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XXXVIII.—*Liphistius* and its bearing upon the Classification of Spiders. By R. I. POCKOCK.

THE characters of the rare genus *Liphistius*, which is known only from a few specimens, one of which is preserved in the British Museum, have been more or less completely set forth in the writings of Schiödte, Cambridge, and Van Hasselt. From time to time, moreover, Dr. Thorell has given us his views on the affinities of the genus and the importance of its peculiarities, his final decision being that it should constitute a distinct tribe of the Tetrapneumones, equal in value to the Territelariæ, the latter group being the tribe to which he had previously referred it. This classification places *Liphistius* on a higher pedestal than it has occupied before; but, as a result of an examination of the Museum example, the conviction has forced itself upon me that even now the significance of its structural features has been immensely underrated and the homologies of some of its characters not properly understood. No excuse therefore need be sought for briefly recapitulating the most important points of its organization.

Fig. 1.



Fig. 2.



Fig. 1.—*Liphistius desultor*. Lower surface of abdomen, to show the eight spinning-mammillæ and the two sterni s.

Fig. 2.—*Filistata*, sp. Spinning-mammillæ, showing the form and position of the *cribellum*.

There are two pairs of spinning-mammillæ, an anterior and a posterior, situated near the middle of the lower surface of the abdomen, immediately behind the posterior pair of lung-sacs. The anterior mammillæ are considerably larger than the posterior, but otherwise scarcely differ from them in structure. Each may be described as consisting of two segments, the distal of which is itself composed of a series of annular sclerites. Between these principal mammillæ there are

two smaller auxiliary pairs, an anterior and a posterior, each corresponding to one of the larger mammillæ, and differing from it in consisting of a single, straight, subcylindrical segment, the principal mammillæ being broad at the base, pointed distally, and crescentically curved. Thus there are in all no less than eight mammillæ constituting the external spinning-apparatus, although the two internal pairs appear to be functionless so far as the emission of silk is concerned (fig. 1).

The upper surface of the abdomen is provided with nine * chitinous tergites, the anterior of which are large and overlapping, the posterior small and widely separated. The anterior two are represented on the ventral surface by two large sternal plates, the anterior of which covers the aperture of the generative organs and those of the front pair of pulmonary sacs, the posterior similarly covering the hinder pulmonary sacs.

The cephalothoracic sternum is extremely narrow, its width being about one third of its length; the carapace, on the other hand, is remarkably wide and flat and the coxæ of the ambulatory appendages, compensating for the narrowness of the sternum, are very long. In the British Museum example, moreover, the labium is very short and wide, much wider in fact than the sternum, its great width being due to the prolongation of its lateral borders beneath the coxæ of the second pair of appendages, so that these segments (the maxillæ) are *in front* of the labium, as in *Hypochilus*.

The basal segments of the mandibles are directed forwards, as in the *Territelariæ*, the plane of their articulation with the cephalothorax being vertical or nearly so with respect to the long axis of the body; but their inner surfaces are not flattened and contiguous to the same extent as in the *Territelariæ*, their distal extremities diverging so that there is a considerable interval between the bases of the fangs; these fangs consequently when closed lie obliquely inwards and backwards, and not directly backwards as in the *Territelariæ*.

In the presence of chitinous plates on the upper surface of the abdomen and of two sternal plates on the anterior extremity of its under surface, in the extreme narrowness of the sternum, but above all in the position and structure of its spinning-mammillæ, *Liphistius* differs from all known spiders; and no gradational forms are known which would lessen the

* *Teste* Schiödte. In the British Museum example the integument at the posterior end of the upper surface of the abdomen has been destroyed, so that of my own knowledge I cannot speak as to the exact number of these plates. Seven, however, are clearly visible.

value of these peculiarities. Therefore the structural interval between *Liphistius* and the Theraphosidæ, which have been looked upon as its nearest allies, is greater than the interval between the Theraphosidæ and the Epeiridæ, two families which, omitting *Liphistius*, lie at opposite poles of the order Araneæ. For striking and important as are the differences between *Theraphosa* and *Epeira*, so many intermediate genera are known that it is almost impossible to give any *one* character that will serve infallibly to distinguish the two sub-orders of Araneæ of which these two genera are types.

The isolated position that *Liphistius* occupies with respect to other spiders can perhaps be best expressed by setting it apart by itself in a group equal in value to a group containing all the others. For these I propose the names Mesothelæ and Opisthothelæ, the terms being derived from the position of the spinning-organs.

This removal of *Liphistius* from the vicinity of the Terretelariæ is further supported by the fact that it shows more than one hitherto, I believe, unnoticed point of resemblance to the Dipneumonous spiders. One of these points is the direction of closure of the mandibular fang; the other, which will require some elucidation, is to be found in the structure of the spinning-mammillæ.

In *Liphistius* it will be remembered there are four large and four small mammillæ, the smaller being placed in pairs between and a little in front of the larger. In the Dipneumones there are two large and one small pair of mammillæ, the small pair being placed between and a little in front of the mammillæ of the posterior large pair. There can be no doubt that the larger pairs of mammillæ are strictly homologous in the two types just considered. Moreover I can see no reasonable grounds for doubting that the intermediate pair of the Dipneumones is also homologous to the posterior auxiliary pair of *Liphistius*. This leaves the anterior auxiliary pair of the latter animal to be accounted for. Now in a few families of Dipneumones there is an additional spinning-organ situated in front of the anterior mammillæ and known as the *cribellum*. This usually has the form of a transversely elongated plate; but in *Filistata* it might be described as a large tubercle placed between the anterior mammillæ, the summit of which is divided by a longitudinal groove into a right and left half (fig. 2). This *cribellum*, I believe, is the homologue of the anterior auxiliary mammillæ of *Liphistius* joined together in the middle line. The double origin of the plate is shown by a groove that marks the surface upon which the spinning-tubules are situated. It

has been suggested* that the anterior auxiliary mammillæ of *Liphistius* correspond morphologically to an unpaired process called the *colulus*, which is found between the anterior mammillæ of many spiders, e. g. *Epeira*. If the *colulus* is not found in any spiders that possess the *cribellum*, it seems to me probable that Dr. Thorell's suggestion is correct. But if the *cribellum* and *colulus* coexist in any spider, it is clear that either my suggestion or Thorell's is erroneous.

If the homologies that I have suggested above are correct, some of the Dipneumones at least possess representatives of all the eight mammillæ of *Liphistius*; but this is not the case with any of the Territelariæ. In this group the spinners are nearly always arranged in two pairs—an anterior, consisting of two short one-jointed segments, and a posterior, consisting of two long three-jointed segments. How these mammillæ are to be correctly compared with those of *Liphistius* or of the Dipneumones is to me by no means clear. The posterior pair may be homologous to either of the principal pairs of *Liphistius* and the anterior pair to either of the auxiliary pairs of this animal; or the two pairs may correspond to the two principal pairs of *Liphistius*. But in either case the disappearance of two pairs has to be accounted for. Some of the Territelariæ, however, such as *Pelecodon* and *Hexathele*, have six mammillæ, the additional ones being short and placed in a transverse line with the ordinary anterior pair. But the anterior series is not alike in the two genera, the two internal mammillæ being considerably larger than the two external in *Pelecodon*, the converse obtaining in *Hexathele*. This renders a comparison between them a matter of some difficulty. I venture, however, to make the following suggestions on the point. In *Pelecodon* the large internal pair is homologous to the anterior pair of the Dipneumones and of the anterior principal pair in *Liphistius*, the smaller external pair being the homologues of the intermediate pair of the Dipneumones and of the posterior auxiliary pair of *Liphistius*. If this be so, the last-named mammillæ have shifted their position so as to lie completely in front of the posterior mammillæ. As regards *Hexathele*, it seems reasonable to suppose that the mammillæ that are present are the same as those that are developed in *Pelecodon*. They may, too, correspond exactly in position although differing in size. An alternative hypothesis, however, is that the large pair of this anterior series in *Hexathele* corresponds to the large ones in *Pelecodon*. In this case the small intermediate pair in

* Vide Thorell, Ann. Mus. Genov. xxviii. p. 29 (1889-90).

Hexathele have moved forwards internally and not externally. This question, however, presents many difficulties in the way of its solution, and requires far more attention than I have so far been able to bestow upon it. Enough, however, has, I think, been said to show that, so far as the spinning-organs are concerned, *Liphistius* seems to approach the *Dipneumones* more nearly than the *Territelariæ*.

If this view as to the correspondence between the *cribellum* and the anterior auxiliary mammillæ of *Liphistius* is correct, it has I think an important bearing on the classification of spiders.

In 1886 Dr. Thorell * gave a concise sketch of the views of his predecessors and contemporaries on the subject of the classification of the *Aranæ*. The object of this paper was the refutation of the system proposed by that eminent entomologist Dr. Bertkau; and at the end of his criticisms Dr. Thorell put forward a classification of his own, introducing sundry changes into that which he had previously used, in accordance with the greater value that was attached by Bertkau to certain structural features that Thorell had previously looked upon as of secondary importance.

In this new system the old divisions of spiders into *Tetrapneumones* and *Dipneumones* is adopted. For subdivisions of the *Dipneumones* the old tribal names *Tubitelariæ*, *Orbitelariæ*, *Citigradæ*, &c. are retained, the two former being subdivided into *Cribellatæ* and *Ecribellatæ*, according as the *cribellum* (and *calamistrum*) are present or not. The *Tetrapneumones* contain the single tribe *Territelariæ*, embracing the families *Liphistiidæ*, *Theraphosidæ*, and *Atypidæ*.

In its main characters this classification has been adopted by Dr. Marx †, in his 'Catalogue of North-American Spiders.' One modification, however, is the introduction into the *Tetrapneumones* of the remarkable genus *Hypochilus*, for which a new tribe, *Umbellitelariæ*, is established. Moreover, Dr. Marx appears not to attach so much importance as Dr. Thorell to the presence of the *cribellum* and *calamistrum*. Furthermore he adopts Dahl's tribe *Plagitelariæ* for the *Pholcidæ*, and creates a new tribe, *Filitelariæ*, for the *Dysderidæ*, *Filistatidæ*, and *Scytodidæ*.

In 1891 Dr. Thorell ‡ favoured us with fresh views on the subject. He forms a new tribe of *Tetrapneumones*, named *Verticulatæ*, for *Liphistius*, and retains *Hypochilus*

* Ann. & Mag. Nat. Hist. (5) xvii. pp. 301-326.

† Proc. U. S. Nat. Mus. xii. p. 498 (1889).

‡ Kongl. Sv. Vet.-Akad. Handl. xxiv. no. 2, pp. 8, 9.

where it was placed by Marx. In the Dipneumones he establishes a second new tribe, Pseudoterritelariæ, for the Dysderidæ, and a third, Cavitelariæ, for *Filistata* alone.

In 1890, however, Mons. Simon*, who has probably examined more spiders from all parts of the world than any man living, proposed a classification which differs materially from that of Thorell. In the first place he divides the order into two suborders, Araneæ Theraphosæ and Araneæ veræ, the former to comprise the Liphistiidæ and Aviculariidæ, the latter the Dipneumones + *Hypo-chilus*. The abandonment of the old names Tetrapneumones and Dipneumones is enforced by the removal of *Hypo-chilus*, which has four lung-sacs, from the vicinity of the Aviculariidæ to that of the tracheate spiders.

This author further subdivides his Araneæ veræ into Cribellatæ and Ecribellatæ, for those with and those without the *cribellum*, and does not follow Dr. Thorell in the adoption of the tribal groups Orbitelariæ, Tubitelariæ, &c.

The classification that I venture here to put forward is new so far as the position of *Liphistius* is concerned, and for the rest is a combination of the systems that have briefly been discussed.

As stated above, it seems to me that the value of the characters of *Liphistius* have been immensely underrated. I consequently propose to divide the Araneæ into Mesothelæ and Opisthothelæ, the first for *Liphistius*, the second for the rest. As regards the subdivision of the Opisthothelæ, I am entirely in accord with Mons. Simon and Dr. Bertkau that *Hypo-chilus* should not be associated with the Theraphosidæ, being more nearly related to the Dipneumones, in spite of its four lung-sacs. This view stands in the way of the adoption of the terms Tetrapneumones and Dipneumones; but since the double terminology of Mons. Simon seems to me somewhat cumbersome, I venture to propose as substitutes the names Mygalomorphæ and Arachnomorphæ †. The former suborder will contain at least two families, Atypidæ and Theraphosidæ or Aviculariidæ. The latter will correspond exactly

* Ann. Soc. Ent. Fr. 1890, pp. 79-82.

† I use the name Mygalomorphæ because the spiders of this group are still spoken of collectively by the uninitiated as *Mygale*; and this name has been introduced into nearly all text-books of zoology and into very many popular and semipopular works on natural history to designate the large hairy Territelariæ, which are so familiar to every one. Similarly the name Arachnomorphæ seems applicable to a group of spiders which embraces all the common house and field species, these being doubtless the kinds that the Greeks spoke of comprehensively as ἀράχνης or ἀράχνη.

to Thorell's Dipneumones + *Hypochilus*, and it may accordingly be divided into Umbellitelariæ, Cavitelariæ, Pseudoterritelariæ, Tubitelariæ, &c. I am inclined, however, at present to follow Dr. Marx in considering that the peculiarities of the Pholcidæ are sufficient to justify Dahl in the establishment of a special tribe, Plagitelariæ, for the reception of this family. Furthermore I do not consider that the presence of the *cribellum* and *calamistrum* is necessarily an indication of affinity between two or more families, even when they belong to the same tribe. I even doubt if the presence of these organs is sufficiently important to form a basis upon which to establish families, and therefore *à fortiori* I cannot agree with Mons. Simon in dividing the Arachnomorphæ into Cribellatæ and Ecribellatæ.

This view as to the value of the *cribellum*, however, requires some justification in the face of the great importance that is attached to it by such eminent arachnologists as Mons. Simon and Dr. Bertkau.

It must be admitted on all hands that the value of this character depends upon our knowledge of its origin. The *cribellum* and *calamistrum* are found in certain families which differ widely in other respects in structure and habits. Its presence in these families may be accounted for, firstly, on the hypothesis that they represent a natural group which has evolved itself in a line parallel to the ecribellate spiders, the two groups independently acquiring a similarity in form and instincts; secondly, on the hypothesis that the *cribellum* has been independently developed in many of the families that possess it; thirdly, on the hypothesis that the ancestor of existing spiders was cribellate, and that only a few of the families in the course of their evolution have retained the organs in question.

The second of these possible explanations seems extremely improbable, and is adopted by no one, so far as I am aware. The classifications, however, of Bertkau and Simon imply a belief in the first. Thorell, on the contrary, accepts the last, although he has not produced a large stock of evidence to support it. Nevertheless that he is right in his opinion I do not doubt, although at the same time I fear that our views are diametrically opposed on the subject of the ancestry of spiders. He does not believe in the descent of these animals from forms allied to the Pedipalpi, and he considers that the resemblances between *Liphistius* and *Phrynus* are merely analogous. I, on the contrary, think that there is a mass of evidence, based upon anatomical and embryological grounds, pointing to the conclusion that the Araneæ are the descen-

dants of the Pedipalpi and the latter of the Scorpions; or, to put it differently, that of existing Arachnida the Pedipalpi come nearest to the immediate ancestors of spiders and the Scorpions nearest the ancestors of the Pedipalpi. I hope in a subsequent paper to work out the classification of Arachnida from this standpoint. At present it will be sufficient to state that the primitive nature of the structure of Scorpions is shown by the metamerism of the body, the serial repetition of similar somites being carried to a greater extreme than in any other order of Arachnida.

This then being my belief as to the ancestry of the Araneæ, I see no escape from the conclusion that *Liphistius* is a transitional form—a missing link—between the Opisthothelæ and the Phrynidæ. Certain it is that *Liphistius* possesses at least two important permanent characters which are only found in the embryos of other spiders. These characters are the segmentation of the abdomen and the anterior position of the external spinning-organs. As is well known, these organs are the third and fourth pairs of abdominal appendages, which are primitively situated in a line with the first and second pairs on the lower surface of the anterior half of the abdomen. The migration of these appendages to the posterior end of the body, which takes place in all spiders except *Liphistius*, is a secondary modification which is no doubt beneficial as conferring a greater freedom and range of movement upon organs requiring considerable manipulation.

Liphistius, then, retains certain embryonic characters that all other spiders lose; we may conclude therefore that the latter are "higher" than the former. Of the other spiders, those that on the whole come nearest to *Liphistius* are the Mygalomorphæ. These therefore are "lower" than the Arachnomorphæ; and the lowest of the Arachnomorphæ are *Hypochilus*, *Dysdera*, and *Filistata*.

Since, then, some reasons have been shown for thinking that *Liphistius* is of living spiders the nearest to the ancestral form, and, secondly, that this spider possesses the homologue of the *cribellum*, we can without difficulty explain the existence of this organ in widely different genera, and its presence at once loses the systematic importance that Dr. Bertkau and Mons. Simon have claimed for it.

The same argument will apply to the presence of two or three claws on the feet of the Opisthothelæ; for since *Liphistius* possesses three well-developed claws, the third claw may have been retained or lost indiscriminately, so to speak, in different genera. So that Bertkau's subdivisions of *Écri-*

bellata into Artionycha and Perissonycha and Ausserer's subdivisions of Theraphosidæ into Dionycha and Trionycha may not represent natural groups.

The principal divisions of the Araneæ that I here propose may be diagnosed as follows:—

- a.* The spinning-appendages retain their embryonic position in the middle of the lower surface of the abdomen; there are eight spinning-mammillæ. The upper surface of the abdomen is furnished with nine distinct tergites and the lower with two distinct sternites. The cephalothoracic sternum is extremely narrow as compared with the width of the carapace **Mesothelæ.**
Fam. *Liphistiidæ.*
- b.* The spinning-appendages migrate to the posterior end of the abdomen; there are never more than six distinct mammillæ. The abdomen is never provided with distinct tergal plates, and the abdominal sternites persist only as the pulmonary opercula and ? the epigyne. The cephalothoracic sternum is much wider as compared with the carapace **Opisthothelæ.**
- a'.* The plane of the joint of the mandible with the cephalothorax is nearly vertical, the fang closing almost directly backwards. Four lung-sacs, the posterior widely separated, close behind the anterior, and with distinct opercula. Usually only four, rarely six spinning-mammillæ **MYGALOMORPHÆ.**
Fam. *Aviculariidæ, Atypidæ.*
- b'.* The plane of the joint of the mandible with the cephalothorax nearly horizontal, the fang closing obliquely inwards and backwards. The posterior lung-sacs almost always replaced by tracheal tubes; when retained, as in *Hypochilus*, they are situated in the middle of the abdomen and covered with a continuous fold of the integument. With six spinning-mammillæ; not uncommonly the fourth pair found in *Liphistius* is retained as the *cribellum* **ARACHNOMORPHÆ.**
Fam. *Hypochilidæ, Dysderidæ, Filistatidæ, Drassidæ, &c.*