PAPILIO.

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ON THE CATERPILLARS OF NORTH AMERICAN PAPILIONIDÆ AND NYMPHALIDÆ.

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Prof. Weismann, in his "Studies on the Theory of Descent," in the hapter on the origin of the markings of butterfly-larvæ, indicates how valuable would be the extension of his researches to other groups of Lepidoptera. He says: "An elaboration of the *Papilionidæ* would appear to me of especial value, not merely of the few European species, but, above all, of the American and Indian. At this time we know almost nothing of the early stages of their caterpillars." I have it from Prof. Weismann, himself, that he had for some time entertained the purpose to pursue this line of study, and had sought to possess himself of the requisite material. At his request the distinguished student of the North American butterflies, Mr. W. H. Edwards, of Coalburgh, sent to him from time to time several almost complete series of the preparatory stages of various species of *Papilionidæ* preserved in alcohol. In addition to these Mr. Edwards presented him with a still larger number of the caterpillars of other butterflies, also in complete series.

As Prof. Weismann was detained by other studies from the elaboration of the collections sent by Mr. Edwards, he handed over to me this valuable, but, as it proves, difficult material. I have now analyzed and figured the greater part of these caterpillars in reference to the finer details of their external structure, and have thus arrived at the results which I now propose to present in this paper. The observations are, it must be admitted, quite imperfect, and if, nevertheless, I proceed to publish them, it is with the conviction that not for a long time, if ever,

shall I succeed in filling the void. Meanwhile I cherish the hope that in presenting these observations, however imperfect they may be, I offer a not entirely valueless contribution to our knowledge of the Ontogeny and Phylogeny of caterpillars.

My researches have been guided by the ideas which Weismann has presented in the above-named treatise, except that my object has been less to represent the coloring and markings of the caterpillars, which, indeed, are not always distinctly seen in alcoholic specimens. I have given more prominence to the appendages of the skin, that is to say, the form and distribution of the bristles, and the size and position of the warts, which serve as a base for the bristles. However insignificant these for the most part microscopic objects may be, it will be seen that many interesting inferences may be drawn from their changes in the course of Ontogeny.

I proceed to give, first of all, a description of the caterpillars as named, in order that I may, in conclusion, arrive with greater certainty at the general results.

DESCRIPTION OF THE CATERPILLARS.

PAPILIONIDÆ.

I have before me nearly complete series of five species, viz.: *Papilio Asterias*, *P. Turnus*, *P. Troilus*, *P. Ajax*, and *P. Philenor*, all from North America, while of our own *P. Machaon*, I have received only the first and second stages. Of *P. Brevicauda*, Mr. Edwards' work (Butterflies of N. America) gives figures of all the preparatory stages, which have been of use to illustrate certain points.

Papilio Asterias. First Stage (fig. 1). The general color of the caterpillar at this stage is deep black, interrupted only by a white spot, which lies like a saddle across the back of the third and fourth abdominal segments. The caterpillar is thickly beset with hairs or bristles which, for the most part, do not spring directly from the skin but from warts or knobs. These are chiefly arranged in four rows, namely, a sub-dorsal and a supra-stigmal row on each side. In addition to these, smaller infra-stigmal warts may be seen, and also similar ones near the dorsal line, which bear only a single bristle. On the head and on the last abdominal segment, as well as near the ventral space of every segment bristles are also distributed in moderate numbers.

Looking at the two principal rows of warts, namely the sub-dorsal and the supra-stigmal, it will be seen that the largest warts are on the thoracic and the last abdominal rings; indeed, the most prominent are on the first thoracic and the last abdominal, and from these to the middle the warts gradually become smaller.

The bristles standing on these warts are rather stout in proportion to their length (therefore not like hairs) and show at the extremity a highly characteristic shovel-formed enlargement (fig. 1*a* and 1*b*).

Second Stage (fig. 2). This stage scarcely differs from the first; the color is still black with the white saddle on the third and fourth abdominal rings. The bristles are fewer, especially on the head and the last abdominal segment. The bristles on the warts are shorter in proportion to the warts than in the first stage and are no longer shovel-formed at the extremity, but are uniformly broad and merely rounded at the point (fig. 2*a*).

Third Stage (fig. 3). After the second moult we still find no essential differences, but the dark color is now more replaced by bright spots, and the white saddle has descended farther on the sides. The warts and bristles scarcely differ from those of the preceding stage, though the former have decreased in size in proportion to the circumference of the caterpillar.

Fourth Stage (fig. 4). From the preceding stage to this one the transition is so abrupt that we seem quite unprepared for it. The heretofore unicolorous caterpillar now shows the coloring and markings which are so familiar in the similar stage of *Papilio Machaon*, viz.: a bright green ground with black bands, which are narrow in the joints and broad on the middle of the segments; these bands are interrupted by brick-red spots, which are arranged in three rows,—sub-dorsal, supra-stigmal and infra-stigmal. The warts, on which the bristles are scarcely perceptible, are still retained, and visibly project, especially on the sub-dorsal line, though in proportion to the size of the body they have plainly diminished; in other words, they have evidently become rudimentary. The bristles have entirely disappeared from other parts.

Fifth Stage (fig. 5). In the last stage the green ground color is more conspicuous, because the black bands on the segments have diminished somewhat, and in some parts only form spots between the red dots; this is especially the case on the middle abdominal segments. The warts, together with the bristles, have totally disappeared, and no indication remains of the previous hairy covering.

Papilio Brevicauda. I have not personally examined this caterpillar, but all of its preparatory stages have been figured by Mr. Edwards. Although the enlargement is not sufficient to show the shape of the bristles, yet it is clearly seen that the warts are very much as in *Asterias*.

Up to the third stage the warts and their bristles are distinctly visible; the color is black, interrupted by a white saddle which lies across the third and fourth abdominal ridges, exactly as in *Asterias*.

In the fourth stage the warts have become rudimentary, while the characteristic markings of the full grown caterpillar have already be-

come established, consisting of a bright green ground, black rings running over the segments and interrupted by yellow dots, sometimes even on the places where the warts had stood.

In the next stage the warts entirely vanish, and the markings become still more regular.

Finally, after the fourth moult, the color is much brighter, the green predominates as the black bands begin to diminish. According to Mr. Edwards, however, there are variations from this pattern in which the bands are still quite broad, and this stage, therefore, in color and markings more nearly resembles the fourth.

I remark that the last stage of *Brevicauda* more nearly resembles the fourth stage of *Asterias* than it does the fifth.

Papilio Machaon (European form, fig. 6). First Stage. The well known rows of warts are present, and bristles growing on them with a shovel-formed enlargement at the end. The color is black, interrupted by a white saddle on the third and fourth abdominal rings.

Second Stage. With the first moult no essential alteration appears, and I am not able to state at what period the change to the green form, furnished with black bands and red dots, takes place. I think I may assume, however, that this change appears after the third moult in this species as well as in *Asterias* and *Brevicauda*.

Papilio Turnus.* First Stage (fig. 7). The brown ground color is interrupted by a white, oblique band, which crosses from the back of the sixth to the ventral side of the first abdominal segment, and appears to divide the caterpillar into two parts. The hairy covering is not very heavy. The bristles stand on warts, which are most fully developed in the sub-dorsal row and sensibly decrease from the ends to the middle. The bristles are short, and have a shovel-formed enlargement (fig. 7*a* and 7*b*).

Second Stage (fig. 8). Of this stage I have had but one badly preserved specimen, yet by comparison with Mr. Edwards' figures I have been able to prove that it does not materially differ from the first stage.

Third Stage (fig. 9). This does not differ from the preceding stage in color, except that an ocellate spot begins to appear on the third thoracic ring.† The warts have become rudimentary, except they still project somewhat more distinctly on the first two thoracic, and especially the last abdominal rings. By the aid of a stronger magnifying power very small bristles, tapering to a point, can be seen on the warts (fig. 9*a*).

* Mr. Edwards, in his "Butterflies of North America," has figured all the stages of *Papilio Turnus* from life with the natural colors, which were not visible in my alcoholic specimens. I therefore depend on Mr. Edwards' drawings. As regards the bristles and warts, his enlargement is not sufficient.

† I cannot decide from my preparation, or from Mr. Edwards' figure, whether this spot had begun to appear in the second stage, as it does in *Troilus*.

Fourth Stage (fig. 10). The brown gives place to an entire green color, on which there is now only a faint indication of the bright oblique band. The ocellate spot is now fully formed. Only an indistinct trace of the warts is now visible on the last abdominal segment.

Fifth Stage (fig. 11). According to Mr. Edwards, beside the green specimens, brown ones are also found. Every indication of the previous hairs and warts has entirely disappeared.

Papilio Troilus. First Stage (fig. 12). In the alcoholic specimens, which were the only ones at my command, the coloring was not distinguishable, but it is probably brown, as in the related species *Turnus*. The numerous bristles stand on warts, which are arranged in longitudinal rows. On each side is a dorsal row of warts, each bearing only one bristle, a sub-dorsal, a supra-stigmal and an infra-stigmal row; there are additional bristles on the head, on the last abdominal segment, on the abdominal legs, etc. The warts of the sub-dorsal and supra-stigmal rows are largest in front and in rear, and smallest on the middle segments. The bristles are stout, and have a shovel-formed enlargement at the extremity (fig. 12*a*).

Second Stage (fig. 13). What was said about the coloring in the first stage holds good here, except that on the third thoracic ring a dark spot now appears, which afterward becomes ocellate. The warts have begun to disappear, and they are still clearly visible only on the thoracic and the last abdominal segments in the sub-dorsal row; toward the middle they have almost entirely subsided. The bristles have become much smaller in proportion to the warts, and have entirely lost the shovel-formed enlargement (fig. 13*a*).

Third Stage (fig. 14). After the second moult the caterpillar is greatly altered. The color has probably become green (as in *P. Turnus*), interrupted by a bright band running obliquely over the first abdominal segments, like that found in *Turnus* up to the fourth stage. On the last abdominal segments also is found a trace of a band running in a similar direction. The black spot on the third thoracic ring has increased in size. The warts and bristles have almost entirely disappeared, and only on the thoracic and the last abdominal rings faint traces of them are still found.

The Fourth Stage has not been at my disposal.

Fifth Stage (fig. 15). The general color is still probably green, but distinct bright spots with a dark outline now appear where the sub-dorsal, supra-stigmal and infra-stigmal warts had previously stood. On the third thoracic ring an ocellate spot of intricate pattern has been formed, while the indication of a similar one is seen on the first abdominal segment. No further trace can be found either of the warts or the bristles; the body of the caterpillar appears perfectly smooth.

Papilio Ajax. First Stage (fig. 16). The color of the little caterpillar is very dark, probably black. Four rows of warts appear on each side,—dorsal, sub-dorsal, supra-stigmal and infra-stigmal. Only a single bristle stands on each of the small dorsal warts, while the others bear many. The bristles on the upper rows of warts are very long, and of a peculiar form, having a furcate division at the extremity. In this they entirely differ from the form of bristles seen in the first stages of the other *Papilionidæ*, which have a shovel-formed enlargement. Nevertheless they may be traced back to the latter, since they are formed by the division of an enlarged extremity.

Second Stage (fig. 17). This stage seems scarcely to differ from the first; the general color, as well as the form of the warts and bristles, is exactly the same as before the moult.

Third Stage (fig. 18). The change from the second to the third stage is an abrupt transition. The color has been suddenly altered; instead of the uniform dark hue, the ground color is now quite bright, and is interrupted by a large number of black bands, four of which are seen on every segment. The lower part of each ring is enclosed by two curved longitudinal stripes. The warts and the long forked bristles have suddenly vanished, and the skin appears quite smooth. I have a preparation in Canada-balsam, in which the skin is just beginning to be loosened, so that under it is visible the form of the caterpillar in the third stage; by the aid of a high magnifying power it may be seen that bristles are still present even in this stage, but very small, and without furcation, and in proportion to the size of the body almost invisible.

Fourth Stage (fig. 19). The only alteration in this stage is that the black stripes have become much narrower, and often appear interrupted, so that the bright general color is now more prominent; between the last thoracic and the first abdominal segment a broad black band appears.

The Fifth Stage has not come under my notice, but I do not believe that it will be found to differ essentially from the fourth.

Papilio Philenor. First Stage (fig. 20). I cannot decide with certainty as to the color from alcoholic specimens, though it seems to be dark. The young caterpillar is beset with very long bristles, which stand on small warts. Each wart in the two dorsal rows bears only a single bristle, while those in the sub-dorsal, supra-stigmal and infra-stigmal rows bear several. In addition to these there are also stout bristles on the head, the last abdominal segment below the infra-stigmal row, and finally on the thoracic feet. Two different kinds of bristles can be distinguished, namely: those having an enlargement above (fig. 20*a*), and others which run to a point. The latter seem to be the more numerous, while the former are confined to the dorsal and sub-dorsal rows of warts.

Second Stage (fig. 21). With the first moult the exterior of the caterpillar undergoes a decided change; the hairs become so short as to be visible only by the aid of a strong magnifying power. The shovel-formed bristles have entirely disappeared. The warts, on the other hand, have not decreased in size; in fact, those on the thoracic rings, the last abdominal rings, and all in the infra-stigmal row have become longer in proportion to the size of the body; the warts standing on the middle abdominal segments in the sub-dorsal row are the only ones that have not grown larger.

Third Stage (fig. 22). With regard to the hair the same may be said as in the preceding stage, while the warts, which after the first moult showed an increase, have become notably larger after the second. A long horn-like formation has arisen from the first thoracic segment.

Fourth Stage (fig. 23). This has not come under my inspection; it will probably be found to differ essentially from the previous stage only in the fact that the bristles on the warts have entirely disappeared.

Fifth Stage (fig. 24). The color of this, as well as of the preceding stages, seems to be uniformly dark. The entire body is smooth, the sub-dorsal warts of the middle abdominal segments have almost entirely subsided, while those which were previously said to be in process of growth have grown to be long horns, which lend, especially to the thoracic segments, a very peculiar appearance.

NYMPHALIDÆ.

Of this family I have also examined a few West Virginian forms from the same point of view, and will briefly give the results, remarking that the genus *Melitæa* was the most thoroughly studied.

Melitæa Phaeton. First Stage (fig. 25). The body of the minute caterpillar is covered with many separate bristles standing on small warts; the latter are arranged in regular rows, namely: one dorsal row, and on each side of the body a sub-dorsal, a supra-stigmal and an infra-stigmal row; in addition to these there are bristles on the head, on the last abdominal segment, and beneath the infra-stigmal row. The latter are slightly curved, and quite fine at the point, but visibly toothed (fig. 25*a*).

Second Stage (fig. 26). After the first moult the exterior of the caterpillar has essentially changed, namely: in place of the small pimples, on which in the first stage the single bristles stood, large warts now project, covered with numerous bristles, as in the first stages of the *Papilionidæ*. In their number and position these warts correspond to the pimples of the first stage, and the bristles planted on them are, like those first described, finely toothed, but somewhat shorter than they in proportion to the size of the body.

The THIRD and FOURTH STAGES have no essential changes to show in comparison with the second. The toothed bristles are always present, and give to the caterpillar its well-known hairy aspect.

The FIFTH STAGE has not been under my inspection; but it does not seem to differ from the preceding ones, so far at least as we may judge from the figures given by Mr. Edwards. That author has figured the entire development of the *Phaeton* caterpillar from life, and with the natural colors, to which I here refer. The magnifying power used by Mr. Edwards is not adequate to the determination of the characteristic form of the bristles.

Melitæa Marcia. FIRST STAGE (fig. 28). One dorsal row, two sub-dorsal, two supra-stigmal and two infra-stigmal rows of single bristles can be seen on the young larva. The bristles are very long, somewhat curved and finely toothed.

SECOND STAGE. On the spots where, before the first moult, the single bristles had stood, high warts have now been formed, which are covered with numerous bristles. The greater part of these bristles resemble those of the preceding stage, but on the warts standing in the sub-dorsal row a part of the bristles are of different form, being destitute of teeth and swollen at the base.

THIRD STAGE (fig. 29). On the dorsal, the sub-dorsal, and the supra-stigmal rows the toothed bristles are entirely supplanted by smooth ones swollen at the base, while on the infra-stigmal row only a single bristle appears on each wart.

FOURTH and FIFTH STAGES. We find the same condition also in the last two stages, *i. e.*, the toothed bristles which were at first exclusively present have now given place to the second form with smooth surface and swollen base.

Melitæa Nycteis. FIRST STAGE (fig. 30). The young caterpillar is covered with long, curved, toothed bristles, which are arranged in the usual regular rows.

SECOND STAGE (fig. 31). After the first moult, in place of the simple bristles, large warts have appeared beset with numerous bristles. A part of these are toothed as in the first stage, a part swollen at the base.

The THIRD STAGE I have not been able to examine.

FOURTH STAGE (fig. 32). In this stage, *i. e.*, after the first moult following the hibernation, the bristles are no longer enlarged near the base, but taper uniformly to a point.

The FIFTH and SIXTH STAGES show no differences worthy of mention.

Melitæa Tharos (fig. 33). FIRST STAGE. This is the only stage of *Tharos* that I have observed, and I find that here also the long, slightly-curved, and finely-toothed bristles are present, arranged singly in the usual longitudinal rows.

Melitæa Didyma. Of this species I have only incomplete investigations to offer, from which, however, I infer that in its development it does not essentially differ from the previously named species.

Argynnis Myrina. First Stage (fig. 34). The young caterpillar is beset with many bristles, which stand singly, and arranged regularly in longitudinal rows,—dorsal, sub-dorsal, supra-stigmal and infra-stigmal. These bristles, as in *Melitæa*, are long, slightly curved and finely toothed.

Second Stage (fig. 35). After the first moult the single bristles are replaced by numerous ones which stand on high warts. A large part of the bristles are still toothed, though many smooth ones already appear among them.

Third Stage. The teeth on the bristles are now scarcely visible, even by the aid of a strong magnifying power.

The Fourth and Fifth Stages have not been at my disposal.

(To be continued.)

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DESCRIPTION OF THE PREPARATORY STAGES OF LYCÆNA MELISSA, Edw.

By W. H. Edwards.

Egg.—Shape of *Pseudargiolus*, round, flat at base, the top flattened and much depressed in middle; the surface covered with a fine lace-work, the meshes of which are mostly lozenge-shaped, and bear a low rounded process at each angle. Duration of this stage about five days.

Young Larva.—Length .03 inch; color yellow-green; surface pubescent; dorsum high, rising to a narrow, flat ridge, which slopes from segments 4 or 5 to 13; on either edge of this ridge is a row of long white clubbed hairs, one at the posterior end of each segment, those on anterior segments curved forward; the others back; along base, both on sides and around segment 13, are similar hairs, bent down; others from segment 2 fall forward, and the effect is that of a fringe around the whole body; head ob-ovoid, black, smooth. Duration of this stage five days.

After first Moult: length .06 inch; color greenish white; shape very much as at previous stage; the dorsum high and flattened; the hairs and fringe as before. To next moult eight days.

After second Moult; length .12 inch; color pale green; very much the same shape as before; same flat ridge, hairs and fringe; surface pubescent. To next moult five days.

Fig. 1

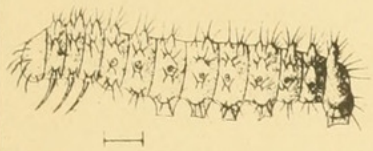


Fig. 1a

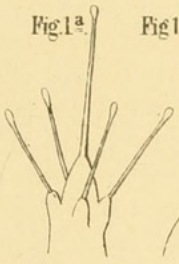


Fig. 1b

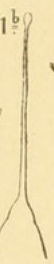


Fig. 7.

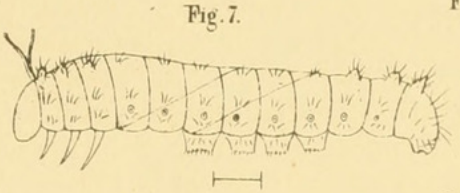


Fig. 7a

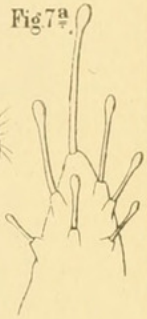


Fig. 2.

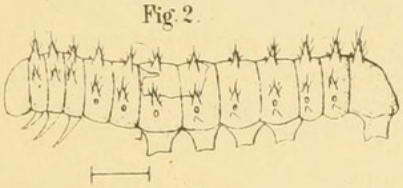


Fig. 2a

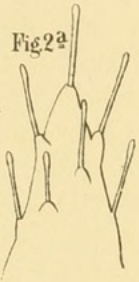


Fig. 8.

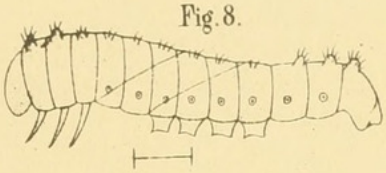


Fig. 7b

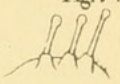


Fig. 3.

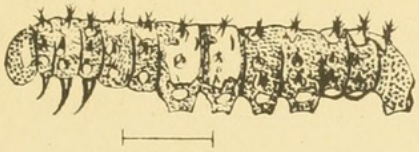


Fig. 9.

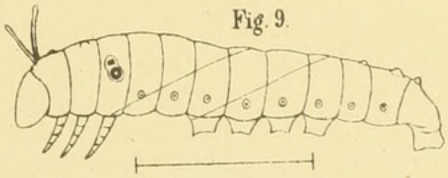


Fig. 9a

Fig. 6.

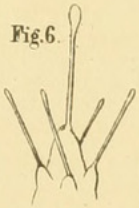


Fig. 4.

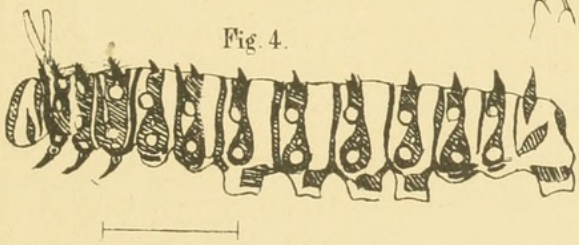


Fig. 10.

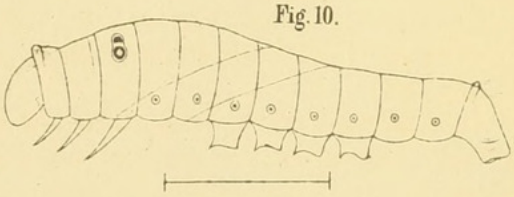


Fig. 5.

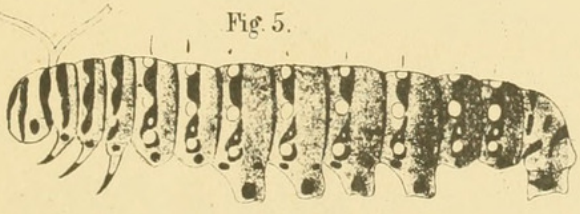


Fig. 11.

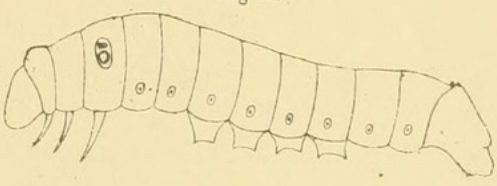


Fig. 12.

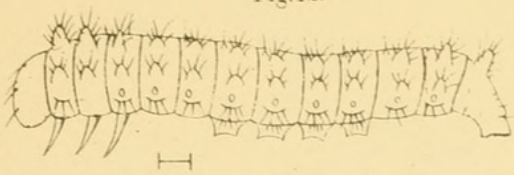


Fig. 12 a

Fig. 16.

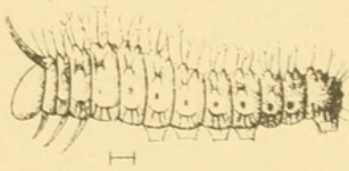


Fig. 13.

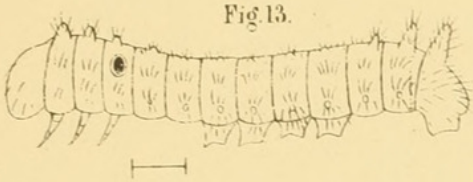


Fig. 17.

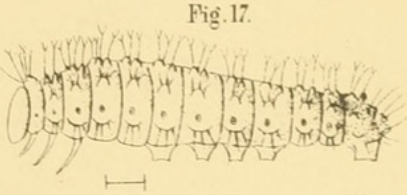
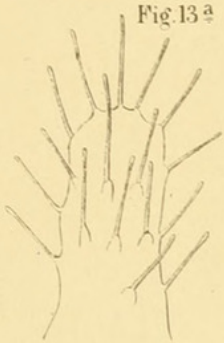


Fig. 13 a



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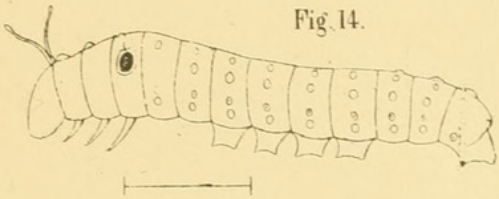

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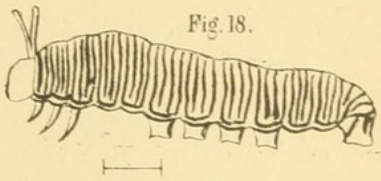
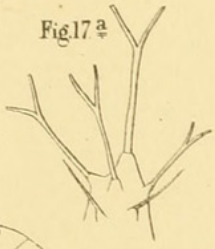


Fig. 17 a



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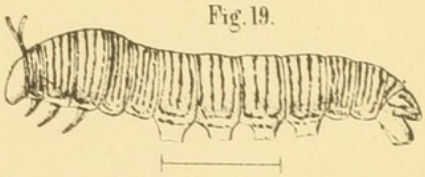

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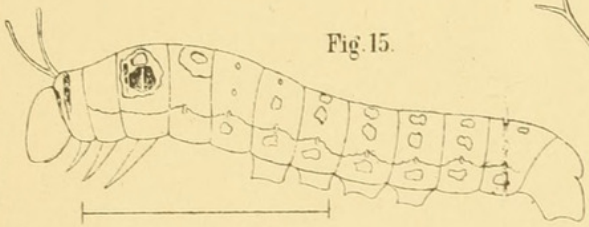


Fig. 22.

Fig. 23.

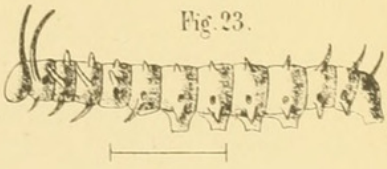
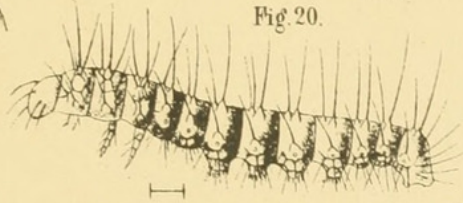


Fig. 20 a

Fig. 20.



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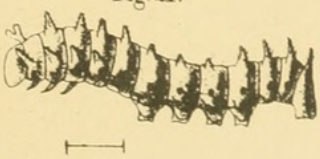
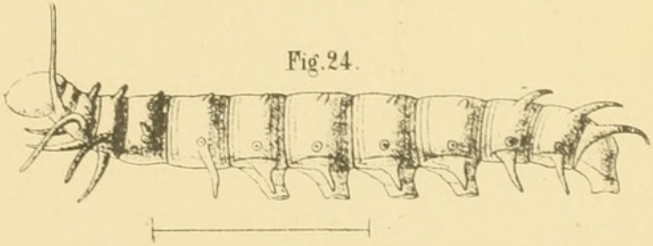


Fig. 21 a

Fig. 24.



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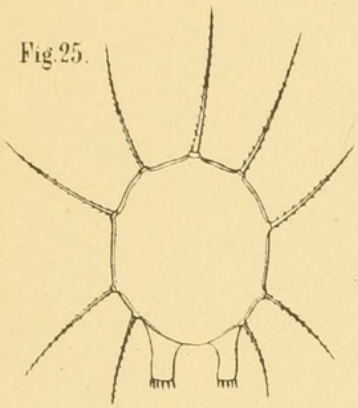


Fig 25 a.

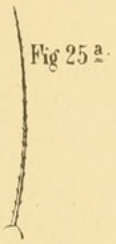


Fig.28.

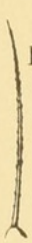


Fig.30.

Fig.33.

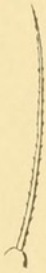


Fig.34.

Fig.29.

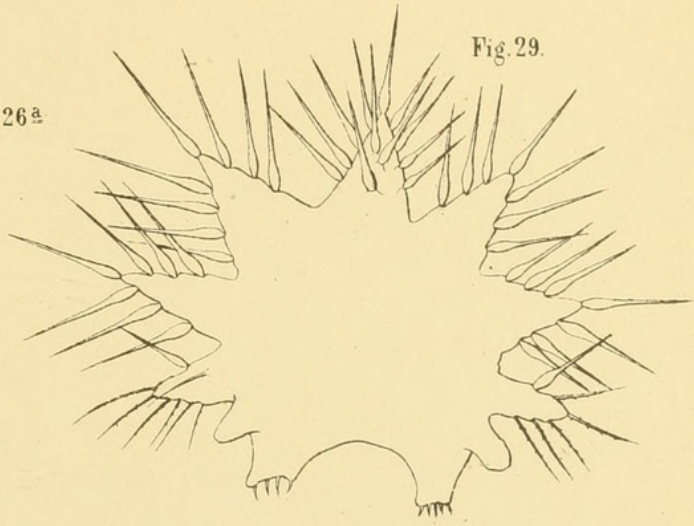
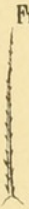


Fig.26 a.



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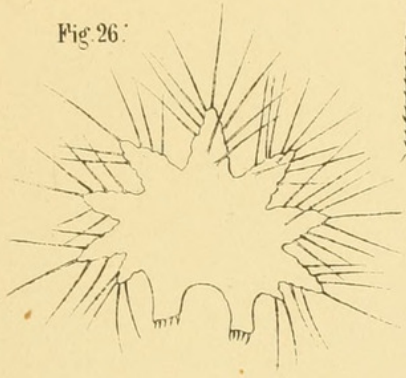

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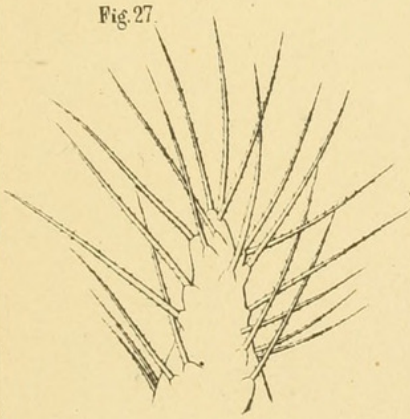
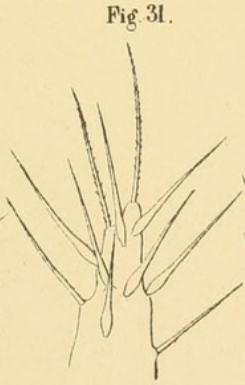


Fig.31.



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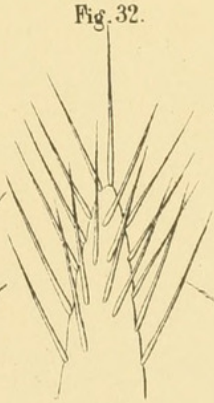

Fig.35.