5. First and fourth segments of antennæ incrassated
Microphyilia Stal
First and fourth segments of antennæ not incrassated.....6
6. Width of dilation of posterior tibiæ less than width across elytra.....*Stenoscelidea* Hope.
Width of dilation of posterior tibiæ greater than width across elytra..... 7
7. Length of basal joint of antennæ less than twice the length of head.....*Diactor* Perty.
Length of basal joint of antennæ at least twice the length of head.....*Anisoscelis* Latr.
8. Second segment of antennæ dilated, third also dilated.....9
Second segment of antennæ simple, third dilated, *Baldus* Stal
9. Second segment of antennæ dilated on both sides
Chrondrocera Lap.
Second segment of antennæ slightly dilated above, not below, 10
10. Posterior lateral angles of thorax produced, or sharply angled
Holymenia Stal
Posterior lateral angles of thorax not at all produced.....
Tarpeius Stal

A PHYLOGENETIC STUDY OF THE TERGA AND WING BASES IN EMBIIDS, PLECOPTERA, DERMAPTERA, AND COLEOPTERA.[1]

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In a previous paper, the Plecoptera, Embiids, Hemimerids, and Dermaptera, were grouped in a superorder called the *Panplecoptera*, and a further study would indicate that the Coleoptera might be included in this group also. There is some doubt as to the Strepsiptera, but certain features point to a rather close relationship between them and the Coleoptera (as is generally thought to be the case, although the investigations of Pierce, 1909, have thrown some doubt upon the current idea of their affinities) and it is quite possible that the Strepsiptera should likewise be included in the superorder mentioned above.

[1] Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.

The Plecoptera, with the Embiids, are very like the ancestors of the insects comprising this superorder, (the Panplecoptera) while the Dermaptera form an offshoot which approaches the Isoptera in many respects—but the strongest affinities of the Isoptera seem to be on the side of the forms comprising the superorder *Pandictyoptera* (composed of the Isoptera Zoraptera, Blattids and Mantids). The Coleoptera have branched off very near the Dermaptera, and have retained certain ancestral features occurring in the Embiids and Plecoptera, but their line of development has apparently paralleled that of the Dermaptera quite closely. Some representatives of the Coleoptera exhibit certain features suggestive of those found in the Blattids; and other Coleoptera have retained certain structures (particularly in the larval stages) suggestive of Neuropteron affinities. However, since both the *Panplecoptera* and the *Pandictyoptera* are descended from common ancestors (which were not unlike the fossil Palaeodictyoptera) it is not surprising that certain features inherited from their common ancestors, should be carried over into both groups; and similarly, since both the Panplecoptera and the insects grouped about the Neuroptera were descended from similar ancestors (the ancestors of the Neuroptera were probably very similar to the Plecoptera) it is not surprising that similar characters should reappear in both the Neuroptera and Coleoptera. At any rate, the closest affinities of the Coleoptera seem to be with the Dermaptera, rather than with the Neuroptera (or with the Blattids) so far as the adult characters are concerned.

The Embiids are extremely closely related to the Plecoptera, as is shown by the character of their thoracic sclerites, legs, etc.; and the fact that the cerci of the Embiids are reduced, does not militate against the argument for the close relationship between the two orders, since certain Plecoptera also have the cerci reduced to two segments.

In both Embiids and Plecoptera, the body is more elongate, and the tergal region of the wing-bearing thoracic segments shows a marked tendency toward becoming longer than broad, in contradistinction to the condition found in the Coleoptera and Dermaptera, in which the tergal region exhibits a tendency to become broader than long, as may be seen by comparing Figs. 1 and 3 with Figs. 2 and 4. In the Embiids and Plecoptera, there is a prescutal

region "psc" demarked in both segments (Figs. 1 and 3), and situated well in advance of the wing bases, while the prescutal region is not so clearly demarked in the Coleoptera and Dermaptera (Figs. 2 and 4), and, when present in the latter insects, it is situated on a line with, or back of, the wing bases (or rather the anterior margin of the wing bases).

In the Plecoptera and Embiids, there is a well developed mesothoracic postscutellum ("psl_2"), while the mesothoracic postscutellum is not developed in the Coleoptera and Dermaptera, nor does the metathoracic postscutellum ("psl_3") dip downward at such a marked angle in the Coleoptera and Dermaptera (Figs. 2 and 4) as in the Embiids and Plecoptera (Figs. 1 and 3). The tegula ("tg") is well developed in both segments in the Embiids and Plecoptera (Figs. 1 and 3) while it seems to be lacking in the Coleoptera and in the metathorax of the Dermaptera, although the mesothoracic sclerite labeled "tg" in Fig. 4 is interpreted as the tegula in the Dermaptera, by Pantel, 1917, in his excellent monograph of the thoracic region of these insects.

In the Coleoptera (Fig. 2) a myodiscus, or muscle disk "d," to which are attached certain muscles connected with flight, occurs in the metathorax, and might be mistaken for the tegula. It is homologous with a smaller disk labeled "d" in the metathorax of the Dermaptera (Fig. 4, "d") which corresponds to the small disk "d" near the tegula "tg" of the mesothorax of the same insect (Fig. 4); and a similar small disk "d" occurs near the tegula in both mesothorax and metathorax of Plecoptera (Fig. 1). Snodgrass, 1908, in his earlier work, which was incorporated in his more extensive studies of the thoracic sclerites and wing bases of insects (Snodgrass, 1909) refers to the sclerite in question as the "muscle disc" in Coleoptera, but does not seem to have found it in other insects. Pantel, 1917, interprets the sclerite "d" in the metathorax of the Dermaptera (Fig. 4) as an intersegmental plate.

The terms axillaries, alar ossicles, and pteralia, have been applied to the little plates by means of which the wings articulate with the tergal region, and in a paper dealing with the nature and origin of the wings of insects (Crampton, 1916) it was pointed out that the alar ossicle "np" (termed the notopterale) is probably a detached portion of the notum or tergal region of the segment. A further examination of these alar ossicles would tend to confirm this sup-

position, since in the Embiids (Fig. 3), the alar ossicle "np" evidently is a portion of the notum which is not yet completely detached, while in the Plecoptera (Fig. 1, "np") it likewise extends for some distance closely applied to the lateral margin of the notum. The only winged Embiid which I have for examination is the male of *Embia major* shown in Fig. 3, but it is very probable that other Embiids will exhibit a type of alar ossicle similar to the elongate "notopterale" "np" of the Plecoptera (Fig. 1), and even in the Embiid shown in Fig. 3, the alar ossicle "np" is much longer than the homologous sclerites "np" of Figs. 2 and 4.

In the metathorax of both Dermaptera and Coleoptera (Figs. 2 and 4) the sclerite "np" is very similar in outline, and in position, being situated much further forward than in the Embiids and Plecoptera (Figs. 1 and 3), and it is not so elongate as in the Embiids and Plecoptera, as was mentioned above. In the mesothorax of the Dermaptera (Fig. 4), this plate "np_2" has become broken up into two parts, the anterior one of which is bent abruptly downward. This has resulted in the incorrect homologizing of the parts of this plate in the mesothorax of the Dermaptera, by some investigators, but the two parts of the mesothoracic plate "np_2" of Fig. 4 are clearly homologous with the single metathoracic plate "np_3" of the same insect.

Snodgrass, 1908–1909, refers to the mesothoracic plate "tg" (Fig. 4) of the Dermaptera, as "a small rod in wing base," apparently not realizing its true nature; but Pantel, 1917, correctly refers to it as the tegula. While the tegula "tg" is well developed in both meso- and metathorax in the Embiids and Plecoptera (Figs. 1 and 3), I do not think that it is developed in the metathorax of the Coleoptera and Dermaptera, unless the region designated as "t" in the metathorax of the Dermapteron shown in Fig. 4 represents the tegula. Pantel, 1917, refers to the region "ptg" in the metathorax of the Dermapteron shown in Fig. 4, as the metathoracic tegula, but this region seems to correspond to the so called parategula of Hymenoptera and Diptera (shown in Fig. 4 "ptg" of the wing base of a Dipteron, by Crampton, 1914_b).

Pantel, 1917, considers the metathoracic sclerite "su_3" of the Dermaptera (Fig. 4) as one of the pteralia, or articulatory ossicles at the base of the wing. As far as I can judge, however, the region "su" of Figs. 1, 2, 3, and 4, is merely an antero-lateral marginal

region of the tergum called the suralare (Crampton, 1914–1916) and serves as one of the pivots for the wing in the movements of flight, although it may become detached from the remainder of the tergum in a few rare instances, as Pantel considers to be the case in the Dermaptera. The posterior wing process "a" of the mesothorax is very similar in both Coleoptera and Dermaptera (Figs. 2 and 4), being rather long and slender in these insects, while it is shorter and more blunt when it occurs in other members of the group (Fig. 1, "a"). The basanal pterale "sa" is proportionately much larger in the metathorax of the Coleoptera and Dermaptera (Figs. 2 and 4) than in the Plecoptera and Embiids (Figs. 1 and 3).

In both the Coleoptera and Dermaptera (Figs. 2 and 4) there is a pronounced tendency for the tergal region of the wing bearing segments to become broader than long, and, with the Strepsiptera, and certain Orthoptera, these insects comprise the few forms in which the metathorax surpasses the mesothorax in size. Unlike the Plecoptera and Embiids, there is a well marked tendency in the Coleoptera and Dermaptera (Figs. 2 and 4) for the mesonotum to take on a triangular outline, and for the scutellar region of the mesonotum to become pointed posteriorly and to overlap the anterior portion of the metanotum behind it. Correlated with this tendency for the scutellum of the mesonotum to overlap the metanotum in the Coleoptera and Dermaptera, there is a well marked tendency toward the reduction of the mesothoracic postscutellum, which is well developed in the Embiids and Plecoptera.

In the metathorax of Coleoptera and Dermaptera (Figs. 2 and 4) two alar ridges or "alacristae" labeled "ac" serve to hold the elytra in place when at rest, and in many Dermaptera, they are provided with bristles which doubtless aid in holding the elytra in position. In both Coleoptera and Dermaptera, the metathoracic scutum is traversed by a "transscutal suture" ("tr" of Figs. 2 and 4) which is apparently absent in most of the other members of this superorder; and it is at once apparent from the study of the tergal region and the wing bases, that the Coleoptera are very similar to the Dermaptera in regard to these features, while the Embiids are very similar to the Plecoptera in the character of their tergal regions and wing bases.

The presence of the posttergal fold "pt" of Fig. 4 is a "Pandictyopterous" character (well developed in Isoptera, Mantids, etc.)

which has been retained in the Dermaptera, but has become lost, or was never developed, in the Coleoptera. A suggestion of this fold is also retained in the Plecoptera, as is shown in the posterior tergal fold designated as "pt" in the metathoracic region of the Plecopteron depicted in Fig. 1. There is a tendency for this region to become reduced, or to unite with the surface which it overlaps, so that the narrow continuation of the surface of this fold toward the point designated as "x" in the metathorax of Fig. 4, may possibly be homologous with the similar narrow continuation of the region beside the postscutellum, toward the point labeled "x" in Fig. 2 (at the base of the sclerite "sa").

In the foregoing descriptions, I have laid especial emphasis upon the resemblance between the Coleoptera and Dermaptera, as illustrated by the preponderance in size of the metathorax over the mesothorax; the relative width, and the outlines of the nota; the triangular shape of the mesonotum, and its overlapping the metanotum, with the consequent reduction of the mesothoracic postscutellum; the development of ridges in the metanotum for holding the elytra in place; the formation of a transscutal suture; the retention of the myodisc rather than of the tegula in the metanotal region; the outline and extent of the pteralia, etc. Similarly, the marked resemblance between the Embiids and Plecoptera is shown in the relative size of the nota, the width and the outlines of the nota; the location of the prescutum in front of the anterior margin of the wing-base; the development of the mesothoracic postscutellum; the development of the tegulae in both segments; the elongate notopterale, etc. On the other hand, in emphasizing these similarities between the Coleoptera and Dermaptera, or between the Embiids and Plecoptera, one should not lose sight of the fact that the Coleoptera and Dermaptera are both related to the Embiids and Plecoptera, although the Dermaptera, being the more primitive of the two, are nearer to the Embiids and Plecoptera than the Coleoptera are.

The cerci of certain larval Coleoptera, such as *Galerita janus*, and of certain Dermaptera such as *Diplatys severa* (in which segmented cerci precede the forceps of the adult forms) are very similar, even when the individual segments are compared together, and the cerci of both groups resemble those of the Plecoptera extremely closely, so that the evidence of the cerci would point to

a "Plecopteroid" ancestry for the Coleoptera and Dermaptera. The segments of the leg are very similar in Embiids, Plecoptera and Dermaptera, and the relationship of the Dermaptera to the Plecoptera is likewise shown by a comparison of the thoracic sclerites (or of the head region) of a nymph of the Plecopteron *Perla* with those of the Dermapteron *Arixenia*, the resemblance being very striking, as has been shown in a paper dealing with the thoracic sclerites of immature Pterygotan insects, which will soon be published. The tendency toward the shortening and thickening of the fore wings is quite marked in certain Plecoptera, and the pleural thoracic sclerites of the Embiids are in many respects very like those of the Dermaptera. In this connection, I would call attention to the fact that in the Embiids (Fig. 3) the nature of the postscutellar region of the metathorax and the first abdominal segment, with the bulging lateral regions, is very suggestive of the condition found in the Strepsiptera; but, since Dr. Pierce is making a comparison of the thoracic region of the Strepsiptera with other insects, which he finds more similar to the Strepsiptera than the Embiids are, the affinities of the Strepsiptera can be more accurately determined when the results of his extended studies are published.

Although the study of the terga and wing bases points to a close relationship between the Dermaptera and Coleoptera, and between the Embiids and Plecoptera, the evidence afforded by these structures alone is insufficient to establish the affinities of the insects in question. On this account, a comparative study of the structures least subject to modification, and those situated in widely separated parts of the body, has been undertaken in order to demonstrate the relationships here proposed. Such an extensive treatment of the subject, however, requires more space and plates than can be afforded a single article; so that the summing up of the arguments for the relationships here proposed, can be more convincingly set forth after the evidence from the more extensive study of the parts has been presented in the proposed series of articles dealing with this subject.

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Abbreviations.

(The subscripts 2 and 3 denote mesothoracic and metathoracic structures respectively.)

a. . . Adanal process (adanale) sometimes a detached plate, but usually serving as a pivot for wing in movements of flight.
abd. First abdominal tergum.
ac . . Alacrista, or alar ridges for holding elytra in place when at rest.
d. . . Myodiscus, or muscle disc.
m . . An alar ossicle, the medipterale.
np. . An alar ossicle, the notopterale.
p. . . Chitinous area possibly homologous with the parategula.
pa. . Prealare, or prealar sclerite.
psc . Prescutum.
psl. . Postscutellum.
pt . . Postplica, or posterior fold of tergal region.
ptg . Parategula?
s . . . Spiracle.
sa . . An alar ossicle, the basanale.
ss . . Scutal suture.
su . . Suralar process (suralare) serving as a pivot for movements of flight.
t . . . Region homologous with tegula?
tg . . Tegula.
tr . . Transcutal suture.

EXPLANATION OF PLATE I.

In all figures only a portion of the terga (which are symmetrical) has been shown, since the missing portions are exactly like those figured.

Fig. 1. Terga and wing bases of a Plecopteron.
Fig. 2. Terga and wing bases of the Coleopteron *Photuris*.
Fig. 3. Terga and wing bases of *Embia major*.
Fig. 4. Terga and wing bases of the Dermapteron *Echinosoma*.

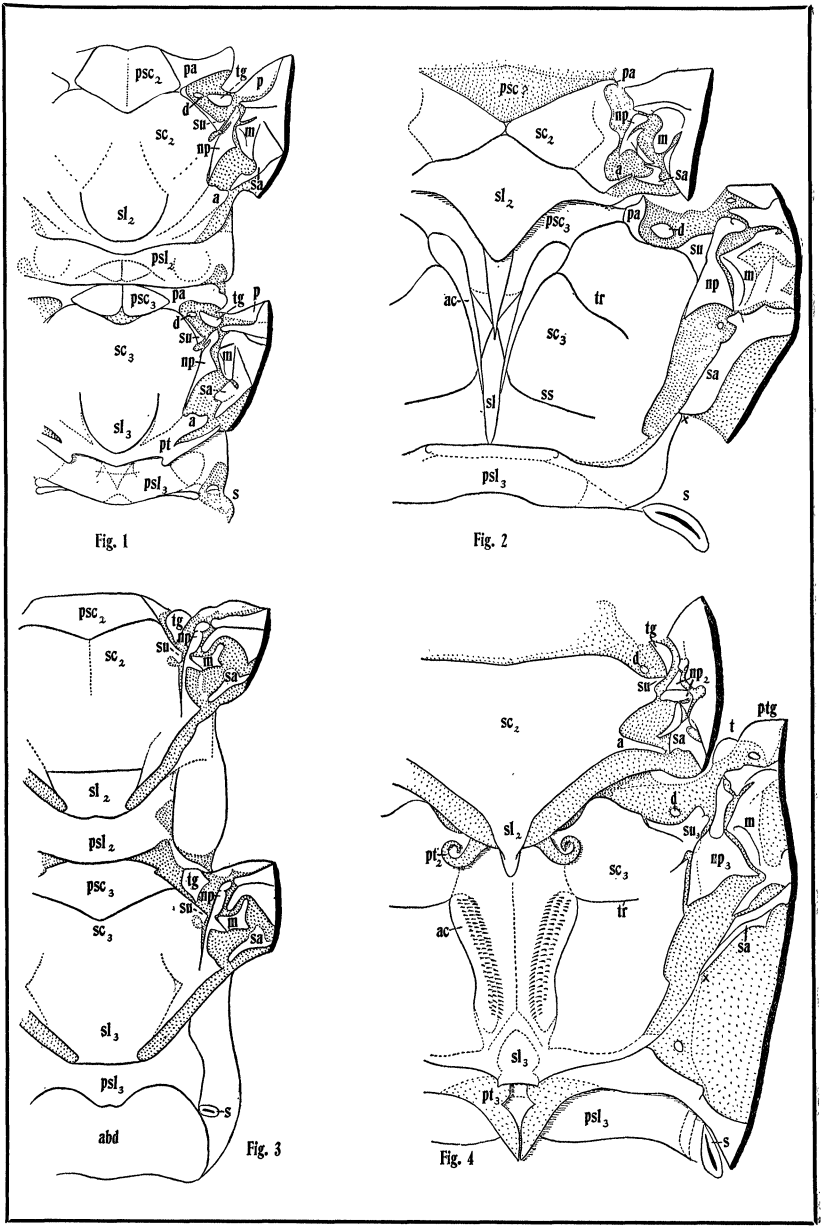
ON THE OCCURRENCE OF A MERMIS EPIDEMIC AMONGST GRASSHOPPERS.[1]

BY R. W. GLASER and A. M. WILCOX.

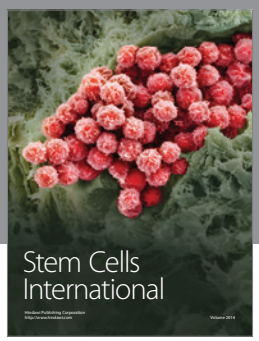
While engaged in some investigations on grasshoppers, near Dummerston Station, southern Vermont, this past summer (1917), our attention was attracted to a high mortality amongst these insects (*Melanoplus atlanis* and *M. bivittatus*). The two species, especially *M. atlanis*, are extremely bad pests in this region of the country, attacking corn, wheat, oats and clover to such an extent that during certain summers the farmers become nearly frantic. Therefore, the high mortality amongst the grasshoppers, which appeared during the latter part of August and the early part of September, was exceedingly gratifying.

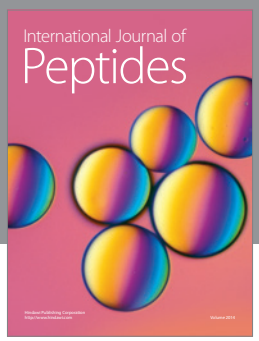
We soon discovered that this mortality was due to a species of Nematode belonging, as we supposed at the time, probably to the family Mermithidæ. Subsequently (Sept. 20, 25 and Oct. 6), we sent large shipments of these worms to Dr. N. A. Cobb, of Washington, D. C., for identification. Dr. Cobb was able to give us only a provisional identification on account of the utter absence of males in all of our shipments. We made collections of parasitized grasshoppers from a large variety of fields and as stated, sent a large number of specimens, but curiously enough no males were found. Dr. Cobb in a letter said: "Nothing I have learned would preclude your specimens from belonging to the same species as that referred to by Leidy under the name of *Mermis ferruginea*, which

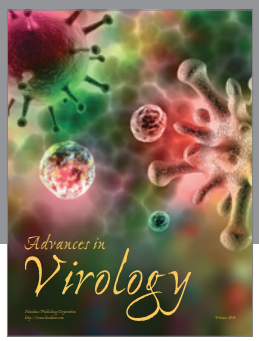
[1] Contribution from the Entomological Laboratory of the Bussey Institution in coöperation with the U. S. Bureau of Entomology. Bussey Institution, No. 146.

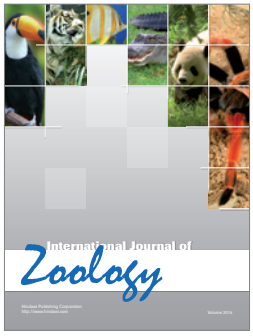


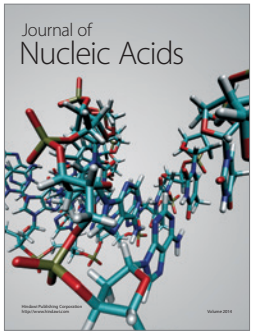
CRAMPTON—Terga and Wing Bases.

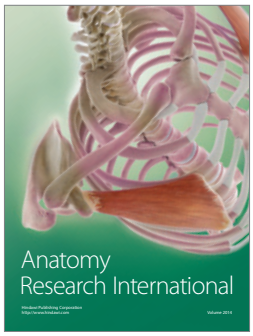


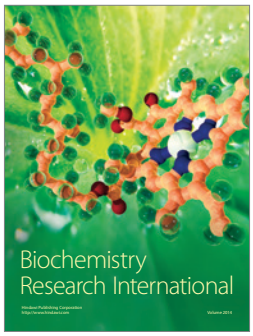


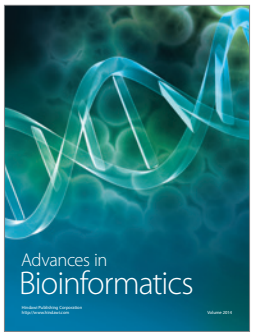


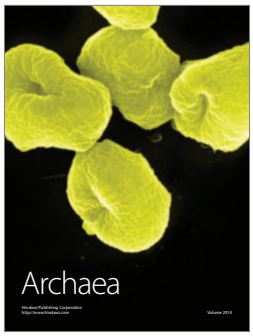


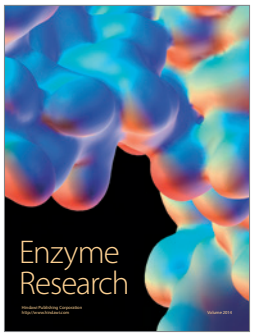


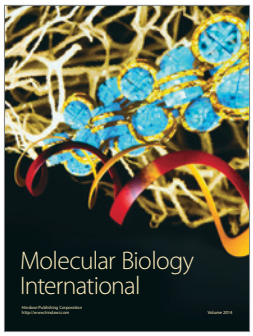












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