops viennensis (Dryopidæ; Europe). Our species have lost 2d A_1.
Fig. 42. Heterocerus pallidus (Heteroceridæ).
Fig. 43. Tenebrio molitor (Tenebrionidæ).
Fig. 44. Penthe pimelia (Melandryidæ).
Fig. 45. Mycterus scaber (Melandryidæ).
Fig. 46. An undetermined species representing the Cistelidæ.
Fig. 47. Pomphopoea sayi (Meloidæ).

PLATE XXXIV.

Fig. 48. Trichodes apivorus (Cleridæ).
Fig. 49. Trogosita virescens (Ostomidæ).
Fig. 50. Tenebroides sp. (Ostomidæ).
Fig. 51. Byrrhus sp. (Byrrhidæ).
Fig. 52. Nosodendron unicolor (Byrrhidæ).
Fig. 53. Mycetophagus species (Mycetophagidæ).
Fig. 54. Glischrochilus fasciatus (Nitidulidæ).
Fig. 55. Phenolia grossa (Nitidulidæ).
Fig. 56. Coccinella transversa (Coccinellidæ).
Fig. 57. Malachius aeneus (Melyridæ; Europe).
Fig. 58. Collops bipunctata (Melyridæ).
Fig. 59. Dinapate wrighti ♀ (Bostrychidæ). Slide by courtesy of Henry Dietrich.

PLATE XXXV.

Fig. 60. Apate capucina (Bostrychidæ; Europe).
Fig. 61. Same. Folding diagram; compare Figures 7, 8 and 9.
Fig. 62. Lucanus dama (Lucanidæ).
Fig. 63. Asemum nigrivenum (Cerambycidæ).
Fig. 64. Distenia undata (Cerambycidæ).
Fig. 65. Leptura canadensis (Cerambycidæ).
Fig. 66. Caryoborus arthriticus (Mylabridæ-Bruchidæ).
Fig. 67. Donacia aequalis (Chrycomelidæ).
Fig. 68. Entomoscelis adonidis (Chrysomelidæ).
Fig. 69. Neuronia species (Trichoptera). Hind wing for comparison with the hypothetical type of the Coleoptera.
Fig. 70. Chorista australis (Panorpata; Choristidæ; Australia). After Esben-Petersen. Hind wing.
Fig. 71. Chauliodes pectinicornis. (Neuroptera; Sialidæ). Hind wing.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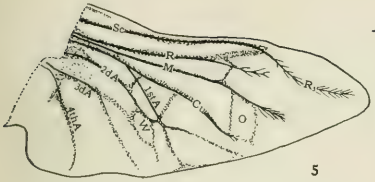

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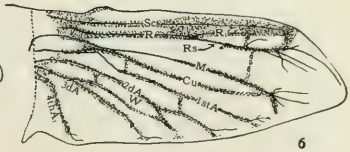

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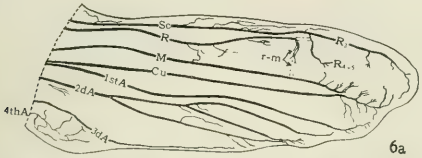

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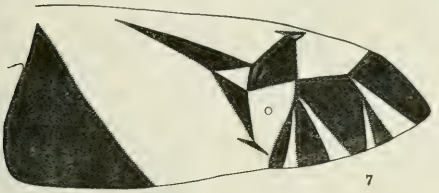

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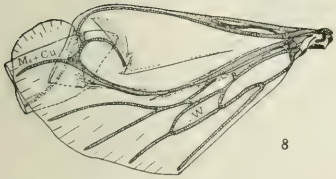

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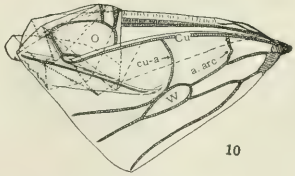

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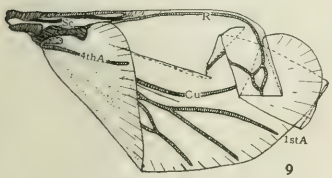

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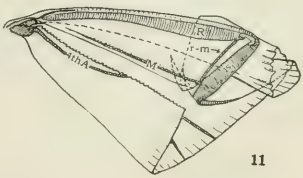

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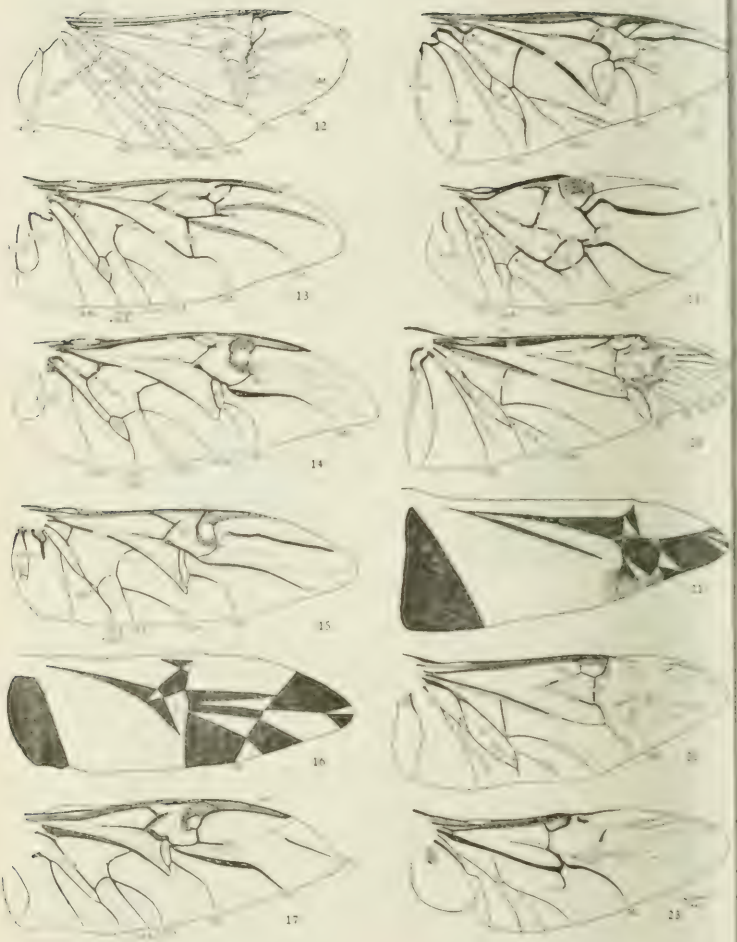

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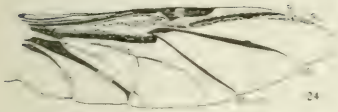

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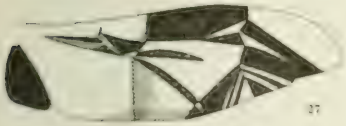

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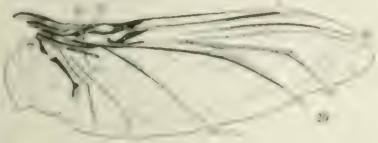

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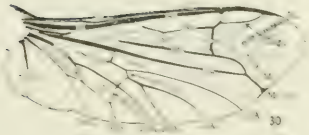

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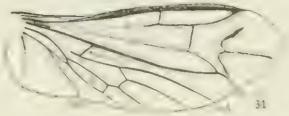

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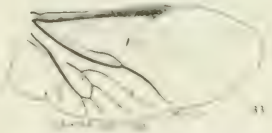

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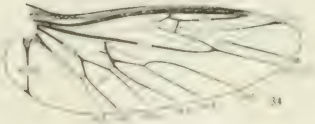

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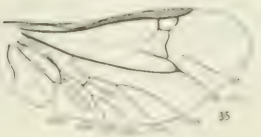

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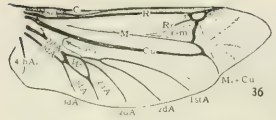

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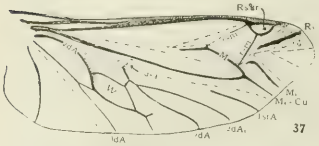

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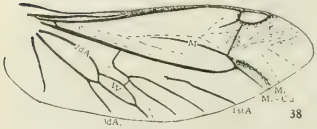

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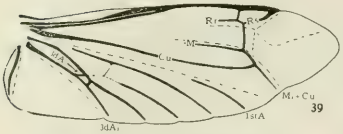

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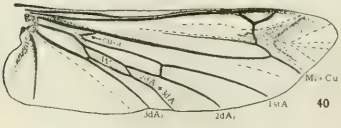

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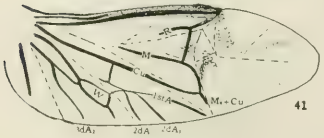

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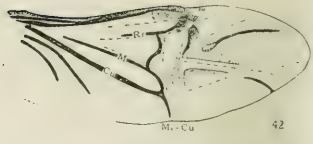

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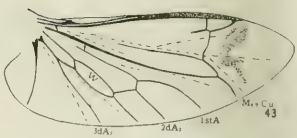

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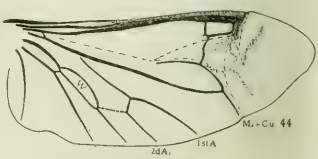

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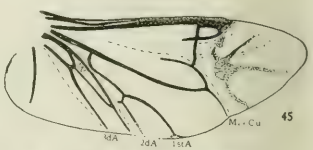

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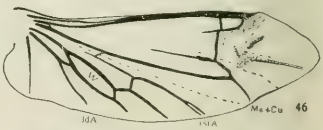

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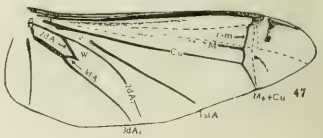

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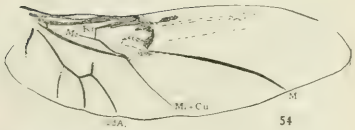

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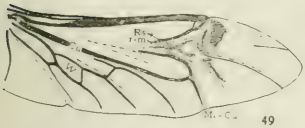

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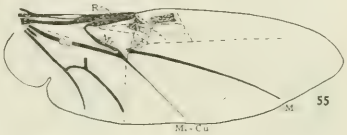

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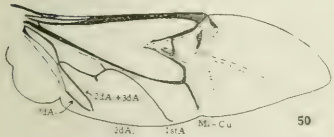

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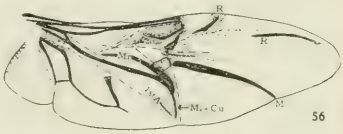

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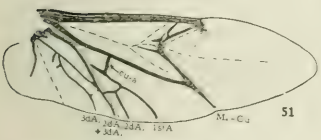

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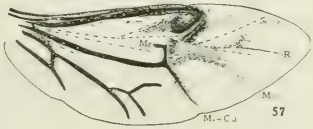

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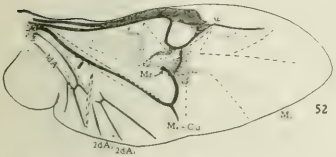

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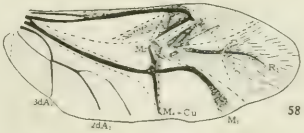

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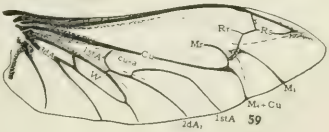

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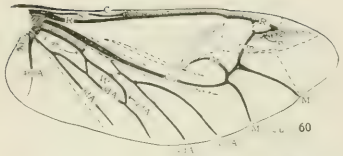
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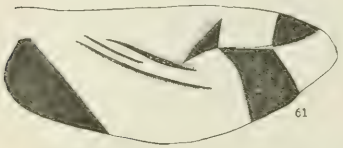
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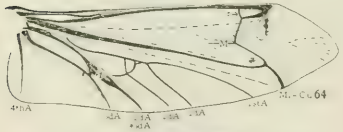
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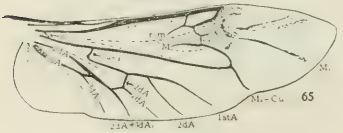
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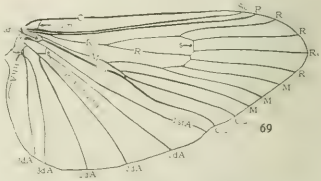
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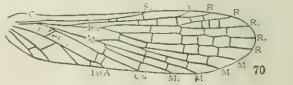
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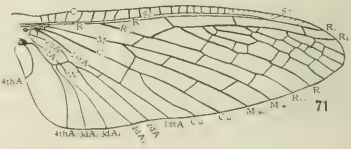
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STUDIES OF THE SPECIES IN THE GENUS CICADELLA LATREILLE (HOMOPTERA) OF NORTH AMERICA, NORTH OF MEXICO.

Chris E. Olsen,
West Nyack, N. Y.

In working over the species in the genus *Cicadella*, which from time to time had gathered in the writer's collection and in collections loaned for study, it was found impossible, from the present literature, to determine and properly place all the forms at hand. Some of these closely related and undescribed forms obviously caused considerable confusion at times and it became evident that a review with further study was quite necessary.

In reviewing this genus the author was confronted by several intricate questions. These questions were communicated to and discussed with other scientists interested in this particular genus. In some of these communications the main points of the author were sustained and a good deal of encouragement was given, while in one or two cases it was pointed out that his views were probably misguided. In such cases of doubt these views were dropped for possible further consideration and study.

Liberal use has been made of "sub-species" in place of "variety"; all forms which show a more or less constant distinction from the typical species, and which it would not, by structural characters, be safe to call species, although in some cases they may be such, are placed as sub-species. All others, more or less varying in color combinations and designs from the typical form, have been given a varietal name where such was deemed advisable for the purpose of identification. In this paper little use is being made of external genital characters for the reason that where the differential characters were mostly wanted the genital differences were too small or too variable to depend on, and preference was given to other structural characters, color designs, and patterns.

The "Reivew of the *Tettigonidæ*" by Ball, 1901, has been taken as basis for this study. This valuable work, which was published twenty years ago, is today still indispensable for the

study of the sub-family *Cicadellinæ*, but since its date of publication a number of changes have been made and some additions have been found of which no records have been made; these changes and additions have all been included in this paper.

Van Duzee, 1916 and 1917, has been followed in the higher names, viz.: Family *Cicadellidæ*, sub-family *Cicadellinæ*, tribe *Cicadellini*, and genus *Cicadella*, as neither literature nor time was available for the checking-up of this.

This genus can be recognized by the two ocelli placed on the posterior half of disk of vertex, about equal distance between eyes and center, portion of the front encroaching upon the dorsal part of vertex, the ledges over the antennal sockets are not prominent and the anterior tibia are not sulcate. Distant, 1908, mentions, in separating it from *Kolla*, that "the lateral margin of the vertex in line with the inner margins of eyes." This is rather misleading, and there is no doubt that what he meant was that the lateral margins were not in line with the outside of the eyes, as they are in *Kolla*.

A number of suggestions have been made; the very first one is to consider *Cicadella viridis* Linnæus as a possible accidental introduction which did not become established on this continent.

In the study of *hieroglyphica*, the writer "struck a snag" in trying to recognize the species from the short and incomplete description by Say. On this particular point the author sought advice from other interested friends.

The answers received were varied, both concurring and contrary to a suggestion of the author. But, as it is exceedingly difficult to prove or disprove the questions that arose, it is better left as it is for the present. It is rather unfortunate that Say's type is not in existence; if it were, there would never have been the slightest doubt, but, as it is, his short description will answer for another species in this genus as well.

Cicadella confluens Uhler has been given specific rank, for the reason given in the article, and the figure will assist in explaining doubtful points. Consequently, Ball's variety *uhleri* has been shifted to be a variety of *confluens*.

Tettigonia compta Fowler, 1900, has been revived as a subspecies, a rank to which it seems surely entitled. It appears to have a different form of habitation, seeking the higher and more arid regions of Mexico. This, together with its great difference of appearance will warrant the designation of sub-species for it.

Kolla similis Walker, 1851, has been included in this genus as it seems to compare better with the type *Cicadella viridis* Linnæus than it does with the type *Kolla insignis* Distant, although I have never seen specimens of the latter type. Taking this species out of *Kolla* may possibly improve that genus, the characters of which at their best are none too good for our known, North-American species.

Cicadella circellata Baker, 1898. It is quite possible that Signoret's *atropunctata* is the same as this; further study is therefore warranted, and particularly of material from Brazil.

Through the courtesy of Mr. Edmund Gibson the writer has had the privilege of studying a collection of specimens in this genus from the United States National Museum. Dr. F. E. Lutz kindly gave permission to examine the material in the collection of The American Museum of Natural History, and Mr. H. G. Barber turned over his very valuable collection to my disposal. Mr. E. P. Van Duzee, Dr. E. D. Ball, and others have kindly assisted with desirable specimens and were kind enough to answer correspondence on this subject. To these gentlemen I am very grateful for their unfailing assistance and to them I wish here to express my sincere appreciation. These collections, together with my own, accumulated material, have made this paper possible.

Cicadella viridis Linnaeus, 1758

This species has been included in our faunal list on the strength of a single record by Provancher, 1889. The specimen was seen in Provancher's collection at Quebec, Canada, and examined by Van Duzee, 1912. Its identity cannot be questioned. This record is rather unique for such a widely distributed species of the Old World. It appears in most of the European lists as a common species abundantly collected; it is reported from the British Islands (Edwards 1888), across the Danish peninsular (Jensen-Haarup 1915 1920), through Russia (Oshanin 1907), to Japan (Onuki 1901); in Europe as far south as Italy (Ferrari 1895). It occurs in damp, grassy locations along edges of swamps and meadows.

Had this species once gained foothold and become established here, there is every good reason to believe that it, like so many other Hemiptera, would find but little difficulty in maintaining itself, if not actually spreading. At least we might

expect to corroborate this old record of Provancher, 1889. Although this record is annotated by "Peu commune, Cap Rouge," it is apparently without a definite date, but must have been collected previous to the appearance of the publication, which was issued about August, 1889, thirty-three years ago.

Until further collecting of this species on our continent occurs, it may be well to suppose that Provancher's specimen was an introduced, stray individual, and that the species so far has not become established here, which explains its absence in all other collections and local lists. Taxonomically it would be most desirable to have this species with us as it represents type of family, subfamily, tribe and genus, but economically we are better off without it. It may be well to suggest to collectors in the northern section of our territory, and especially in Eastern Canada, to be on the look-out for the possible occurrence of this species.

Cicadella marathonensis, Olsen, 1918.

Recently described and figured by the author, in the Bulletin of The American Museum of Natural History, from a female specimen collected by Dr. F. E. Lutz, at Marathon, Texas. It is regrettable that this should be the only specimen known, but it is so distinct from all our other known *Cicadellidæ* that it cannot be confused with any other species.

It has been suggested by one of our eminent cicadelists that this species may belong in the genus *Kolla* and perhaps be one of the species described there. This point has been carefully considered; although there is very little difference between the genera *Cicadella* and *Kolla* yet *marathonensis* fails to compare with the latter. The vertex is more obtuse, the area between the eyes and ocelli is slightly shallow (not foveate as in *Kolla*), and the sides of the pronotum are entirely different from that of *Kolla,* more nearly like those of *Cicadella.*

Cicadella multilineata Fowler, 1900.

This very large species was described by Fowler from Pinas Altos in Chihuahua, Mexico, and it seems that it has not been reported on since. It is quite distinct both in size and color from all our other known North American species.

Vertex well produced, markings of vertex, pronotum, scutellum and veins of elytra black in strong contrast to the yellowish-gray

ground color, with apex of vertex, anterior part of pronotum, cell between the two claval veins and subcostal cell strongly tinged with bright yellow. Size: Length 10.1 to 10.5 mm., width 2.7 to 2.9 mm.

Twelve specimens were collected by Mr. H. G. Barber at Huachuca Mountains, Arizona, July 12th to August 3rd, 1905, which agree admirably well with Fowler's description and figure except as to the color of the underside. They fail to have the bright red venter and legs described for the species, but have a pale, orange-yellow color with indications of the varigated black and testaceous rather weakly shown.

Cicadella hieroglyphica Say, 1831.

This species was described by Say from specimens collected in Arkansas. Its color and markings are subject to variation but Say mentions only one color-form and neglects altogether the details of the markings which are so important distinguishing characters at the present time. He apparently made an error or else he did not describe the commonest form when he mentions in his description "hemelytra obsoletely spotted, nervures being pale." The writer has not seen any example among the great number examined which could truly be said to have "nervures pale," except in some forms where it was evident that the pigmentation in general had not developed, or in a few examples in which the nervures were pale near the base of the elytra and for a very short distance beyond. It is not probable that Say should have selected such a specimen or specimens to describe; at least this part is a serious discrepancy in his description as throughout the whole series of *hieroglyphica* and its allied forms (except one extreme subspecies, which may, when enough collecting has been done, be considered a good species), the veins appear dark. Is it possible that Say should have had a *gothica* before him? This would be an exceedingly hard question to settle as there are no types in existence. The description in general can be applied to both species except for the "pale nervures" which would fit *gothica* much better than *hieroglyphica*. However, taking all in all and arguing for and against, it is not advisable at this time to propose any change in the taxonomy, if indeed there is to be any, but, at the same time, it is well for those that try to identify *hieroglyphica* by Say's original description to bear in mind that they have dark veins in general.

Several new forms have been recognized as additional subspecies and varieties of this species; they could not well be identified with *hieroglyphica* or any of its described varieties. It was, therefore, obvious that the describing and naming of these forms would materially lessen the difficulty in identifying both *hieroglyphica* and *confluens*. In most cases and as far as this study has revealed, these new forms are more or less confined to certain geographical areas.

Typical form: Vertex well produced, obtusely conical, about a right angle; length of head, .8–.9 mm.; width, including eyes, 1.7 mm., anterior lateral margins bulging from just before the eyes, taking up with the obtuse apex, posterior margins rather evenly and strongly arched, disk evenly and gently convex, a very slight depression between the eyes and ocelli, sculpturing not very strong, general appearance rather smooth. The general color varies considerably from yellowish-gray to greenish, and from a brick-red to a grayish-green or brown with indistinct spots and blotches on head and pronotum, with the characteristic black markings surrounding an imaginary light T and usually with streaks, more or less conspicuous, and dark veins on the elytra. Males and females of about the same color.

Say, in his description of this species, mentions only one color form, i. e., "dull rufous"; this must then be considered the typical color. It is found very commonly in this color, from which it varies into several other colors as mentioned above.

The "slaty form" mentioned by Dr. Ball, 1901, should, without doubt be referred to the variety *dolobrata* rather than to *hieroglyphica*, (see variety *dolobrata*). This color transition is more evident in the females than in the males of these two forms.

In Van Duzee's Catalogue, 1917, the distribution for this species and the there mentioned three varieties is given in common. It seems obvious and quite important that the distribution should be considered apart for each of these forms, at least in this case. Dr. Ball, 1901, arranged them in two groups and gave the distribution of each group, which was more nearly correct. These two groups will not always be found in the same territory; at least one of the groups has quite a distinct distribution. There are several other closely related, yet undescribed forms (which will be treated in the pages to follow), that have been the cause of a good deal of confusion and it is obvious that local distribution must be considered for

each one of these forms even though in some instances repetition will occur.

The range of this species, typical form, extends from the Rockies about Colorado, east throughout Nebraska and Iowa to Illinois, south-west to New Mexico and Arizona. In the East it is represented by a single capture in Tennessee, De Long 1906, and another single example in the writer's collection from La Grange, Georgia, 17, VIII, 1918, taken by Dr. A. H. Sturtevant. A quite northern record is Wisconsin, which is probably correctly identified by Saunders and De Long, 1917.

Cicadella hieroglyphica var. **dolobrata** Ball, 1901.

Shape and characters similar to that of typical *hieroglyphica* but color darker, especially in the males, which range from all black with but few light markings, to black specimens irrorate with white on vertex and pronotum.

The characteristic markings of the species are usually obsolete in the males, but not so obscure in the females and sometimes rather well defined. Their color is slate to nearly black; I have never seen a female that would answer entirely to the color description of this variety.

Following is the result of the study of two collections: First lot: Langdon, Mo. VII, 14, —VIII, 28, H. G. Barber. Seventeen specimens, nine males, (typical *dolobrata*), eight females, rather slate gray in general appearance, with a good deal of light pattern in strong contrast to the markings on the vertex and anterior part of the pronotum. They would very well pass for Ball's "slaty form" but are undoubtedly the females of the above mentioned males. The lot is fairly constant and collected in a space of about six weeks. Second lot: From "C. Mo. 96." (abbreviation for Central Missouri 1896?), U. S. National Museum Collection. Ten specimens pasted on a card, seven of which are typical *dolobrata* males, the remaining three were females with vertex and pronotum as in the former lot, but a shade darker on the elytra. These are almost indisputably males and females of the same brood.

The distribution of this variety follows that of the typical *hieroglyphica* except that it is not reported from as many places. Dr. Ball, 1901, gives the same general distribution for both, additional distributions are Olsen, 1918, Boulder, Colorado; De Long, 1916, one specimen from Colliersville, Tennessee.

There is no doubt that this variety will be found wherever the typical form occurs, if thorough collecting is done.

Cicadella hieroglyphica sub-species **lutzi** n. sub-sp.

Male: Vertex shorter and wider in proportion than in either *hieroglyphica* or the variety *dolobrata*, eyes more prominent, two longitudinal, slightly elevated ridges passing over the ocelli, leaving the central disk and the area between the ocelli and eyes slightly but distinctly concave. The whole vertex has otherwise a rather flat appearance. Pronotum rather short, and only slightly convex, lateral margins of the elytra, from dorsal aspect, tapering gradually to an acute point.

Color. A shining black spot on the apex of vertex and face, the reflexed portion of the face is finely lineated with brown, curved lines, lateral edge of vertex just behind the reflexed portion of face with a strong, short, black line almost touching the eyes. Front yellowish-white, mottled with black, but little broken up; this mottling is extended so that it connects with the apical spot at four places, a strong, median light stripe running from the black spot at the apex to the clypeus, sometimes interrupted by the black mottling crossing it. Genæ pure white, immaculate. Loræ bright yellow, fuscous along the clypean suture. Clypeus cream yellow with a dark, narrow median line. Pectus black with a broad white spot just below the eyes followed by a smaller one. Vertex with the characteristic *hieroglyphica* "T," but differing principally from the typical *hieroglyphica* as follows: A strong black line following around the base of the "T" up along both sides of the stem, following along under the divergent and recurved parts of the "T," going back obliquely across the ocelli, striking against the eyes, a lateral branch shooting forward between the ocelli and eyes, terminating before it reaches the margin in a somewhat angulate spot; the light stem of the "T" passes uninterruptedly through to the apical spot.

The suture between the reflexed portion of the face and vertex marked with a delicate, black line, pronotum dark with an anterior light band irregularly marked with black and dark brown, markings more pronounced, and of a vermiculate character on the anterior band. Scutellum with two black vittæ running from basal margin slightly inside and parallel to the lateral margins until it strikes the dark, impressed suture, directly backwards striking the lateral margins before the tip. Elytra bluish-black, the costal margin and margins of claval suture bright bluish-gray, sometimes with green mottling, nervures dark, cells irregularly sparsely spotted or mottled with gray.

Females unknown.

This sub-species can be separated from typcial *hieroglyphica* and var. *dolobrata* by its shorter, broader and flatter vertex, smaller size and more pointed posterior. Its general dark-

bluish and somewhat shining color will readily separate it from *hieroglyphica* while the light markings of the vertex will serve to distinguish it from *dolobrata*.

Described from eighteen males, specimens all from Arizona. Five males from "Phoenix, Arizona, R. Kunze Collection" American Museum of Nat. Hist. collection; seven males from "Phoenix, Arizona, R. Kunze Collection"; and one male from "Phoenix, Arizona, 6-1-02," H. G. Barber Collection. Two males from "Arizona C. U. Lot. Cornell U .Lot 411 and 414," one male from "Arizona U. Lot P. R. Uhler Collection," collection of United States National Museum. In time, it may prove to be a perfectly good species. This can better be ascertained when the female becomes known. At present the rank of sub-species will serve every purpose. Male holo-type and three male para-types in The American Museum of Nat. Hist.; four male para-types in Mr. H. G. Barber's collection; four male para-types in U. S. Nat. Mus. Coll.; six male para-types in author's collection.

Cicadella hieroglyphica sub-species **barberi** n. sub-sp.

Small, slender, pale yellowish-green, scarcely marked. Vertex, anterior pronotum, scutellum, costal margins of the elytra and all beneath from a pale straw-yellow to a slight greenish-yellow. Vertex with apical black spot, disk very lightly marked with fuscous, pattern scarcely discernible, in some specimens entirely obliterated, leaving the vertex clear yellow with only the eyes, ocelli and apical spot dark. Pronotum without maculation, posterior disk yellowish-green. Scutellum with faint traces of maculations. Elytra yellowish-green. Face and all beneath pale straw color, immaculate or slightly marked. Veins usually pale in the females.

Four females, from "Phoenix, Arizona," American Mus. of Nat. Hist. Four females, "Phoenix, Arizona, May 25, to June 8, 1902," H. G. Barber Collection. One female "S. Col." One female, "Pecos, New Mexico, August 11, Ckll.," and one female, "Santa Fe, New Mexico, Ckll.," United States Nat. Mus.

Seven males from "Glen, Sioux Co., Neb.," H. G. Barber Collection and one male, "Col. Aug. Uhler," U. S. Nat. Mus. Collection, may possibly be referred to this sub-species; they have a trifle more markings on the vertex than the females as above described and also the veins of their elytra are set off with a darker color.

Female holo-type and two female para-types in The American Museum of Natural History Collection. Male allo-type, four male para-types and two female para-types in H. G. Barber's collection. Three female para-types in U. S. Nat. Mus. Coll. Three female and three male para-types in author's collection.

Cicadella hieroglyphica var. **inscripta** n. var.

Shape and size similar to *hieroglyphica*. Face yellow, mottled with brownish. Vertex bright yellow, the disk washed with green, usual markings shining black, apical spot prominent. Pronotum dark bluish-green on disk, anterior margin more or less bright yellow, with a series of prominent black inscriptions across the entire width, which is vanishing in some specimens. Scutellum yellow with usual black margins. Elytra bright bluish-green with the margin of the claval suture yellowish-green, and the costal margins yellow to yellowish-green. Face mottled with testaceous. Venter and all beneath pale yellow, except the claws, which are dark, and a few fuscous spots on the sternum of some of the specimens.

Five females, three labeled "Arizona (Col. Baker)," one "Pecos ,New Mexico, Aug. 26 Ckll., *Verbesina exauriculata*," (Probably food plant), one "Colorado Springs, Colo., July 21, 77." All from the U. S. Nat. Mus., Washington, D. C.

Female holo-type and three female para-types in U. S. Nat. Mus. one female para-type in author's collection.

Cicadella confluens Uhler, 1862.

When Uhler described this species he placed it in the genus *Proconia* and compared it with *Proconia costalis*, now known as *Oncometopia lateralis* Fabricius. From this it is evident that the insect he described appeared to him rather closer related to *lateralis* than to any of the *Tettigonia* species. It is not easy to say why he did this for his species lacks characters to admit it into this group, perhaps its appearance was rather coarse for *Tettigonia*.

Ball, 1901, reduced Uhler's *confluens* to a variety of *hieroglyphica* and described two other varieties, *dolobrata* and *uhleri*. After studying a considerable number of specimens I have come to the conclusion that *confluens* should be considered as a distinct species with *uhleri* as a variety of it. These always possess the broadening and shortening of the vertex which Dr. Ball, 1901, refers to in the introduction of his paper. Besides

this, the front or face is considerably less convex and usually very pale with much less marking than is found in *hieroglyphica* and its varieties. Comparing it with *hieroglyphica* both in width and length, its head is broader and shorter in comparison to its total length; the lateral margins of vertex are straighter; vertex not quite so convex; elytra longer, mostly with a spotted pattern seldom displaying any stripes; general color dark brownish to bluish-black; markings on vertex quite different, the longitudinal bar of the T and the black margins bordering it are proportionately longer and thinner, appearing more drawn out and crowded together; the apical black spot is usually joined by the other black markings, sometimes barely separated; face is pale, sometimes slightly mottled; front broader, flatter, and not quite so strongly inflated.

This species is undoubtedly confined to the extreme western states, specimens are determined from British Columbia, Washington, Idaho, and California.

Certain forms of *hieroglyphica*, especially from Colorado, (perhaps a new variety) very much resemble this species and have probably been the cause of confusion; they can, however, always be separated from it by the front being darker, more mottled, narrowed and more inflated or convex, and their shorter elytra and they do not have the slender black and light lines on the disk of the vertex. Some of these specimens in the National Museum collection where labeled with a Uhler ms. name.

Cicadella confluens var. **uhleri** Ball, 1901.

This variety compares well with Uhler's *confluens* except in color, which is a grayish-green with bluish, greenish or brownish mottling, much lighter than typical *confluens*. Vertex, face, scutellum and costal margins of elytra usually brighter and more yellowish; black markings of vertex and scutellum are more delicate and fainter, sometimes vanishing; it also has longer elytra.

Occurring practically with *confluens*, perhaps ranging more eastward toward the Rocky Mountains. Specimens at hand from Washington, California, Nevada and Colorado. These localities conform with Dr. Ball's (1901) statement of distribution which names the states in the Rocky Mountain region except Montana and follows westward to the coast. Tucker

(1907) confirms the Colorado locality, whereas Gibson and Cogan (1915), if their determination is correct, extend the distribution considerably eastward, giving the western half of the state of Missouri.

Cicadella gothica Signoret, 1855.

This widely distributed species, occurring practically over the entire continent, extends its range considerably northward over a wider stretch than any other member of the genus. It is common in all the north-eastern states extending into Canada. Provancher, 1889, lists it as *Diedrocephala hieroglyphica* Say common at Cape Rouge, Ont. Mr. E. P. Van Duzee, 1914, reports it as abundant throughout the year at San Diego County, California. In the south-east it seems to cease at Tennessee, De Long, 1916; South Carolina, Metcalf, 1915; North Carolina, Olsen, 1918.

Specimens at hand from Arizona vary slightly in size and markings from those of elsewhere: (a) about the same size but all markings on vertex obliterated or nearly so, elytra unicolorous with veins faintly discernible, pale; (b) ranging considerably smaller in size, markings on vertex present and elytra of a deeper color with veins pale.

It is readily separated from the *hieroglyphica* group by its designs of the vertex. The elytra of this species has the nervures pale. It does not exhibit as great variation as *hieroglyphica*.

Cicadella circellata Baker, 1898.

It seems somewhat doubtful whether this name is valid or not. There is a good reason to believe that *atropunctata* Signoret is the same thing; his description fits tolerably well, although based on a specimen collected in Brazil, but the illustration is indeed very misleading and poor, as are many of the illustrations in the same work. However, this will need further study and especially of material from the south. Meantime, it may well be carried along as above.

Lawson, 1920, is evidently of the same opinion since he in his recent paper on "The Cicadellidæ of Kansas" calls this species *atropunctata* Signoret.

Cicadella occatoria Say.

Described by Say from Indiana. Fowler, 1900, gives a very fine color figure of this insect. It is variable to some extent in the amount of green and yellow color, also the markings show a gradation of various tints from reddish-brown to brown and black.

Dr. Ball, 1901, lists *Tettigonia compta* Fowler as a straight synonym of this. I would hesitate that our common form in the south-eastern states should be identified with *Tettigonia compta* because of Fowler's description and particularly his color figure which is very well executed. Therefore, I would separate this form from *occatoria* and consider it a a sub-species at least, to which, I am sure, it is entitled. Dr. Ball, 1901, records it as common in Florida, Mississippi and Texas. To this must be added Gibson and Cogan, 1905, common in eastern Missouri; De Long, 1916, specimens swept from various places in Tennessee; Metcalf, 1915, two localities in North Carolina; and Lathrop, 1917 and 1919, three localities in South Carolina. The type locality is in Indiana. Its range extends far to south of our fauna.

Cicadella occatoria sub-species **compta** Fowler.

Comparing this form with the true *occatoria* it will at once be seen to be of much redder color, but lacking the green. On the vertex the two outer of the four red vittæ are much broadened on the reflexed portion of the face, and are subdivided into two or three narrower stripes on this place; they are really a continuation of a series of ten or twelve red arches on either side of the face, which extend up to this part of the vertex and take up with the stripes running back over the pronotum and clavus. The inner pair of vittæ form a decided loop at a distance of two-thirds from the base of the head and run back over the pronotum, scutellum and clavus. The fifth or central vitta commences on the pronotum and runs back over it and the scutellum.

The red vittæ of the elytra are much broadened and leave only narrow, yellow vittæ between them. The apex of the elytra is hyaline and the characteristic "blackish tip with yellowish band" as mentioned in Say's description, is wanting.

This form seems to frequent more elevated and arid regions of Mexico, whereas typical *occatoria* is usually found along the south-eastern coast-line at comparatively low elevations.

Six specimens in the collection of Mr. H. G. Barber come from Huachuca Mountain, Arizona, July 13 to 22, 1905.

Cicadella dohrnii Sign.

I have seen only a few examples of this species from Arizona and Mexico. It was described by Signoret from Mexico, and without doubt this is the insect which later was described by Baker, (1898, p. 286) as *Tettigonia aurora* and by Fowler (1900, p. 269, Pl. XVIII, Fig. 5) as *delicata*. This has been pointed out by Dr. Ball, 1901, who gives a very comprehensive description and an excellent figure by which it can be readily determined.

Cicadella similis Walker, 1851.

In comparing this species with the description of the genus *Kolla* Distant, 1908, I find that it does not agree very well. In the first place, the vertex is obtuse, rounded anteriorly rather than subconically narrowed; in the second place, the fovea next to the eye is scarcely discernible, variable, and amounts in many cases to a shallow depression which is so often seen in the genus *Cicadella*.

The face has the lateral areas somewhat strongly striate, but this is also a character in most of the *Cicadella* species. The centrally longitudinal area is sometimes flattened, and sometimes gently rounded, the dark and light arches meeting a narrow, light, central longitudinal vitta. The outline or profile of the face is markedly different from our species of both *Cicadella* and *Kolla*, bending rather abruptly just before the clypeus and the latter itself having quite a bend, these two bends producing a wavy appearance to the lower part of the profile of the head. Considering the above characters, I suggest that this species be placed in the genus *Cicadella*, where I think its color pattern, shape and general appearance will be in greater agreement.

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EXPLANATION OF PLATE XXXVI.

Fig. 1. Dorsal view of *Cicadella multilineata* Fowler.
Fig. 2. Dorsal view of *Cicadella hieroglyphica* Say.
Fig. 3. Dorsal view of *Cicadella hieroglyphica* subsp. *lutzi* n. subsp.
Fig. 4. Dorsal view of *Cicadella hieroglyphica* subsp. *barberi* n. subsp.
Fig. 5. Dorsal view of *Cicadella confluens* Uhler.
Fig. 6. Dorsal view of *Cicadella occatoria* Say.
Fig. 7. Dorsal view of *Cicadella similis* Walker.
a, front view of face; *b*, side view of head; *c*, apical half of elytra.

C. E. Olsen

NEW SYRPHIDÆ (DIPTERA) FROM MISSISSIPPI.

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Mississippi is in a region that is as yet almost wholly unexamined in regard to its dipterous fauna. The discovery of two very interesting new species of Syrphidæ from the trifling number that have thus far been collected in the state argues a rich return from collecting in the future. The writer wishes to express his appreciation to Mr. C. H. Curran, who has kindly verified his determinations, particularly of the *Microdon*.

Microdon (Omegasyrphus) **painteri,** new species.

Male: Face and front dark shining metallic bronze, of medium width and nearly parallel. Oral margin and cheeks shining black. Cheeks and posterior orbits white pilose. Pile of face and lower half of front white, on upper half of front and vertex brownish yellow. Marking the anterior third of front is a shallow grooved depression somewhat in the shape of a "Y" the upper arms of which are wide apart and reach to the eyes. Face projecting for about half of its width, beginning just below the eyes. Eyes bare. First joint of antennæ reddish, darker at tip; second and third joints black. Third joint distinctly shorter than first and second combined, pointed at tip and approximately twice as long as broad. First and third joints about equal in length; second joint short. Arista scarcely as long as last joint, reddish orange, brownish and considerably thickened at base.

Dorsum of thorax feebly shining bluish black; with five shining, purplish bronze stripes of which the middle one is very narrow and the lateral ones quite wide; these stripes merge into a similarly colored area both on the anterior end of the dorsum and just before the scutellum. Scutellum shining metallic; spines small and separated by a distance slightly greater than their length. Pleuræ and humeri strongly purplish bronze. Pile of dorsum short and of a yellowish cast, that of pleuræ longer and white. Squamæ pale yellowish.

Abdomen: First segment dull brownish black, but little shining. Second widened and considerably depressed so that the lateral margins have a much thickened and rounded appearance on the edges; a large indistinct triangle of dark golden brown which in some lights has a greenish reflection, its apex reaching the posterior margin, has its base along the anterior margin. The remainder of this segment and the rest of the abdomen light, slightly brownish red becoming a little darker on the fourth segment. Whole abdomen faintly shining; pile

or pubescence short, white longer on the lateral margins and more noticeable on the third and fourth segments. Venter concolorous with the dorsum with the exception of the first segment which is blackish.

Femora black, shining, with very short and sparsely white pile; apex of femora and trochanters reddish. Tibiæ reddish, piceous at their outer ends, covered with short abundant white pile; first joint of hind tarsus considerably enlarged. Wings hyaline with a dark brownish cloud in the middle on the anterior half of wing, smaller clouded areas following the veins closing first and second posterior cells and about the marginal and submarginal cells. Veins brown; stigma luteous. A stub of a vein extrudes half way across the first posterior cell at its middle.

Female: Very similar to the male. All three joints of the antennæ light yellowish brown, outer half of last joint grayish or blackish; Arista entirely reddish yellow. Front noticeably wider. The ground color of thorax appears more metallic and greenish. Scutellum more purplish bronze. The second segment lacks the brown triangle and is entirely reddish.

Femora dark shining red. Tibiæ and tarsi light brownish red; pile of the former white, of the latter brownish yellow. Infuscated spots and veins of the wing smaller in extent. Ocelli bright shining red.

Length: 10 mm.

Holotype male and two paratype males taken in a cypress swamp on September 18, 1920, at Greenville, Miss., F. M. Hull). Allotype female from College Station, Texas, September 28, 1920, (H. J. Reinhard).

Holotype and paratype in the collection of the author. Allotype in the collection of Mr. Reinhard.

It gives me pleasure to name this species in honor of Mr. R. H. Painter who has been active in the collection of the Syrphid fauna of the region.

Somula mississippiensis, new species.

Male: Antennal process extraordinarily long and prominent; the distance from base above to tip being approximately half as long as the distance from the base above to the epistoma or twice the length of the process in *Somula decora* Macquart; yellow below, entirely black above, the black extending to the eyes, its margins straight. Antennæ black; second and third joints covered with microscopic, light colored pubescence; arista yellowish red near base, blackish apically. Face below antennal process only slightly concave and a little convex on lower part; descending perpendicularly considerably below the eyes; shining pale yellow, with a black median stripe extending from the epistoma to half the length of the antennal process on its lower surface. Cheeks shining black. Front black, almost destitute of the rather long, yellow pile that sparsely covers the occiput and the posterior orbits

below. On each side of the antennal process, with their bases against the eyes, are two triangular areas with microscopic, almost white pubescence.

Thorax a faintly shining black with five, dorsal, narrow, obscure metallic golden green stripes, merging into similarly colored area both at the anterior end and just before the scutellum, which gives to the black of the thorax a greenish cast. Scutellum shining; entirely metallic greenish black. Pile of medium length, rather thick and yellowish. Humeri opaque yellow, yellow pilose. Mesopleuræ black, with an oval yellow spot, yellow pilose. Squamæ yellow.

First segment of abdomen black, feebly shining. Second, third and fourth segments black, nearly opaque, each with a pair of opaque yellow spots and a shining, metallic, brassy band on posterior margin. Dorsum of abdomen short yellow pilose throughout. The posterior band of second segment is uniform in width, does not quite reach the lateral margin but turns up along the sides and reaches the anterior margin of the segment. The metallic part of the third segment is similar except that the posterior band is much wider in the middle and narrower on the sides. On the fourth it covers practically the whole of the segment and the black is limited on the posterior side to a narrow band encircling the spots. Fifth segment wholly shining metallic. Hypopygium feebly shining brownish or reddish. The spots of the abdomen are well separated, do not reach the lateral margin and are much smaller and more transverse than those of *Somula decora* Those of the second segment are oblong and slightly narrowed on the inner end, and not quite twice as long as wide. Those of the third segment are not pyriform but are oblong, nearly three times as long as wide, slightly concave on the anterior and convex on the posterior side. The spots of the fourth segment are similar but somewhat smaller and a little more concave. A small yellow oblique triangle has its base on the anterior margin, touching lateral margin of the second segment, and a much smaller but similar pair of spots on the third segment. Venter shining black with yellow posterior margins to the segments, those of the first and fourth being widest. Legs light brownish yellow and covered with thick yellow pile. Hind femora along the inside with a number of short black bristles like hairs.

Last three joints of all the tarsi blackened; with blackish pile. Wings dark brown before the fourth longitudinal vein, becoming yellow near the base, hyaline posteriorly.

Female: Very similar to the male. The posterior metallic band of the second segment is nearly wanting, the yellow triangles in the anterior corners of the second are smaller, those of the third segment obsolete. The hind femora lack the black bristle like hairs on the inside. The black facial stripe extends narrowly to the tip of the antennal process; in one male paratype this is also true.

Length, including the antennal process: 17 mm.

Curiously enough, the first specimen of this magnificent species, a male, was taken at Agricultural College, Mississippi, May 6, 1920, dead but in perfect condition, from a cobweb! On March 3, 1921, a fragmentary but unmistakably identical specimen was taken from a cobweb in the same locality. Subsequently three specimens, two males and one female, have been taken by Mr. R. H. Smith on flowers of *Cratægus*, on April 2, 1922, at the college.

This species will be at once distinguished from *S. decora* Macquart, by its unusually long antennal process, its black facial stripe and the shape and configuration of the abdominal spots besides minor differences.

Types in the collection of the author.

NOTES.

Among the papers being published as reports of the Barbados Antigua Expedition of the Iowa State University* there have appeared two on insects which will be of interest to Entomologists. The first is a paper by Professor Dayton Stoner, on the Scutelleroidea, pages 3 to 17, with three plates. Seventeen species are listed with careful notes on distribution and ecology, and while most of the species are common to the West Indian regions, these records give valuable data as to the local distribution. The report on the Orthoptera and Dermaptera, pages 19 to 44, by Mr. A. N. Caudell, includes detailed records for a number of interesting species, the distribution of which has been much extended, and also descriptions of four new species.

The report of the proceedings of the 4th Entomological Meeting at Pusa, February 7th to 12th, 1921, edited by Bainbridge Fletcher, Imperial Entomologist, like the preceding reports for 1918, 1919 and 1920, contains a wealth of material on the Entomological work in India. The papers on Pink Boll Worm, by E. Ballard, and the one on Winter Spraying against the Mango Hopper and also the article on the use of Bichloride of Mercury, in the Destruction of Mosquito Larvæ, by Mr. Sen, will be of particular interest to American Entomologists, the first on account of the present fight against the dispersal of the species in our cotton states—the latter two as related to control measures for leafhoppers and mosquitoes.

H. O.

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