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1909

Häftet	1—3	innehållande	N:o	1—13	utkom	den 21 juli 1909.
»	4	»	»	14	»	» 13 okt. 1909.

ARKIV FÖR ZOOLOGI.
BAND 5. N:o 12.

On the biology and development of *Clitostethus arcuatus* (Rossi), an enemy of the Aleyrodidæ.

By

IVAR TRÄGÅRDH D. SC.

Upsala.

With 1 Plate and 7 Textfigures.

Communicated April 14th by Chr. Aurivillius and Y. Sjöstedt.

While studying the Aleyrodidæ last year at the Entomological Laboratory of the R. Scuola Superiore d'Agricoltura in Portici I had an opportunity of studying the biology of *Clitostethus arcuatus* Rossi and was able to follow the development from egg to adult; this I intend to describe on the following pages.

It is true that two authors, Rey[1] and Hegeer[2], pretend to have discovered the larva of this beetle. But as to Rey,[1] his only reason for referring the larva he describes to *Cl. arcuatus* is, that he found both on the same tree, a hawthorn, a fact which to most entomologists would not appear to be a conclusive proof on that point. And, as a matter of fact, the larva described by Rey is not the larva of *Cl. arcuatus*, that is obvious from his statements of antennæ with several joints, (how many he does not tell us!) of the colour etc.

As to Hegeer's[2] description, which is accompanied by figures, it conveys, at the first glance, the impression that it is quite authentic, and it has as a matter of fact induced Clément to the following eulogy, in which he holds it out

[1] Annales de la Société Linnéenne de Lyon. T. 28. 1881. p. 131—133.

[2] Sitzungsberichte d. Kais. Akademie d. Wissenschaft. Matem.-Naturw. Classe. T. 24. 1857. p. 326—330. Taf. 5.

as an example worthy of imitation to his country fellows, BOUCHÉ and PERRIS, whose descriptions of the larvæ of other Scymnidæ he criticizes. He says[1] (p. 342) »Les metamorphoses des *Scymnus arcuatus* ROSSI (et *ater* KUGEL) ont été au contraire fort bien étudiées par HEGEER et les exellentes planches qui accompagnent ces deux mémoires présentent des qualités qui en garantissent suffisamment l'exactitude.»

This eulogy is however utterly uncalled for, at least as regards *Cl. arcuatus*, because the larva described under that name by HEGEER is not at all the larva of that beetle, as I am going to prove.

From the account HEGEER gives of the opportunity he had to observe the life history of *Cl. arcuatus* it is evident that he has not followed the development from egg to the adult. He says (p. 326) that in the spring 1856 he found some small, white-powdered larvæ together with *Aleyrodes immaculata* STEPH. These he recognized at once as Coccinellid-larvæ, and after zealous researches he found in the same locality a beetle, in which he, although it managed to escape, while he was looking at it with his pocket lens, at once recognized *Clitostethus* *arcuatus*. He brought home a plant, on which were eggs and larwæ of *Al. immaculata*, and was able to observe that the larva of the beetle fed on *Al. immaculata*. In June HEGEER went abroad for some days and, at his return, he found that the larvæ had disappeared and during the summer he failed to find either *Al. immaculata* or the supposed larvæ of *Cl. arcuatus*.

Later, in the beginning of August, he found again eggs and larvæ of Aleyrodes and adults of *Clitostethus*.

It is not easy to see, how, from the data given above (which are quoted from his paper), HEGEER could be able to tell us both how many days the different larval stages and how many the pupal stege requires, and there seems to be no other explanation for this left, than that he states as facts his own assumptions.

As a matter of fact the larva described by HEGEER is certainly not that of *Cl. arcuatus* and I very much doubt that it is a larva of a beetle at all. Because, to judge from the drawing HEGEER gives (Fig. 10. Pl. 5.) of the mouthparts, they appear to be veritable sucking mouthparts.

[1] Annales de la Société Entomologique de France. Série 5. T. 10. 1880.

If, in consequence, neither the larva described by Rey, nor that of Hegeer, is the larva of *Cl. arcuatus*, it is on the other hand highly probable that already Réaumur, this marvellous and sagacious observer, has noticed it.

Réaumur tells us[1] that he found the larva of a beetle, feeding on Aleyrodes (*A. brassicæ*) on cabbage, and he succeeded in breeding it. The figure he gives of the beetle (Fig. 21. Pl. 25) exhibits on the elytra a pair of dark spots, as in many *Cl. arcuatus*, and the figure he gives of the larva (Fig. 20. Pl. 25) resembles in all respects my fig. 2. Pl. I.

Development.

The eggs are deposited one and one on the under surface of those leaves of *Phillyrea* which are infested by *Aleyrodes Phillyrea* Haliday, and it very seldom occurs that more than two are deposited on one leaf, and, when two, they are always placed widely apart, one on each side of the median nervule.

The eggs are 495 μ long, 234 μ wide and oval; they are broadly rounded at both ends, of a milky-white colour and have a polygonal structure.

I have not been able to ascertain how many days elapse before the eggs hatch, because I could never induce the adults to lay eggs in captivity: but one egg which I found the 28 of March hatched the 6th of April, and thus required at least 8 days.

First larval stage (Textfig. 2)

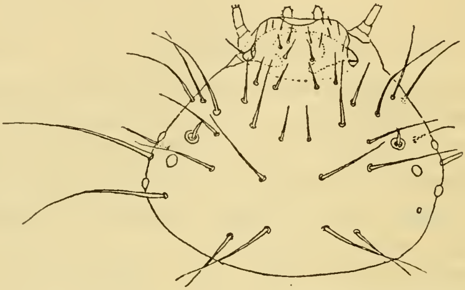
The larva is, when newly hatched, nearly white and somewhat translucent; it attains then a length of 540 μ. Later on it grows to a length of 675 μ and a width of 240 μ.

The larva is exceedingly slow in his movements and feels his way very carefully with his legs, until he has got a good footing, when he lets go his hold with the anal bristles, and curves the tip of the abdomen forwards underneath the abdomen, fixes the anal feet firmly and repeats the same movements, thus marching along much in the manner of the larvæ of the Geometridæ.

The head (Textfig. 1) is small, rounded pentagonal on dorsal view, $^2/_3$ as broad as the prothorax, and bent downwards at a right angle with the longitudinal axis of the body.

[1] Mémoires pour servir à l'Histoire des Insectes. Amsterdam 1737. T. 2. Part. 2, p. 71.

There are numerous hairs on the upper side of the head, several of which are of conspicuous length and evidently are tactile hairs. They are placed as follows: near the posterior margin there is a transverse row of two pairs; further forward, at the anterior margin of the vertex, there is another transverse row of two pairs, and on the genæ we notice two pairs which are very finely pointed and nearly twice as long as the other. The space between the anterior vertex hairs and the basis of the labrum, the clypeal portion, has 8 pairs of hairs, the three lateral pairs of which are the longest.



Textfig. 1. Head of 1st larval stage, front view. × 100.

The antennæ (Figs. 3 & 4 Pl. I) are greatly reduced and placed remarkably far backward. They appear as circular pores with raised walls, in which a blunt, hair-like appendage is inserted; the ridge which surroundes the pores has small, radiating spinules which seem to be mere modifications of the small conical nodules of the cuticle.

Eyes (Textfig. 1) There are three pairs of small ocellæ with red pigment, arranged in a triangle far backwards at the broadest part of the head.

The mouthparts.

The labrum is weakly chitinized, soft and indistinctly demarcated at its base; it is nearly twice as wide as it is long and slightly convex anteriorly in the middle. It projects forward beyond the tips of the mandibles, which consequently are completely hidden underneath.

The mandibles (Fig. 10. Pl. I.) are edentate, falciform, as long as they are wide at the base and have curved and sharply pointed tips; the median edge rises proximally to a low and blunt but wide molar.

The maxillæ (Fig. 14, Pl. I.) have either lobus externus and lobus internus fused, or the former is completely reduced; whichever is the case, we notice a thin-walled, reniform plate, which joins the stipes with very narrow base: it has 4—5 stout and short spines near the median edge and two long pointed hairs anteriorly.

The maxillary palps (Fig. 14, Pl. I.) are three-jointed and taper gradually towards the top; the terminal joint is as long as the other two together, nearly cylindrical and rounded at the top, where 5—6 small blunt spines and one pointed hair are inserted.

The labium is broad and projects on a level with the anterior edge of the labrum, so that the labial palps, which are single-jointed and placed near the median line, are plainly visible on dorsal view.

The body is almost cylindrical and tapers gradually from the metathorax towards the posterior end; it consists of 3 distinct thoracic and 10 abdominal segments, the terminal one of which is not however visible on dorsal view.

The cuticle is minutely spinulated (Fig. 5, Pl. I), the spinulæ which are thickenings of the cuticle being narrow and pointed; they are longer on the legs than on the body.

The pleuræ of all segments except the terminal and subterminal one project as horizontal conical processes; those of the thorax are more rounded, whereas the other are triangular in outline.

The prothorax is slightly narrower and shorter than the meso- and metathorax, which are of equal size.

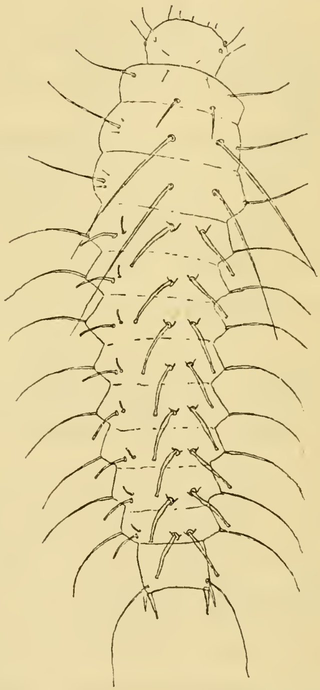
Hairs. The dorsal side is provided with numerous, regularly placed hairs which differ in size and number in the different stages. The hairs are of two kind, viz. finely pointed, setiform hairs and glandular hairs. The former are, as a rule, to be found at the top of the lateral processes, the latter occur on the dorsal side.

In the first larval stage the thoracic segments have one pair of slender lateral hairs each, which point nearly straight outwards and slightly upwards and are inserted on a higher level than those of the abdominal segments; around the base of these hairs there are 3—4 small inconspicuous hairs.

On the dorsal side, near the median line, they have one pair of hairs each, and of these the meso- and metathoracic pairs are conspicuous through their great length, projecting backwards to a level with the middle of the 2nd and 3rd abdominal segments resp.

The abdominal segments.

The lateral processes of the 1—9th segments have one pair of terminal hairs each; these are perfectly horizontal, nearly as long as the width of the segments, very finely pointed and curved in an even curve backwards; the 9th segment has a pair of similar but longer hairs at the posterior angles.

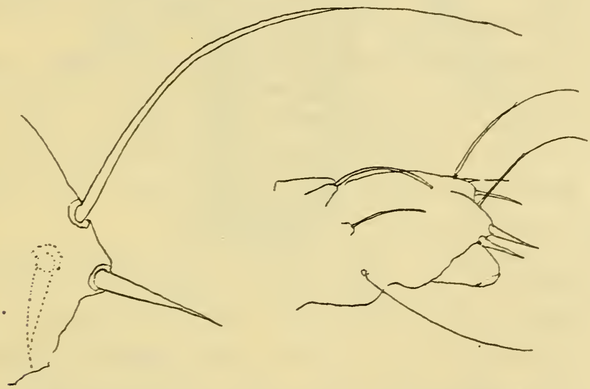


Textfig. 2. 1st larval stage. Dorsal view. × 120.

These hairs, which project very close to the surface, on which the larva marches along, or even touch it, are probably of some use at the locomotion.

The glandular hairs are present in the number of 3 pairs on each of the 1—8 segments, viz. one pair, which is large, browncoloured and comparatively more developed in this stage than in the subsequent ones, is placed on low conical tubercles close to the median line and points obliquely backwards and upwards; two pairs are placed dorsolaterally, close together; of these the median pair is very small and points obliquely forwards and upwards, whereas the lateral pair, which is more than twice as long as the median one, but not half so large as the dorsal hairs, points nearly straight outwards or slightly backwards.

The glandular hairs (Fig. 8, a, b and c, Pl. I) resemble very much the glandular hairs described from several caterpillars. They are hollow tubes, slightly wider at the base and at the top, where they widen to a cup, the edge of which is divided into 4—5 minute teeth.



Textfig. 3. Textfig. 4.

Textfig. 3. Projection of 9th abdominal segment, with locomotorial bristles. dorsal view.

Textfig. 4. Top of abdomen, side view. × 150.

The 9th segment has no glandular hairs, but is, at the posterior angles which are slightly projecting, provided with two pairs of stout and very sharply pointed bristles (Textfig. 3) the use of which has been related above. When the top of the abdomen is examined on lateral view we notice a short conical processe at the top of which the anal aperture is situated; this is probably the 10th + 11th segment (Textfig. 4).

When the larva has attained the length of 1,26 mm. it becomes motionless, remains so during twenty-four houres, whereon it leaves the old skin which splits dorsally along the middle of the thoracic segments.

Second larval stage.

When it first makes its appearance, the larva is quite white, but later it grows somewhat darker. It is at first 1,44 mm. long and 0,4 mm. wide, but, when fullgrown, attains a length of 1,665 mm.

In the shape of the head and the mouthparts the 2nd stage does not differ from the 1st stage, but the number and size of the dorsal and lateral hairs is different.

On the prothorax there are two pairs of dorsal hairs, the anterior pair of which, although present even in the 1st stage, but then very inconsspicuous, has grown and become nearly as long as the posterior pair. The small lateral hairs which were to be found round the base of the pair of large hairs in the 1st stage have also grown, almost attained the length of the latter and become glandular.

On the meso- and metathorax the dorsal pair is greatly reduced in length and is no more longer than the dorsal hairs of the abdominal segments. The space whereon they are inserted has risen to a short, conical and darkcoloured processe. Of the lateral hairs three pairs have grown so as nearly to match the one long pair of the 1st stage.

On the abdominal segments, the median dorsal hairs have not increazed in size and are consequently comparatively smaller than in the 1st stage; the conical tubercles on which they are inserted have on the other hand increazed and become more dark coloured. The anteriorly pointing hairs of the two dorso-lateral ones have increazed and attain $^2/_3$ of the length of the other pair and the portion of the cuticle on which they are inserted has rizen to broad conical processes.

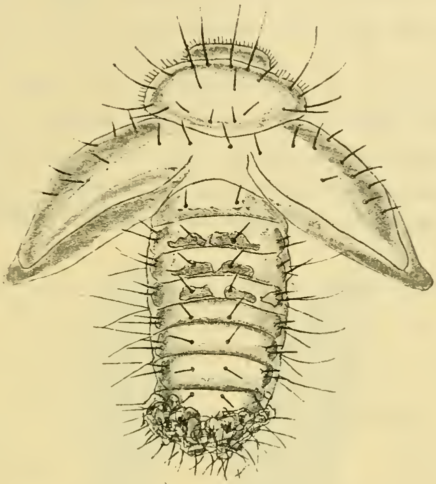
Finally, on the lateral pleural processes we notice one pair of small slender and glandular hairs which are inserted subterminally, close at the back of the terminal hairs.

The tips of these hairs are shaped differently from those of the other hairs; they are cut off obliquely so that the ventral edge is longer, and the dorsal wall is thin and covers the ventral one in the shape of a thin plate, tripartite at the top (Fig. 7 a, b & c, Pl. I.).

The 3rd stage attains a length of 2,3 mm. and differs from the 2nd one only through the appearance of one pair of hairs at the postero-lateral angles of the prothorax, the growth of the 5th dorsolateral glandular hairs of the meso- and metathorax and of the subterminal glandular hairs of the abdominal pleural processes.

Furthermore the median dorsal tubercles have grown darker.

The *4th stage* does not differ from the 3rd one except by its greater size and by the dorsal tubercles becoming darker.



Textfig. 5. Pupa, dorsal view.

The *pupa* (Textfig. 5).

In the cases when I observered how the larva made ready for pupatión, it always left the leaf and attached itself to the walls of the glasstube. From what we know about the behaviour of other Scymnidæ, which all attach themselves to the under surface of leaves, it is probable that the difference in this respect in *C. arcuatus* was due to the confinement, in which it was hold.

The larva remained inert during 4 days, after which the larval skin split and shriveled to a wrinkled mass round the top of the abdomen.

The pupa is at first white but darkens later. There are a pair of dark, irregular and transverse spots on the dorsal side of the 3—5th abdominal segment, near the median line; and the tips of the alæ are blackish. The pupa is richly provided with dark spines and hairs. On the prothorax there are in all 9 pairs of which 2, placed at the anterior margins, and 4 pairs, at the lateral angles, are as long as 1/2 the width of the prothorax. Besides these there are numerous small perpendicular hairs both on the prothorax and the head.

On the elytra we notice about 8 pairs of comparatively short, black hairs, and a dense row of small perpendicular hairs at the anterior margin.

On the abdomen we find nearly the same arrangement and number of hairs as in the larval stages, only there are no tubercles and the hairs appear to be glandular no more.

At the top of the abdomen there is a pair of finger-shaped appendages, curved slightly inward and slightly constricted at the top (Fig. 6. Pl. I); near the base at the median edge and subventrally they are provided with a pair of sucker-shaped appendages and bear numerous small spinulæ, arranged in transverse groups of 3—4 and directed forwards, thus acting as hooks.

Two features seem to me to be of special interest in the organisation and development of *Cl. arcuatus:* firstly that the glandular hairs, which it possesses alone of all known larvæ of the Scymnidæ, is a characteristic which it shares with the immature stages of *Aleyrodes Phillyrea* HALID., on which it feeds; secondly, that the dorsal glandular hairs are most highly developed in the 1st larval stage, during which there are no other glandular hairs, and that they later diminish in size at the same time as the other glandular hairs appear.

Data regarding the metamorphosis.

Egg found	28. III.	eggstage at least 8 days	
hatched	6. IV.		
became inert.	14. IV.	1st larval stage	8 days (inert 1 day)
changed skin	15. IV.		
became inert	18. IV.	2nd stage	4 days (inert 1 day)
changed skin	19. IV.		
became inert.	22. IV.	3rd stage	6 days (inert 3 days)
changed skin	25. IV.		
left the leaf and attached itself to the glasstube	3. V.	4th stage	12 days (inert 4 days)
Pupa	7. V.	pupal stage	8 days
Adult.	15. V.		
		Total (at least) 48 days.	

Taking for granted, that the data given above are perfectly typical, it is noteworthy: firstly, that both the 2nd and

3rd stages are very short, since the larva is active only during 3 days, secondly, that the time during which the larva remains inert increazes from the 1st to the 4th stage, viz. 1, 1, 3, 4 days resp.

From the facta gathered concerning the metamorphosis it seems clear that the beetle hibernates as adult. In the end of March the females, which however at that time are comparatively rare, lay egg, which develop during April and become adult in the middle of May.

At that time the adults were very common and were often found in copula on *Phillyrea*. At the same time *Aleyrodes Phillyrea* becomes adult and starts laying eggs. Consequently it is evident that the propagation of *Clitostethus* is closely adapted to that of *Aleyrodes Phillyrea* HALID.

Textfig. 6. Leaf of Phillyrea, under surface, infested with *Aleyrodes Phillyrea* HALID. Nat. size.

How many specimens of *A. phillyrea* a *Clitostethus* requires for his development, I have not been able to ascertain, but it is certanily a voracious insect and I generally had to change its »menu» every other day and one leaf of *Phillyrea* is apt to lodge up to 150 specimens of Aleyrodes (Textfig. 6).

The adult.

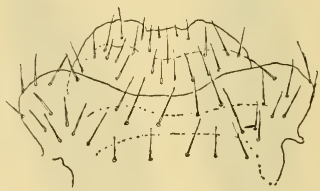
Both the typical form, dark with double yellow luniform spot, ab. *Hausmanni* CREDLER, dark with only one luniform (the median one) spot and var. *Hegeeri* GANGLB. yellowish brown with one dark spot, were abundant at Portici in May.

Allthough the adult has been described by HEGEER (l. c.

p. 329). I do not think it inappropriate to give a more detailed description of the mouthparts.

The antennæ (Fig. 9, Pl. I.) are 11- jointed; the 1st joint is as long as the 2nd + 3rd + 4th joints, 2 1/2 as wide as the 3rd and 1 1/2 as wide as the 2nd; it is club-shaped and provided with numerous hairs especially in the median 1/2; the 2nd joint is half as long as the 1st and pyriform; the following 3 joints (3—5) are of equal size, the following two are shorter, but with the 7th joint the joints begin to increase in width towards the three last ones which are as wide as the 2nd one. The terminal joint is pointed and has externally near the top a depressed area which bears a dense bunch of small hairs.

All the joints bear numerous hairs which increase successively in length towards the top.



Textfig. 7. Clypeus and labrum of adult. × 155.

The mouthparts.

The labrum (Textfig. 7) is twice as wide as it is long, soft and excaveted in the middle. The clypeus is deeply concave anteriorly and has the lateral angles strongly projecting.

The mandibles (Fig. 13, Pl. I) strongly chitinous, with narrow pointed tips, curved at a nearly right angle with the longitudinal axis. The median margin bears, a little in front of the middle and close behind the lacinia, two stout and short conical molars on the same level, one above the other; the lacinia or prostheca is a thin hyalin lamina, which is as wide as 1/3 of the width of the mandible at the base; its edge is very finely serrated or fringed. On the ventral surface of the mandibles there are several rounded pores and at the anterolateral angle there are 4—5 hairs.

The maxillæ Fig. 11, Pl. I).

The palpi are 4- jointed, but the demarcation line between the 1st and 2nd segment is partly obliterated, the 1st joint is narrow, cylindrical and bent outwards at a right angle at the top; it has no hairs. The 2nd joint is semispherical in outline and nearly twice as wide as it is long, it has 5—6 long straight and pointed hairs at the anterior edge. The 3rd joint is as wide and as short as the 2nd one and has a ring of long hairs at the anterior margin. The 4th joint is very large and cylindrical, but obliquely truncated at the top with convex terminal side; it is as long as the 2+3 joints and as wide, and is densely clothed with small hairs, the terminal area is densely clothed with minute hairs. The lobus internus is narrow, curved inwards at the top and provided with a dense comb af hyalin bristles, which are as long as the width of the lobus externus. Lobus externus of almost uniform whidth throughout and rounded at the top; it curves inwards in an even curve and bears about 12 straight, pointed hairs and 4 stout, hyalin blunt bristles at the top.

The labium (Fig. 12, Pl. I).

The labial palpi are 3- jointed; the 1st joint is very small; the 2nd joint is as long as the 1st and 3rd one together and club-shaped; it has 3—4 hairs distally and exteriorly. The 3rd joint is conical and obtusely rounded at the top.

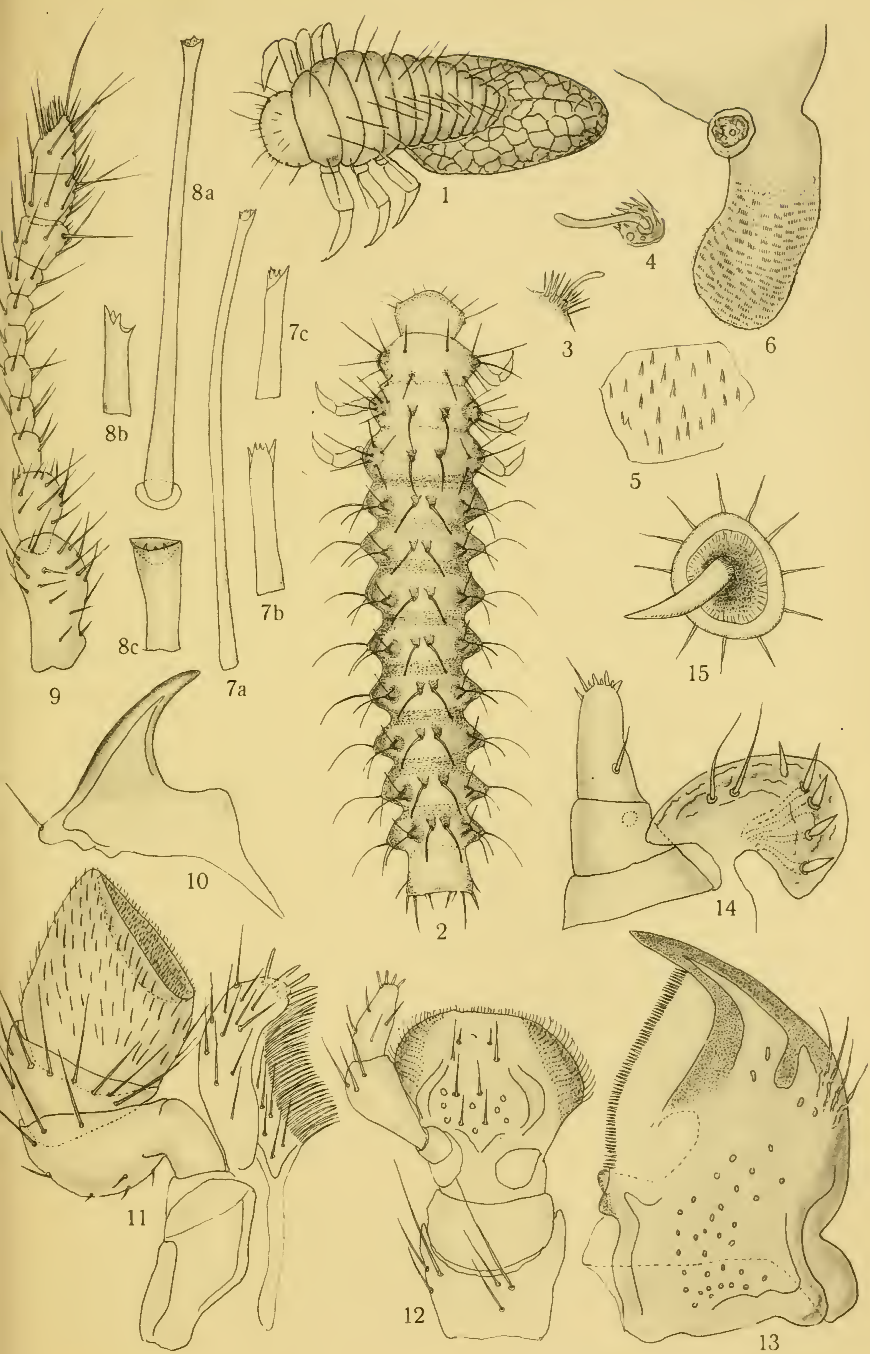
Explanation of the plate.

(All the drawings are made by the author, with help of ABBÉS camera lucida.)

Fig. 1. Young larva in the act of leaving the eggshell, × 52.
» 2. 3rd larval stage, dorsal view. × 20.
» 3. Antenna with surrounding spinulæ, lateral view; 1st larval stage. × 412.
» 4. Antenna seen from above; 1st larval stage × 540.
» 5. Portion of the cuticle of the head; 1st larval stage. × 540.
» 6. Abdominal appendage of pupa, with sucker-plate (?). × 206.
» 7 a. Ventrolateral, glandular hairs of the larva; 3rd stage
» b. and c Tip of the same.
» 8 a. Dorsolateral, glandular hairs of the larva.
» b. and c Tip of the same.
» 9. Antenna of adult. × 206.
» 10. Mandibel of the larva; 3rd stage. × 540.
» 11. Right maxilla of adult with maxillary palp, ventral view. × 412.
» 12. Labium with labial palp, ventral view. × 412.
» 13. Left mandibel of adult, ventral view. × 412.
» 14. Maxilla with maxillary palp of the larva, 3rd stage. × 540.
» 15. Antenna of the larva, seen from above, 3rd stage, × 540.

Tryckt den 17 juli 1909.

Uppsala 1909. Almqvist & Wiksells Boktryckeri-A.-B.



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