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CORRELATING EARLY WAX SECRETION BY THE LAC INSECT WITH ITS BODY SEGMENTS

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Abstract. The first stage lac larva produces dorsally a shield of hard wax divisible into 11 plates. From the sides ribbons of hard wax fibres are secreted. Body segment No. 2, has the largest plate of wax and from its sides two ribbons are produced on each side, not one as has been previously stated. Each of these ribbons lies on either side of the major spiracle. Ventrally the precursor of vaginal opening lies between the body segments 7 and 8.

In as much as the female lac insect alone is the main producer of lac to determine the sex-ratio of a generation is to forecast the crop it is likely to produce. Such a possibility depends upon early sex identification. This, however, has been demonstrated long ago.[1] Briefly the posterior end of the female crawling larva is U-shaped, while that of the male V-shaped.

Qadri[2] had preserved some larvae of *Kerria sindica* in dilute alcohol and glycerine. On reexamining them soon after she discovered a typical female larva. It is an instance which confirms the maxim, 'exception proves the rule'. Her illustration confirms the posterior outline as U-shaped (Fig. 1).

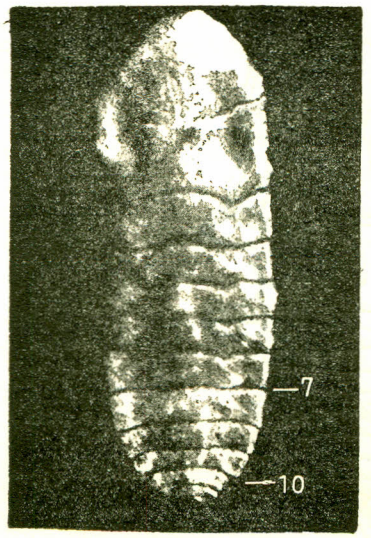
As soon as the young insect leaves the mother cell it is bright red or scarlet. This is due to the transparent or thin larval skin and the red lac dye within the body. But after a week in a case when the first ecdysis occurs about the third week, it appears pink. This is due to the insect secreting a thin coat of transparent hard wax which protects it like a dorsal shield. Observers have described the young lac insect, both as red and as pink, hardly paying any attention to this subtle difference in colour and to its cause. It could have never occured to them that the red larva is now pink because it has meanwhile covered itself with a shield of wax. In fact the lac insect has never been suspected of producing wax from special glands. It was believed, instead, that what we call lac, is a sort of emulsion of resin and wax. Thus the young lac insect covered by a wax shield was inconceivable. But, the wax shield can be seen as the replica of the young larva. This has been very well shown by Qadri[2] who offers a photograph of it under polarized light (Fig. 2). Now this wax shield persists as relic on the top of the full grown lac cell. Here it was observed by Green[3] and, seeing it identical in shape with the young lac larva, he mistook the wax shield for the moult skin. Accordingly he writes: "the medium dorsal area (of the full grown lac cell) with indications of segmentation (as in Fig. 2 here) represent the larval exuviae". The shield is clearly composed of eleven wax plates and it is natural to assume that each plate is the secretion of the body segment just beneath. The correlation is so good that the shield itself can identify the sex of the larva as Fig. 2 does of the female. This, however, is true of the dorsal surface of the insect.

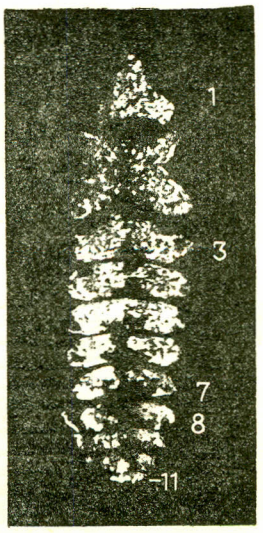
The matter is no longer easy when we examine the ventral surface of the young larva. The body does not show the segments so clearly as the dorsal surface. Then we have to consider theoretically what may be expected as segments even on examining the ventral surface. In order to find them following possibilities may be provisionally granted. The following would be the body segments of the young larva (Fig. 3).

1. Beginning of head with antennae and eyes; 2 prothorax; with the main skeleton of head, carrying the first pair of legs; 3(a) mesothorax; just below the first leg lie the major spiracles. The head is mainly here; 3(b) further down are the second pair of legs. The 'beak' of the mouth is clearly protruding; 4(a) metathorax; just below the 2nd pair of legs lie the minor spiracles; 4(b) further down lie the third pair of legs.

Thus the three pairs of legs, in longitudinal order, belong to pro-, meso- and metathorax. The 'beak' of the mouth also protrudes from mesothorax. In as much as the young lac insect has not been properly analysed in terms of body segments it became necessary to correlate wax secretion with body segments producing it. Taking the last pair of legs as belonging to body segment no. 4, the wax plate no. 4, of the dorsal shield, would be the secretion of the same body segment. Then the last pair of legs correspond to wax plate no. 4, on the dorsal surface. Here we have a point which enables us to interpret other relationships. Fig. 3 shows, between segements 7/8, a subtle feature which is seen in the drawing better than what can be explained. The same region in the adult female will give rise to the vaginal opening. The corresponding area on the dorsum, between wax plates 7/8 (Fig. 2), would produce the spinoid tubercle, a feature which characterizes the lac insect. Then the skin between segments 7/8 ventrally produces the vaginal opening and dorsally the spinoid tubercle. This conclusion is of great importance in studying the biology of the lac insect. On account of its importance it has to be confirmed.

The adult lac insect is morphologically a degenerate insect. It has bag like body, devoid of proper segmentation. Therefore, a model insect had to be sought where the segments are quite obvious. This happened to be *Dactylopius longispinus*, as illustrated by Berlese[4] (Fig. 4). The figure to the right represents the ventral view of the adult female. Its vaginal opening as indicated by Berlese lies between body





1 2

Fig. 1. Crawling female larva with posterior end U-shaped. Body clearly divisible into 11 segments. Fig. 2. Dorsal wax shield composed of 11 plates, each secreted from the body segment beneath.

segments 7/8, as can be calculated properly. Taking the last pair of legs, belonging to body segment no. 4, the vaginal opening lies between segments 7/8 (Fig. 4). Figure 3. which shows the young lac larva ventrally, also reveals the precursor of the vaginal opening, lying between segments 7/8.

In the shorter life-cycle the first stage larva takes 3 weeks. During the first week it secretes the dorsal shield on account of which it appears pink, instead of red. After 2 weeks more it is full grown first stage cell. Such a cell was treated with alkali solution which dissolves the lac but leaves the waxes *in situ* (Fig. 5). The young larva grows lengthwise as also in height. It is easy to imagine a horizontal expansion, as that of a cockroach. But a flea grows vertically because its hard chitin serves as exo-skeleton. On the contrary the lac insect has a delicate skin. It builds a cell to protect itself. As soon as the dorsal shield is formed it begins to secrete wax from its sides. Wax appears as hard fibres forming ribbons and these exude from pores of patches all round the insect body. Each ribbon presses against the surface of the host-plant, or ventrally, thereby raising, the body vertically. When this happens all round the body larva grows upwards. In Fig. 5 wax shield has separated itself in two places because the larval body has lengthened itself whereas the dorsal shield has not expanded at all. This distinctly shows that later on wax was being secreted only from the sides. The original body of the crawling larva is left by its margin of shield, indicated by cr.m., crawling larva margin (Fig. 5). The dorsal shield shows a central ridge, which Green also noticed, with each wax plate having a thinner flap on either side. The wax plate 5 shows the raised portion, with flat extensions as 5′a. The wax plates on the dorsum have been selectively numbered as 1,′ 5′ and 8′. These plates have to be compared with those of the intact shield (Fig. 2). The

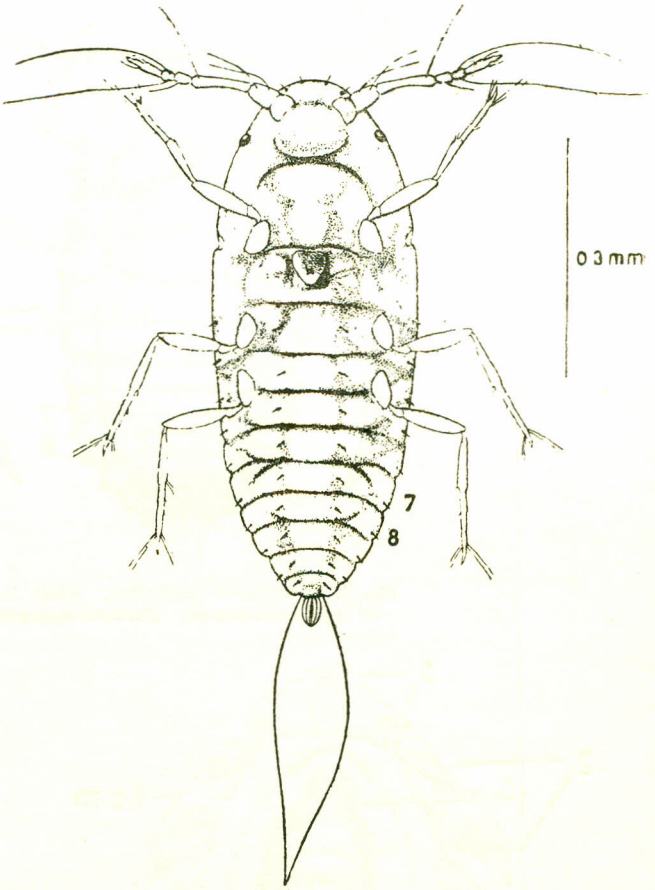


Fig. 3. Female crawling learva seen ventrally. First pair of legs belongs to prothorax next pair to mesothorax, to which also belongs the 'beak'. Last pair of legs represents metathorax. Between segments 7/8 iies, ventrally, the progenitor of the vaginal opening of the adult.

separation among wax plates occurs in two places, between plates 2/3 and 7/8 in Fig. 5. These two areas correspond to certain structures that arise in the young adult later on. What is situated between wax plates 2/3 would develop as a pair of brachial tubercles, associated with the major spiracles: and what now lies between 7/8 would have in the adult a spinoid tubercle. This is a nail like structure which fixes the dorsal skin into the ceiling of the lac cell. Thus the two separations among wax plates are forerunners of structures of the adult insect. Coming to the full grown body of the first stage larva this is shown by its body wall, b.w. The full grown cell also has its margin marked, f.s.m., first stage cell margin. Between the body wall and the external cell margin lay a wall of lac resin which has been dissolved out. Waxes were impregnated within this wall and are left here *in situ.* These waxes serve as skeleton work which supports the lac cell as a whole; lac is a relatively soft material while wax ribbons are quite rigid for the purpose. Examining Fig. 5 we find the ribbons separate and as originating from different segments of the body. But in as much as the body segments are not clear either ventrally or on the sides, it is a problem to correlate the wax secretion as ribbons with precise insect morphology. Dorsally there was no such difficulty for Fig. 1 gives the clear presence of 11

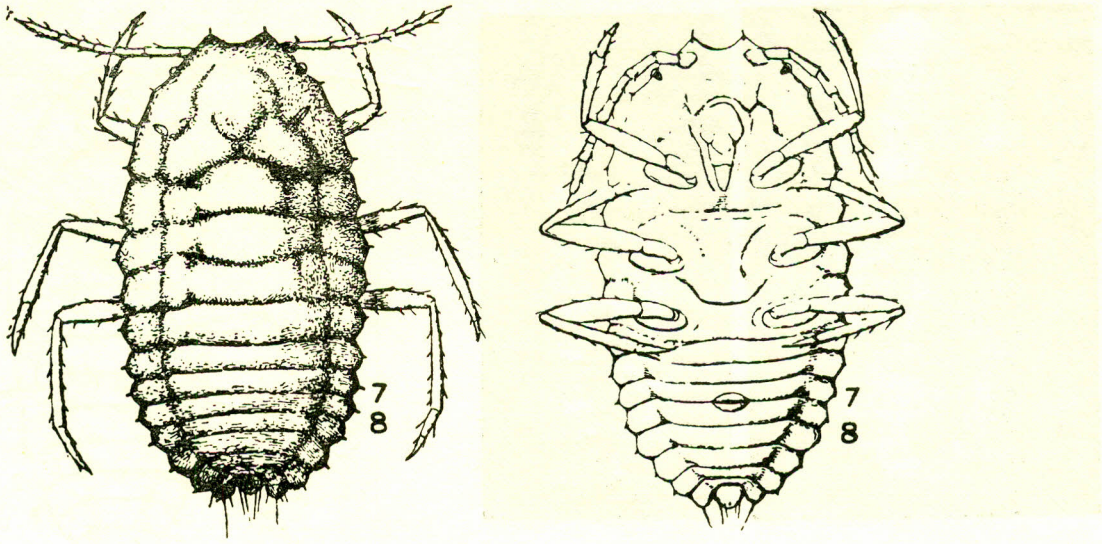


Fig. 4. *Dactylopius longispinue*, adult female. Antennae belong to first segment; last pair of legs to the fourth. Between segments 7/8 is the vaginal opening (compare Fig. 3).

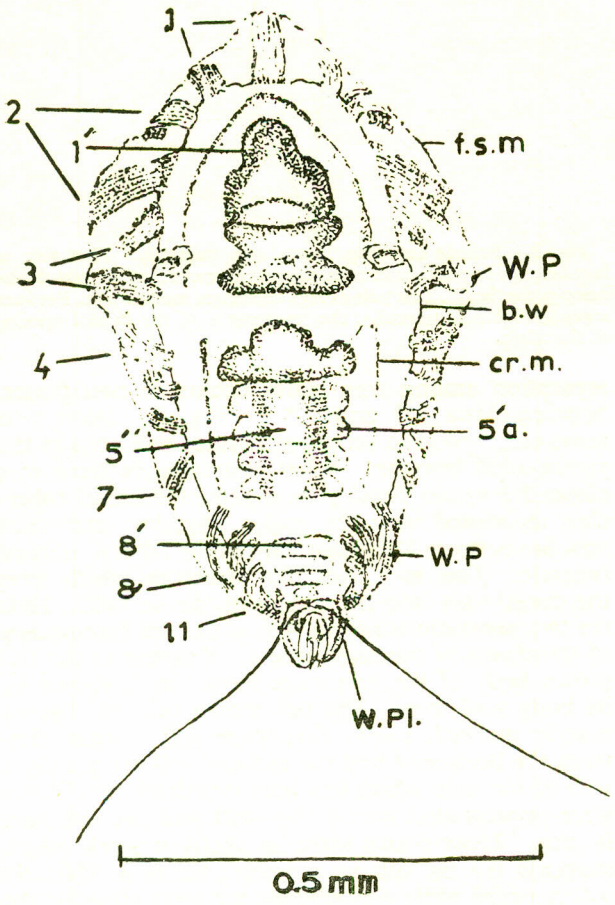


Fig. 5. Full grown first stage lac cell. Wax shield has plates 5′ and 8′. Relic of larval margin, cr.m., is crawling larva margin. The body of full grown larva is, b.w., body wall. Full grown cell margin, f.s.m., is first stage cell margin. Ribbons of hard wax secreted from sides as wax pencils, w.p. The ribbons on the left are numbered as produce of respective body segments. Ribbons no. 3 belong to mesothorax, one ribbon on either side of the major spiracle. The anal opening is supported by wax plates, w.pl., secreted by the 12th segment.

segments covered by 11 plates of dorsal shield Fig. 2. But we have considered enough already to show that the last pair of legs belongs to mesothorax, which is the fourth segment. Accordingly in Fig. 5, the body segment, of the full grown first stage larva, produces three ribbons, of which, on the left, two are marked, no. 1. The second segment, prothorax, produces a pair on either side, on the left bearing no. 2. Third segment, mesothorax, also produces a pair on the left, indicated as no. 3. Between the two ribbons of the mesothorax lies the major spiracles, on the side of the body, and is not visible. But in the same line, on the dorsal surface, is to be found the brachial plate, seen like an eye-shaped object. The brachium is a dish like chitinous plate of fused wax glands producing soft wax threads. When the brachium above and the major spiracle on the side form a vertically passage, on either side of it there must be a wax ribbon, and such a pair is numbered 3, in Fig. 5. The metathorax and all abdominal segments, up to body segment no. 11, would have one ribbon on either side. In earlier communications the metathorax has been credited with producing two ribbons while mesothorax with only one. This has been corrected here as shown in Fig. 5. Of ribbons produced by abdominal segments the representative ones have been numbered, the last as 11.

The anal opening is supported by a circle of six anal ring hairs. Adjoining are found long apical hairs, self-evident in Figs. 3 and 5. The anal end of the body is supported from below by miniature concave plates of wax, marked w.pl. wax plates. The adult has a long anal tubercle which, in turn, lies between semicylindrical wax plates together forming a cone-shaped structure. Within this hollow tube of hard wax the anal tubercle can move freely up and down. In Fig. 5 there are only shallow plates corresponding to the wax cone of the adult. These wax plates w.pl. (Fig. 5) cannot have any dorsal plate for the anal end is to be kept open. The wax plates are secreted ventrally and represent secretion of body segment no. 12.

In conclusion it must be pointed out that physiologically there are two phases of the first stage larva, secretion of dorsal wax shield, and later, of ribbons of wax fibers from the sides. The later secretion follows the former. As the larva grows it shows two areas of growth lying between wax plates 2 and 3 and between 7 and 8. From the former, corresponding to mesothorax, arise a pair of spinoid tubercles. The dorsal skin, between plates 7 and 8, gives rise later on to spinoid tubercle and on its ventral side to the vaginal opening.

References

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