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### LII.—On the development of the pedipalpi

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examination in life would show some silvery lines and longitudinal brownish stripes. Mr. Cunningham adds that the resemblance of this spider to a caterpillar is very remarkable; and no doubt in life the caudal prolongation is mobile.

The genus *Ariamnes* has a very wide range; but I have not before seen an example of it nearer the East Indies than Ceylon.

## EXPLANATION OF PLATE XXII.

Fig. 1. *Ariamnes similans*, ♀, enlarged.

Fig. 2. Ditto, in profile, less enlarged.

Fig. 3. Fore part of the caput, showing the position of the eyes.

Fig. 4. Genital aperture.

LII.—*On the Development of the Pedipalpi.* By Dr. A. STRUBELL, of the Zoological Institute of Bonn am Rhein\*.

IN view of our scanty knowledge of the natural history of the Pedipalpi, I made it one of my principal tasks during a lengthy sojourn in the Malay Archipelago to follow out in greater detail the development and life-history of a representative of this group of Arachnida, which offers so many points of interest. As the subject of my investigations I selected *Thelyphonus caudatus*, which, while widely distributed in these islands, is particularly common in Java, where I spent several months.

Guided by the erroneous statements of the text-books, according to which the Pedipalpi are viviparous, I commenced by sacrificing a considerable number of specimens without ever discovering embryos in their genital ducts, until towards the end of October I received a female, to the ventral surface of which there was attached a fairly capacious egg-sac.

I am indebted to my little Malay friends for the gradual acquisition of a larger number of eggs, representing a developmental series, which is not absolutely continuous, it is true, but nevertheless embraces the most important stages.

As regards all details of my results I must refer the reader to a fuller account which I hope shortly to be able to lay before those who are interested in the study of the group; I now merely desire to give a brief outline of the development of the external bodily form.

\* Translated from the 'Zoologischer Anzeiger,' xv. Jahrg. (1892), nos. 385 and 386, pp. 87-93.

At the period of oviposition the female *Thelyphonus* buries itself fairly deep, often as much as a foot and more, in the earth, and there lays its eggs. Simultaneously with these there issues from the genital aperture a secretion which speedily hardens in the air and surrounds the eggs in the form of a thin-walled transparent sac. This is attached to the ventral surface of the animal, and contains a variable number (fifteen to thirty) of ova.

The ovum, which is oval in shape and rich in yolk, is of the considerable size of nearly 3 millim., and is surrounded by a chorion of a yellowish colour, to which a delicate vitelline membrane is closely attached.

After the formation of the blastoderm there appears near one pole of one side of the ovum, which is somewhat flattened, a roundish white spot, from which, in consequence of a local multiplication of the blastoderm cells, an area which likewise appears white, but is as yet indistinctly defined, soon extends towards the other pole. Upon this disk-shaped region there now appear, as the earliest traces of the future embryo, a series of transverse furrows, which are at first shallow and which apparently arise almost simultaneously and divide the embryonic rudiment into a number of segments. In the first instance seven such divisions are distinguishable. After the first and largest section—the cephalic plate, which, however, is not yet sharply circumscribed,—the second is constituted by the segment which furnishes the pedipalpi, and this is succeeded posteriorly by four other segments, from which the ambulatory limbs subsequently proceed. Finally the seventh and last section, which, in contradistinction to the other fillet-shaped sections, is semicircular in shape, with its periphery directed forwards, may in consequence of its function be termed the abdominal plate. All these segments are primarily unpaired structures. While, however, they become further and further separated from one another, there soon appears in the median line a shallow and narrow longitudinal groove, which divides the whole of the segments, with the exception of the abdominal plate, into two symmetrical halves. This median furrow proceeds from the posterior towards the anterior end of the embryo. The last four thoracic segments are the first to divide, and these are subsequently followed by the segment which gives rise to the pedipalpi, and thereupon also by the eighth division, the segment of the chelicerae, which has in the meantime become separated off from the cephalic plate, which likewise divides into two apical lobes. While this process is taking place the unpaired abdominal plate increases in breadth; at its

lateral margins there appear distinct depressions, which, becoming deeper, give rise to the first pair of the abdominal segments. This is succeeded by the second pair, which are produced by further constriction. Owing to the fact that the abdominal segments become intercalated between the abdominal plate and the last thoracic segment, and that, in consequence of the lateral expansion of the median groove, the posterior thoracic segments separate more and more from one another, the primitive streak gradually loses its disk-like form, and, while it now becomes more sharply marked off from its environment, assumes the shape of a pear. At this period the earliest rudiments of the appendages become visible upon the several thoracic segments. The latter have in the meantime increased in extent and have become fused together at their margins. The appendages appear near the middle of the segments as small knob-shaped prominences, and the pedipalpi as well as the ambulatory limbs precede the chelicerae in development. Meanwhile the abdominal segments have further increased by the process of splitting off from the abdominal plate, and hand in hand with this the median groove, which may now be more appropriately termed the median area, has also expanded still more in its posterior section.

It naturally follows that with this process the primitive streak once more becomes changed in appearance. We may now compare its form with an isosceles triangle, the apex of which is occupied by the cephalic plate, while the two widely divergent halves of the primitive streak form the sides, and the base is represented by the abdominal segments, which adjoin one another almost in a horizontal plane.

Simultaneously with the appearance of the appendages the rudiments of the nervous system arise as two rather broad bands, which run on the inside of the thoracic segments as far as the abdomen, and soon divide into a series of six pairs of ganglia, in correspondence with the number of the segments. These two bands come into contact with one another at the cephalic plate, where the mouth has already become visible as a small pit between the apical lobes.

No material change in the relative position of the primitive streak and yolk has taken place during this period. In consequence of the longitudinal growth of the embryonic rudiment the cephalic plate has indeed curved over slightly towards the dorsal side; but so striking a flexure as has been frequently observed in the true spiders is never found in *Thelyphonus*. The ventral surface of the ovum, upon which the primitive streak lies in its entire extent, still exhibits a

pronounced convexity, which does not become incavated until later.

The changes which now take place and are externally visible are primarily exhibited in the further development of the segments of the body which have already been mentioned. In the first place the abdomen again increases considerably in size. While more segments are continually separated off from the median unpaired abdominal plate, the latter with its adjoining abdominal divisions moves out from its previous horizontal position, and gradually projects forwards at an acute angle.

The formation of the twelfth pair of abdominal segments completes the series; the abdominal plate then lies as a terminal piece at the tip of the abdomen, and from it the caudal filament is subsequently developed. It is especially worthy of remark that provisional appendages, such as those with which we are acquainted in the case of the scorpions and the true spiders, are not to be found at any period upon the abdominal segments of *Thelyphonus*. On the other hand, small thickenings appear at an early period on the inner margin of the several segments, and, gradually becoming more sharply defined, represent the ganglia of the abdominal portion of the ventral chain.

If we now take a lateral view of the ovum, we observe that the upper portion of the ventral surface has become flatter, while the posterior division projects somewhat towards the protruding abdomen. The development of the embryo now makes rapid progress. Two semicircular pits appear at the hinder margins of the apical lobes. The labrum becomes visible above the mouth, while the labium arises as a narrow protuberance at its lower border. In proportion as the brain continues to develop the further forward does the mouth advance, until it finally comes to lie between the chelicerae, which are situated close to one another. The limbs, too, have in the meantime increased in length and their segmentation is already visible, although not yet distinct.

Simultaneously with this a peculiar hemispherical structure comes into view between the first and second ambulatory limb. It first appears as a small lateral prominence at the base of the second limb, which is still knob-shaped; but it soon becomes constricted off, and then assumes the above-mentioned position. (I am unable to make a definite statement as to the significance of this organ. The fact that at a spot on the inner side of the chorion corresponding with this body a brownish substance is excreted, which projects like a tooth between the two limbs, seems to betoken a secretory

function. This structure is likewise found in *Phrynus*, only in this case it does not change its original position, but remains at the base of the second limb.

When the extremities have already attained a considerable length, and before all the other organs which have just been mentioned have arrived at the stage of development which has been described, there begins to be noticeable upon the ventral surface a slight groove, which gradually becomes deeper and finally leads to a separation between the cephalothorax and the abdomen. The former at last bends so far towards the abdomen that the extremities lie close to the sides of the latter. At this period there also takes place the closure of the dorsum. Shortly after the formation of the rudiments of the appendages there are already to be observed on the outer side of the two halves of the primitive streak small quadrate areas which adjoin one another, and in the course of the development grow out laterally, to subsequently unite in the median line of the dorsum with the formation of the heart. This closure takes place very rapidly, though we are able to observe that it proceeds from in front towards the rear. It is only at this stage, when the dorsal sides have grown together, that the final development of the ventral surface likewise takes place. Hitherto the six pairs of thoracic ganglia lay, in accordance with their origin, at the sides of the widely divergent halves of the primitive streak, separated from one another in the shape of a bifurcate fork, open posteriorly; and in the same way until now the two abdominal ganglionic cords had preserved their position unchanged at the boundary between the dorsal and ventral surfaces. These also now travel towards the median ventral line of the abdomen, and there unite to form a continuous chain.

With this the development of the embryo is essentially complete. It only remains to be mentioned that some time previously a delicate cuticular envelope was formed, which clothes all parts of the body; upon this envelope we observe at the base of each of the ambulatory limbs, as well as of the pedipalpi and chelicerae, a pointed thorn of chitin, which is destined to facilitate the process of hatching. With the help of these egg-teeth the embryo now breaks through the shell, stripping off its first cuticular coat in so doing, and attaches itself firmly to the dorsal or ventral surface of the mother, by which it is still carried about for some time longer.

The just-hatched young at first exhibits only very slow awkward movements, and is so remarkably different from the

adult *Thelyphonus* in appearance that it may well be termed a larva with some degree of justice.

In colour it is yellowish white. The abdomen, which is cylindrical in shape in consequence of the still abundant yolk which is stored up within it, materially exceeds the cephalothorax in volume. Upon the cephalothorax are situated three pairs of pale red, tube-like, ambulatory limbs, which exhibit no distinct segmentation, and at their tips instead of the claws bear adhesive disks of considerable size. The pedipalpi, like the unsegmented caudal filament, are still relatively short; their terminal joint, which in the adult is developed into a powerful chela, is still unpaired. The eyes still lie beneath the larval skin, while the lung-sacs do not yet communicate with the exterior.

Particularly striking, however, is the primitive condition of the ventral nerve-chain, which is distinctly perceptible beneath the thin chitinous covering; for while the adult animal exhibits only a single large ganglion in the cephalothorax, from which, besides a few lateral branches, a simple central main cord runs through the abdomen, to expand posteriorly into a small ganglion, the larva still possesses a completely segmented ventral chain. The six pairs of ganglia of the cephalothorax are still sharply distinguishable from one another; the abdominal section consists of ten pairs of ganglia, of which the first six pairs are connected with one another by transverse and longitudinal commissures, while the four terminal ones, which are more closely united together, constitute a common but still segmented mass.

It is only during this larval period that the development of the organs is completed in the form in which we find them in the adult *Thelyphonus*. While this is taking place the larva remains constantly upon the body of the mother, and in the meantime consumes the yolk-material which it has brought with it. After some time a second ecdysis takes place, whereupon the creature, now equipped with all the attributes of the parent, leaves its mother, henceforth to seek its food independently in the same pugnacious manner.

It will be seen from what has been stated above that the mode of development of *Thelyphonus* exhibits a greater agreement with that of the true spiders than with that of the scorpions. The pronounced divergence of the two halves of the primitive streak and the other phenomena connected with this are characters which have to be taken into consideration in this connexion equally with the entire absence of embryonic membranes.

In the detailed paper it will be my task to enter more fully



into the question of affinities, and with the help of figures to give a more exact account of the development of the bodily form, of which the above is only a cursory sketch, as well as of the organogeny.

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LIII.—*Limax maximus*, L., and its Variety *cinereo-niger*, Wolf. By WALTER E. COLLINGE, Demonstrator of Biology in Mason College, Birmingham.

As there seems to be a general misunderstanding as to what the *L. cinereo-niger* of Wolf really is, notwithstanding a number of important papers that have been written upon its anatomy &c., and having had the opportunity of examining a series of British examples, I desire to make a few remarks upon the same, from which it will be evident that this slug is simply one of the many colour-variations of the well-known *L. maximus*, L. It is the more important that this should be done as Mr. Roebuck \* has stated that "it [*L. cinereo-niger*] is now separated by the best continental authorities" and "that there are also important differences between the two species in the genital apparatus." It is upon this statement that its right to rank as a species is based in this country. Now it is to be greatly regretted that Mr. Roebuck has never thought it worth while to point out these *important differences* in the genital apparatus, for Simroth †, who has described the anatomy, fails to see any difference in it from *L. maximus*. Dr. Scharff ‡, who has still more recently examined the anatomy, says, "I found no difference anatomically between it and a typical *L. maximus*, except in the origin of the retractor muscle of the penis" §.

In face of these statements, to which I have quite recently drawn Mr. Roebuck's attention, he still || classes it as a species, adding a note to the effect "that it is at least entitled to subspecific rank," its external characters being "so distinct and unmistakable," not a word being said as to the previous-named *important* differences in the reproductive organs.

\* Journ. Conch. vol. iv. p. 38 (1883-85).

† Zeitschr. f. wiss. Zool. vol. xlii. (1885).

‡ Trans. Royal Dublin Soc. vol. iv. ser. 2, p. 518 (1891).

§ Variations in the point of the origin of the retractor muscles are one of the commonest, and are met with in typical examples of all species of slugs.

|| Journ. Conch. vol. vii. (1892).