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**FURTHER MATERIAL OF CONCHASPIS FROM SOUTHEAST ASIA
(HOMOPTERA : COCCOIDEA : CONCHASPIDIDAE)**

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Abstract

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Five species of *Conchaspis*, *C. angraeci*, *C. buchananiae*, *C. vaccinii*, *C. garciniae* and *C. socialis*, are revised on the basis of material collected in Malaya and Sarawak in 1991 and Singapore in 1992. *C. malesiana* is synonymized with *C. vaccinii*, which is interpreted as a variable species occurring in Malaya, Sarawak and Singapore on various plants. *C. buchananiae* and *C. socialis* are recorded from Sarawak. Observations are made on some features. Supplementary notes are given on the formation of the female test in *C. garciniae*. In *C. socialis* a remarkable sexual dimorphism was found in the larval stage; the possibility is suggested that the dimorphism in the 1st instar reflects the sexual difference of activity in dispersal in association with the formation of a familial test. A key to the adult females and larvae of the 5 species is given. Importance of ontogenetic approach and functional morphology in systematics is emphasized.

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1. INTRODUCTION

The family Conchaspididae now comprises 4 genera, *Conchaspis*, *Fagisuga*, *Paraconchaspis* and *Asceloconchaspis* (Williams, 1992). The known species, about 30 in total, have been recorded mostly from South America, Madagascar and Africa. In 1992 I published my study on the material of *Conchaspis* collected in Malaya in 1990. I found 4 species in the material and described two of them as new: *C. angraeci*, *C. buchanae*, *C. garciniae* and *C. vaccinii*. I recognized *C. garciniae* as a species related to *C. malesiana*, which was described by Ben-Dov and Williams (1984) from Singapore, on account of the common possession of cicatrices on the dorsal surface of the head.

The present paper is based on further material collected in 1991 in Malaya (Semenanjung Malaysia or West Malaysia) and Sarawak (East Malaysia) and in 1992 in Singapore, and is supplementary to my previous paper. In the course of my study on the new material I have found that the cicatrices of the head are variable in occurrence and development, and that their presence cannot be adopted as a stable specific character. *C. malesiana*, once supposed to be a distinct species on the basis of this feature, cannot be distinguished from *C. vaccinii* now.

In the new material I have recognized 5 species: *C. angraeci*, *C. buchanae*, *C. vaccinii*, *C. garciniae* and *C. socialis*. *C. malesiana* is regarded here as a variation within *C. vaccinii*. *C. hainanensis*, described by Hu (1987) from Hainan Is., China, was not mentioned in my previous paper. So far as based on the description, however, it may also be conspecific with *C. vaccinii*. *C. socialis* was described from Sri Lanka 100 years ago, and since then there has been no further record of it.

I have realized that I overlooked in my previous work the occurrence of cicatrices on the head in the larval stage of *C. vaccinii*. I have also noticed that the setae occurring on the terminal segment of the antenna are not always stable in number. On the other hand, not all of these setae are always easily observable when the segment is heavily sclerotized and wrinkled. I have prepared new drawings of antennae for *C. buchanae*, *C. vaccinii* and *C. garciniae* on the basis of my examination of the new material.

Mamet (1954) recognized 3 larval instars in the female of *Conchaspis*, but in my previous work I failed to find more than 1 instar in the stage intermediate between the 1st instar and the adult female. There was, in this stage, no definite evidence for the occurrence of 2 instars in the length of the hind trochanter+femur and in the frequency distribution of tubular ducts (Takagi, 1992). In the present study, too, the frequency distribution of tubular ducts in the intermediate stage has proved to be unimodal (some examples from the new material are given in Tables 4, 5 and 7). It is improbable that successive larval instars if any are so close in the number of tubular ducts. I have been almost fully convinced that the intermediate stage contains only 1 instar, and, therefore, I call the stage 'the 2nd instar' hereafter.

I have observed a remarkable sexual dimorphism in the 1st and 2nd instars of *C. socialis*, the male and female obviously differing in the legs and antennae. In *C. buchanae*, *C. vaccinii* and *C. garciniae* I have failed to discriminate the sexes in the larval stage. There is, however, some basis for assuming that the 2nd instar males of these species tend to be larger at full growth and to have more tubular ducts than the 2nd instar females. The examined samples should include larvae of both

sexes, but the sexual difference may be so small as to be lost in individual variation (this assumption is supported by the larvae of *C. socialis* [5.4.]). No discrimination, therefore, is made between the male and female in mentioning the larval instars of these species. In *C. angraeci* I have found no male tests: the examined larvae, therefore, should all belong to the female.

2. MATERIAL, PREPARATION, AND REMARKS ON QUANTITATIVE DATA

Abbreviations. Gg : Gunong (Mountain) ; Bt : Bukit (Hill) ; Pl : Pulau (Island) ; HS : Hutan Simpan (Forest Reserve) ; TN : Taman Negara (National Park) ; Bhg : Bahagian (Division or District).

2.1. *Conchaspis angraeci*

Recorded by Takagi (1992) from Malaya [Kuantan, Pahang, on *Trigonostemon malaccanus*].

Further material was collected in the grounds of the Forest Research Institute of Malaysia, Kepong, Selangor, Malaya, on branches of *Trigonostemon* sp. [Euphorbiaceae], Oct. 30 and 31, 1991 [91ML-299 and -307]; on Bt Cendana, Pl Pinang [Penang Is.], Malaya, on branches of *Homalium longifolium* [Flacourtiaceae], Nov. 18, 1991 [91ML-453].

2.2. *Conchaspis buchananiae*

Originally described by Takagi (1992) from Malaya [Bt Bauk, Terengganu, on *Buchanania arborescens*].

Further material was collected on Gg Santubong, near the summit (807 m), Bhg Kuching, Sarawak, on *Bulbophyllum* sp. [Orchidaceae]. Oct. 24, 1991 [91ML-260]. New to Sarawak.

2.3. *Conchaspis vaccinii*

Originally described by Khoo (1978) from Malaya [Gg Bunga Buah, Selangor, on *Vaccinium malaccense*]. Recorded by Takagi (1992) also from Malaya [Bt Bauk, Terengganu, and Kuantan, Pahang, on *Garcinia opaca* and *G. andamanica*; Desaru, Johor, on *Payena lucida*]. *Conchaspis malesiana* described by Ben-Dov and Williams (1984) from Singapore [Bt Timah, on a plant of the family Apocynaceae] is regarded here as a variation within *C. vaccinii*. New synonymy.

Further material was collected in Sarawak, Malaya, and Singapore on the petioles of the host plants as follows :

Sarawak. TN Bako, Bhg Kuching, on *Payena* sp. [Sapotaceae] and *Willughbeia* sp. [Apocynaceae], Oct. 9 and 11 [91ML-101, and -136]; Gg Santubong, Bhg Kuching, at an altitude of 535 m, on *Mangifera griffithii* [Anacardiaceae], Oct. 24, 1991 [91ML-256]. New to Sarawak.

Malaya. Gg Jerai, Kedah, at altitudes of 930-1,120 m, on *Symplocos adenophylla* [Symplocaceae] [91ML-313, -341, and -390] and *Planchonella firma* [Sapotaceae] [91ML-391], Nov. 5-10, 1991; Bt Wang, near Jitra, Kedah, on *Urophyllum* sp. [Rubiaceae], Nov. 12, 1991 [91ML-401]; HS Pantai Acheh and Bt Cendana, Pl Pinang [Penang Is.], on *Urophyllum glabrum*, Nov. 20 and 21, 1991 [91ML-488 and -498].

Singapore. Bt Timah, on an undetermined plant, 'cf. *Mallotus*' (Prof. Hsuan

Keng) [Euphorbiaceae] (the host plant appeared to me very similar to *Elateriospermum tapos* [Euphorbiaceae]), July 9, 1992 [92SP-60].

Adult females in poor condition or larvae probably belonging to this species were collected from the following plants: *Gaertnera vaginans* [Rubiaceae], Bt Wang; *Aporosa aurea* [Euphorbiaceae] and *Symplocos cochinchinensis*, Bt Cendana; *Payena lucida*, Bt Timah.

2.4. *Conchaspis garciniae*

Originally described by Takagi (1992) from Malaya [Kuantan, Pahang, on *Garcinia scortechinii* and *G. nigrolineata*].

Further material was collected on Gg Jerai, Kedah, Malaya, at an altitude of 930 m, on *Garcinia rostrata* [Clusiaceae (Guttiferae)], Nov. 5-10, 1991 [91ML-315, -351, and -392].

2.5. *Conchaspis socialis*

Originally described by Green (1896) from Sri Lanka [Tangalla, on an unidentified shrub]; redescribed by Mamet (1954) [based on specimens from the type material].

Material was collected in TN Bako, Bhg Kuching, Sarawak, on branches of *Madhuca* sp. [Sapotaceae], Oct. 13, 1991 [91ML-152]. New to Southeast Asia.

2.6. Preparation

Material preserved dry or immersed in 75% isopropanol was used. Dry material was put in humid atmosphere sterilized with creosote for some days. For light microscopy insect bodies, moist or immersed, were 1) treated with 10% KOH solution for 2 nights at room temperature, 2) heated at 60°C in lactic acid, with acid fuchsin and azophloxin dissolved, for 1 hour, 3) heated at 60°C in acetosalicylate [acetic acid 1 part and methyl salicylate 1 part], 4) transferred to carboxylol [phenol 1 part and xylool 3 parts], and 5) mounted in Canada balsam. At the end of step 1, bodies were gently pressed by the use of a forceps with spatulate tips in the fluid to cause a rupture on the body wall (usually on an intersegmental membrane) and to express the body contents; larger specimens were, then, gently heated in the fluid. When clarifying proved still insufficient or bodies were stained too dark at step 3, bodies were heated again in lactic acid (with no stain) and then in acetosalicylate. Finished slides were cured in an oven (45°C) for a month. [The mixture of the stains was made as follows: acid fuchsin (1 gram) was dissolved in a bottle of lactic acid (500 cc) and azophloxin (1 gram) in another bottle of lactic acid (500 cc), and some drops of these solutions were mixed at step 2.]

For scanning electron microscopy immersed or moist insect bodies and tests were dehydrated in alcohol, critical point dried, and coated with gold. Dehydrated insect bodies were treated with chloroform in an ultrasonic cleaner and then returned to alcohol for further procedure.

2.7. Remarks on quantitative data

The number of multilocular disc pores, the number of tubular ducts, and the length of the hind trochanter + femur are main quantitative characters I have used in studying the conchaspids. However, it has not been without difficulty to use the latter two.

The tubular ducts are ventropleural, occurring in a marginal to submarginal

position. In the mounted specimens they often overlap on the margin, and overlapping ducts are not always easily distinguishable from one another. When tubular ducts are numerous, it is often difficult or even impossible to count all the ducts of an individual exactly. This was the case especially with the adult female specimens of *C. garciniae* and also of *C. vaccinii* from some localities.

The total number of tubular ducts occurring on both sides of the body may be preferable to that of ducts occurring on one side from the viewpoint of individual variation, but the former tended to have scattered values and scattered frequencies. Mean, standard deviation, and standard error, whenever given, were calculated for the total of ducts occurring on one side of the body.

The border between the trochanter and femur is often obscure. I have adopted, therefore, the length of the hind trochanter+femur instead, but I felt some difficulty in applying the ocular micrometer to the basal end of the trochanter when the hind legs are improperly mounted. The length has been adopted with the expectation that it may correlate with the body size at full growth. However, the obtained values often did not agree, and sometimes differed considerably, between the right and left legs of the same individuals. (This may mean that the length was not always adequately measured.) The length should be adopted only as a rough index to the body size.

3. OBSERVATIONS ON SOME FEATURES

3.1. Cicatrices of head

In my previous work I observed a pair of small sclerotized structures occurring laterally to the cephalic dorsal spots ('eye spots' or 'dorsal ocellar spots' of authors) in *C. malesiana* and *C. garciniae*. When well developed, these structures or 'cicatrices' are elliptical and divided medially to form 2 cells (or constricted medially in scanning electron microscopy; see Takagi, 1992, Fig. 23). They are, so far as known, quite unusual in the genus. Their occurrence, therefore, was supposed to well characterize *C. malesiana* (Ben-Dov and Williams, 1984) and to show a close relationship of *C. garciniae* to *C. malesiana* (Takagi, 1992).

However, *C. malesiana* and *C. vaccinii* could not be distinguished from each other in the numbers of the tubular ducts and multilocular disc pores, in the length of the hind trochanter+femur, and in the occurrence of the dermal invaginations of the thorax, and were separated only by the presence or absence of cicatrices on the head (Takagi, 1992, Table 3). I have found that the specimens (42 in total) collected on Gg Jerai on *Symplocos* [91ML-313, -341, and -390] and *Planchonella* [91ML-391] are variable in the occurrence and development of this feature: some of them show well-developed cicatrices, while some others have more or less abortive ones (small and not divided into 2 cells) and the rest have only one, which is usually abortive, or none. The view, therefore, is adopted that *C. malesiana* falls within the variation of *C. vaccinii*. All the other specimens (65 in total) here referred to *C. vaccinii* [2.3.], including the 5 specimens [92SP-60] collected on Bt Timah, Singapore (the type locality of *C. malesiana*), show no trace of cicatrix.

Cicatrices also occur in the 2nd instar of *C. vaccinii*, but in this instar, too, they are variable. They are present, though sometimes abortive, in most of the examined specimens (52 in total) from Gg Jerai. In the other samples (145 speci-

mens in total) they occur less frequently and are often abortive, or are not found at all. Four of the specimens were collected on Bt Timah [92SP-60] : two of them have an abortive cicatrix on one side only and the other two none. In this instar an abortive cicatrix is sometimes represented by 2 small circles detached from each other, apparently corresponding to a 2-cellular one.

I have found cicatrices in most of the examined specimens (110 in total) of the 1st instar of *C. vaccinii*. They are abortive only occasionally.

Part of the specimens of *Conchaspis* collected in 1990 and examined in my previous work are deposited in the collection of the Laboratory of Systematic Entomology, Hokkaidō University. I have reexamined them for the cicatrices. In *C. vaccinii* 29 adult female specimens have been reexamined and none of them have cicatrices ; in the 2nd instar 9 out of 20 specimens show more or less abortive cicatrices on both sides or an abortive cicatrix on one side only, while the other 11 specimens none ; in the 1st instar 20 specimens have been available and possess well-formed cicatrices almost without exception. As to *C. garciniae*, the reexamined specimens (33 adult females, 35 2nd instar larvae, and 16 1st instar larvae) mostly possess well-formed cicatrices, and only 1 adult female specimen shows no trace of the feature.

The specimens collected in 1991 on *Garcinia* on Gg Jerai are referable to *C. garciniae* [5.3.], but only 5 out of the 40 examined specimens of the adult female have cicatrices on both sides, other 4 show an abortive cicatrix on one side only, and the other 31 specimens none. More than 30 specimens of the 2nd instar have been examined, and most of them possess well-formed cicatrices. Fifteen specimens of the 1st instar have been available ; most of them have cicatrices, which are, however, represented by a small circle without cells.

After all, cicatrices occur in the 1st and 2nd instar larvae and the adult females of *C. vaccinii* and *C. garciniae*. This feature is, however, not stable in occurrence and development, being often lost in the adult female and the 2nd instar, and sometimes abortive even in the 1st instar. Curiously enough, among the adult female specimens of *C. vaccinii* ever examined by myself the feature has been found only in the samples from Gg Jerai, except for the type specimens of *C. malesiana*.

Our knowledge on the larval stage of *Conchaspis* is still very poor, and we have no clear idea about the occurrence of cicatrices on the head in the larvae of other species. In some of the 1st instar specimens of *C. buchananiae* [91ML-260] I have found a pair of small circles on the head between the dorsal spots and the bases of the antennae (Fig. 5), but these spots are membranous and obscure, so that they have been clearly discernible only by phase-contrast microscopy.

3.2. Dorsal spots

The structures known under the name 'eye spots' or 'dorsal ocellar spots' are unique to the Conchaspidae. Following my previous study I call them 'cephalic dorsal spots', adopting the view that these structures have nothing to do with eyes or ocelli. In many species they appear to be transparent areas in light microscopy. In scanning electron microscopy, however, they are full of creases radiating from an invaginated point (central or nearly so in position) or a longitudinal fold (crease type). The invaginated centre or fold suggests that the spots are eversible. In fact, they can be swollen, and it seems that they have a definite role in test formation.

Figs. 20 and 21 show swollen and flattened dorsal spots of *C. vaccinii*. I am not sure how much the cephalic dorsal spots can be swollen, but they may be fully swollen only momentarily when, in my assumption, pushing up on the ceiling of the test under construction.

In some species of *Conchaspis* the cephalic dorsal spots 'are very conspicuous, being circumscribed by a ring of chitin within which a well-sclerotized disc occurs centrally' (Mamet, 1954) (disc type). *C. socialis* belongs to this type (Figs. 23 and 25). The central disc is not smooth but irregularly rugged on the surface (so that it cannot be an ocellar lens) (Fig. 24). It seems that the cephalic dorsal spots of this type are also projectable to bump against the ceiling of the test under construction (Fig. 23). In the 1st and 2nd instar larvae of *C. socialis* the cephalic dorsal spots are of the crease type (Fig. 22). Therefore, evolutionarily as well as ontogenetically the disc type should be preceded by the crease type.

Less conspicuous dorsal spots, with irregular creases, occur submedially across intersegmental furrows on the thorax and the base of abdomen (see Takagi, 1992, for details). They, too, may be eversible, having the same function as the cephalic dorsal spots, but I have failed to observe them in the supposed swollen state.

3.3. Antennae

In my previous paper I discussed the ontogenetic change of the antennae. I recognized among the species evolutionary stages in the decrease of the segments during the ontogenetic development caused by the incorporation of the basal 1 or 2 segments into the head and the fusion of segments. In the newly available *C. socialis* the change goes otherwise. In this species the antennae of the adult female appear to correspond to the 2nd to 6th segments of the 1st instar's antennae, but are scarcely or only obscurely segmented and wholly sclerotized (Fig. 8).

In the course of the present study I suspected that in *Conchaspis* species the number of the setae occurring on the terminal segment of the antenna might basically be 8 in spite of decreased setae observed especially in the 2nd instar and the adult female. It seemed also that these setae were somewhat variable in number even in the same species. I, therefore, carefully examined many specimens for the setae occurring on the terminal segment by oil-immersion microscopy. In the adult female and the 2nd instar larva of *C. angraeci* the terminal segment is plain, with no wrinkles, and the setae were always easily observed. In the examined specimens of the adult female the number of the setae varied from 4 to 6: there were always 2 fleshy and 2 long, stiff setae, all well developed, and sometimes also 1 or 2 short and slender setae (Takagi, 1992, Fig. 4C shows 1 extra seta in addition to the 4 well-developed setae). In the examined specimens of the 2nd instar female, too, there were 2 fleshy and 2 long, stiff setae as shown by Takagi (1992, Fig. 4B), and occasionally there was 1 small additional seta. No variation was found in the 1st instar, which possessed 8 setae—4 fleshy setae, 3 long, slender setae and, at the apex of the segment, 1 stiff seta (Takagi, 1992, Fig. 4A).

Variations were also observed in *C. buchanae*, *C. vaccinii* and *C. garciniae*, but I doubted that all the observed variations were real, because small or slender setae were not always easily discernible owing to the strong sclerotization and wrinkles of the segment and sometimes may have been overlooked. However, I have succeeded in finding specimens that have a complete set of 8 setae in all of the

1st and 2nd instar larvae and the adult female in all the 3 species (in addition, the spatulate seta of the penultimate segment is sometimes dislocated onto the terminal segment in the 2nd instar and the adult female). I have, therefore, prepared new drawings of antennae (Figs. 5-7), which should replace the previous ones (Takagi, 1992: Figs. 5 and 6). In the new drawings the terminal segments are all set with 8 setae. Nevertheless, variations may really occur, and a few setae, especially small ones, may sometimes be lost.

In *C. socialis*, too, the 1st instar showed 8 setae on the terminal segment in both male and female (in this species the male and female larvae can be easily distinguished [5.4.]) (Figs. 8 and 9). In the 2nd instar female (3 specimens examined) 4 thick setae were observed on the terminal segment (in addition, the spatulate seta of the penultimate segment was occasionally dislocated onto the terminal segment) (Fig. 8); 1 specimen, however, showed 1 short seta in addition to the 4 thick ones on one of the antennae. In the 2nd instar male (11 specimens) 4 thick setae and 4 or 3 short setae were found on the terminal segment (Fig. 9). Some specimens of the adult female, which were in good condition, showed 5 well-developed setae around the apex of the antenna (Fig. 8); the most remarkable, spatulate one of them, however, should originally belong to the penultimate segment.

I, therefore, adopt the view that in *Conchaspis* the antennae basically possess 8 setae on the terminal segment (Table 1). In *C. buchanae*, *C. vaccinii* and *C. garciniae* all these setae occur, though at times a few of them may really be lost especially in the 2nd instar and the adult female. In the 1st instar larvae of *C. angraeci* and *C. socialis* the setae are complete, but are variable in the 2nd instar and the adult female of *C. angraeci*, and are decreased to 4 in the 2nd instar female and adult female of *C. socialis*.

Apparently in many species of *Conchaspis* the antennae were described and figured only roughly and inaccurately by authors. They should be reexamined carefully for segmentation and setae, preferably in oil-immersion microscopy, and especially for their ontogenetic development. I believe that in *Conchaspis* the ontogenetic succession of antennal characters is worthy of study for elucidating phylogenetic relationships among species [7.].

3.4. Pectinae

In my previous work, structures that had not been known in *Conchaspis* were discovered by scanning electron microscopy—'pectinae' or fimbriate processes occurring dorsally at the apex of the pygidium. They are quite similar in shape to the pectinae ('plates' in authors) of diaspidids, which occur, however, ventrally along the margin of the abdomen. *C. angraeci* possesses 3 broad pectinae, 1 median and 2 laterals, in all of the 1st and 2nd instar larvae and the adult female. In *C. garciniae* the lateral pectinae alone are developed, and broad and well fimbriate in the 1st instar, but slender and less fimbriate in the adult female (the pectinae of the 2nd instar, which were not examined in my previous study, are still well fimbriate); the median pectina may be lost or much reduced in this species.

The other 3 species have also proved to possess pectinae. *C. buchanae* shows 3 broad pectinae in all of the larval instars and the adult female (Fig. 26: pectinae in the adult female). In *C. vaccinii*, the 3 pectinae are all broad and well fimbriate in the 1st instar, but in the adult female the lateral ones are slender and less

fimbriate and the median one, though still present, is not always easily observable (Figs. 27 and 28).

In *C. socialis* I have confirmed the occurrence of lateral pectinae alone. In the larval instars they are broad and fimbriate (Fig. 29: pectinae in the 1st instar). In the adult female they are slender and less conspicuous than thickened setae occurring around the anus (Fig. 4).

Fagisuga and *Asceloconchaspis* possess well-developed pectinae, which are observable by light microscopy (Williams, 1992). In *Conchaspis angraeci* and *C. socialis* (Figs. 4, 18 and 19), too, the pectinae are, though very small, visible by light microscopy, but in the other 3 species under my study (Figs. 15-17) their occurrence can be confirmed only by scanning electron microscopy. Probably these structures, however minute, are universal and persist in *Conchaspis*. Basically there are 3 pectinae, 1 median and 2 laterals, but the median one may be reduced or lost. Occurring at the apex of the pygidium, just dorsally (median pectina) or laterally to the anus, they are assumed to perform an important function at the excretion of the anal substance, which is used for constructing the test [4.1.].

3.5. Tubular ducts and '2-fissural disc pores'

The tubular ducts, occurring in the adult female and the 2nd instar, had long been supposed to open dorsally in *Conchaspis* until Khoo (1978) observed 'long glassy filaments' arising from the 'ventro-lateral' region of the segments bearing tubular ducts in *C. vaccinii*. I (Takagi, 1992) confirmed the ventropleural opening of tubular ducts in *C. buchananiae* and *C. garciniae*, too. In all these species the ducts are membranous around the orifice, which is, therefore, not easily observable, while they are strongly sclerotized at the inner end, which may come close to the dorsal derm of the body. Such being the case, the ducts may easily be mistaken for being dorsal especially under less powerful a microscope (I made the same error in my observation on the 1st instar of a certain diaspidid).

I have confirmed that also in *C. socialis* the tubular ducts open ventropleurally. The adult female becomes sclerotized throughout, and on the sclerotized derm the orifice of each duct is surrounded by a strongly sclerotized rim as illustrated by Mamet (1952). There seems to be no reason for mistaking, yet both Green (1896) and Mamet (1952) erroneously described the ducts as dorsal. This is, however, not wholly mysterious. As I stated previously, it is natural to presuppose that any ducts or pores responsible for the formation of a dorsal test should be dorsal.

Apparently *C. socialis* is not closely related to *C. buchananiae*, *C. vaccinii* and *C. garciniae*, yet it agrees with them in the ventropleural occurrence of tubular ducts. The view may be adopted that universally in the genus the tubular ducts are ventropleural.

Khoo (1978) observed disc pores of a peculiar type in the 1st instar larva of *C. vaccinii*. I found disc pores of the same type in *C. buchananiae* and *C. garciniae*, too, and called them '3-fissural disc pores' (Takagi, 1992). In the 1st instar of *C. socialis* 3 disc pores occur on the margin of the 1st to 3rd abdominal segments, but they have only 2 fissures meeting together at an angle and thus forming a widely opened V shape (Fig. 30). Dr Khoo pointed out a possible connection between the 3-fissural disc pores and the tubular ducts and suggested how the ducts could arise from the pores (see Takagi, 1992, p. 20, footnote). It seems that such 2-fissural pores as found

in *C. socialis* represent a step required by him in the arising of the tubular ducts from the 3-fissural disc pores. If his supposition is correct, the tubular ducts of conchaspids must have evolved within the family (thus having no immediate connection with the tubular ducts of other families), with their precursory structures (3- and 2-fissural disc pores) being still manifested in the 1st instar. (This assumption is harmonious with the fact that *C. angraeci* has no disc pores in the 1st instar and no ducts in the 2nd instar and adult female. It should also be noted that no tubular ducts occur in *Fagisuga* and *Asceloconchaspis*, which may be primitive genera in the family. In these genera, however, no disc pores similar to the 2- or 3-fissural ones are known to occur, either.) Little is known about the wax-secreting organs of the 1st instar in other *Conchaspis* species. Mamet (1952) and D'Ascoli and Kosztarab (1969) described the 1st instar larvae of *C. vayssierei* and *C. lata* as having short ducts. These species should also be reexamined from the new viewpoint based on the Asian species.

3.6. Dermal slits

'Dermal slits' (Takagi, 1992) are small slitlike invaginations occurring on the ventral surface of the abdomen. They are present in the 1st instar larvae of all the 5 species, but in the adult females they are decreased in number or absent (Table 2). Their function is unknown, but they may have some taxonomic value.

3.7. Sexual dimorphism in the larval stage

The male occurs in *C. buchananiae*, *C. vaccinii* and *C. garciniae*, but I have failed to discriminate between the male and female in the larval stage. The 1st instar larvae are somewhat variable in the depth of the hind femur, and I suspect that the variation involves sexual difference. In the 2nd instar, so far as based on some specimens having a developing adult female or a developing prepupa within the skin, the male tends to have larger values in the length of the hind trochanter + femur and in the total number of tubular ducts. However, in both instars the observed values afforded no sufficient difference for recognizing the sexes [also see the last paragraph of the section 5.4.].

In *C. socialis* the male tests do not occur separately, but are always collected together in the large female test (Green, 1896) [4.2.]. Male and female larvae can thus be segregated, and obvious differences have been found between them. The male larvae have much shorter legs in both instars (Figs. 3, 41 and 42). The antennae of the 1st instar larvae are also shorter in the male (length in the male, 106–114 μm , mean 111.4 μm , based on 10 antennae of 10 individuals; in the female, 118–130 μm , mean 124.3 μm , based on 7 antennae of 7 individuals); in the 2nd instar the antennae are thicker in the male (in the male, 40–44 μm thick; in the female, 30–34) (Figs. 8 and 9). In short, the male is reductive in the length of legs in the 1st and 2nd instars and also of the antennae in the 1st instar.

In all of these 4 species the male tests are much smaller than the female ones, but the 3 species except *C. socialis* show no recognizable sexual dimorphism in the larval stage. Indeed, the greater part of the female test is constructed by the adult female, and the larval stage may have no concern with the size difference between the completed male and female tests. However, the possibility is not definitely excluded that in *C. socialis* the formation of the especially small male test (compare Fig. 40 with Takagi, 1992, Fig. 78) requires less movement of the male larva and,

thus, is responsible for the reduction of the legs and antennae in the male larva.

I here suggest another possibility. Suppose that males in a female test are all sons of the female insect, then the male 'crawlers' need not crawl out of their mother's test for establishing themselves elsewhere. The size reduction of the legs and antennae in the 1st instar male should reflect the reduction of activity in dispersal. This supposition alone, however, does not explain the shortened legs in the 2nd instar male.

I am not sure whether *Conchaspis* crawlers disperse by wind in general. However, the 1st instar larva of *Conchaspis* is provided with a pair of long setae arising ventrally on the margin of the 6th abdominal segment, suggesting the possibility of dispersal by wind. In the female larva of *C. socialis* these setae are fairly long, attaining about 245 μm , while in the male larva they are much shorter, 78 μm or so. It is possible that the shorter setae also reflect the reduced dispersal activity of the male larva.

C. socialis is not the only species with an assumed familial test. Some other species are also known to have the male tests occurring in the female test. Their larvae are worthy of study from the viewpoint of sexual dimorphism.

4. NOTES ON TESTS

4.1. Supplementary notes on the female test of *C. garciniae*

The tests of *Conchaspis* species are made of substance from the anus, and, in the species with tubular ducts, ribbonlike wax filaments broken into short and long pieces are mixed in the substance like pieces of aggregate in concrete. The female test of *C. garciniae*, when completed, is very thick in the dorsal portion, which is composed of 3 zones—outer, intermediate and inner zones. The outer and inner zones are relatively thin, with pieces of wax filaments laid horizontal to the zones in tightly accumulated anal substance. The structure of these zones suggests the application of some pressure from inside the test at their formation [3.2.]. On the other hand, the intermediate zone is, as a whole, a coarse accumulation of lumps of the anal substance and pieces of wax filaments. However, some regularity is recognized in the accumulation (Takagi, 1992, Figs. 64 and 65).

The inner surface of a test in which the intermediate zone is under construction shows a number of ridges radiating from the centre (Figs. 32 and 33). Each ridge is the inner end of a wall. The intermediate zone is, thus, composed of radiating walls standing vertical to the outer zone (and also to the inner zone when the test is completed). The walls, formed from irregularly shaped lumps of the anal substance mingled with pieces of wax filaments, are never neatly shaped, being rugged, bent, curved, and interrupted here and there (Figs. 34-37).

The radiating walls, which are deepest at the centre of the test (Takagi, 1992, Fig. 64-66), suggest how the insect behaves when constructing the intermediate zone. Apparently, after completing the outer zone, it keeps the head below the centre of the ceiling of the test, bends the abdomen up so that the tip of the abdomen may attain the ceiling just above the head, and, applying the anus on the ceiling and excreting, draws the abdomen back. Thus a ridge will be formed from the centre towards the margin on the ceiling. Then, I assume, the insect moves a little aside and forms another ridge alongside. A round of such movements will make a circle

full of radiating ridges on the ceiling. Later movements and excretion will follow the ridges once formed, and thus the ridges will gradually grow to walls. The features around the anus—pectinae, setae, and a pair of round prominences situated just ventrally to the anus—will function in recognizing the ceiling and ridges and in controlling the anus to excrete properly.

The manner of secreting wax filaments is another reason to suppose that the insect bends the abdomen up when constructing the dorsal portion of the test. The tubular ducts open ventropleurally [3.5.]. Wax filaments, when secreted, are directed posteriorly, growing a little curved mesad (Fig. 31). Those arising from both sides of the body extend along the lateral sides of the abdomen eventually to meet together across the ventral surface of the apical region of the abdomen (Takagi, 1992, Fig. 38). The insect does not need to apply the ventropleural region of the body (where the tubular ducts open) to the ceiling of the test. The act of applying the apex of the abdomen to the ceiling will supply wax filaments as well as lumps of the anal substance to the test. The *Conchaspis* species are peculiar in the anus which opens not dorsally but just at the apex of the abdomen in all of the larval stages and adult female. Undoubtedly this character is associated with their behaviour in forming the test.

4.2. Familial (?) test in *C. socialis*

Green (1896) gave a detailed description of the female and male tests of *C. socialis*—the female tests ‘look like warty excrescences on the twigs of the shrub, and in spite of their size are very inconspicuous’; the male tests ‘do not occur separately, but are always collected together, in ten or more, beneath’ the large female test.

I observed the same in the material from Sarawak. The female test is composed of a thin dorsal portion and a skinny ventral portion (Fig. 39). On the branch of the host plant it is flat and covered with a thin upper layer of the bark (Fig. 38). Apparently the insect burrows under the upper layer of the bark; thus the test looks like an inconspicuous warty excrescence on the branch and is similar to the tests of the burrowing females of certain diaspidids. The male tests, always found in a mass in the completed female test, are very small in comparison with the female test and elongate, with the ventral portion relatively well formed (Fig. 40). It was often difficult to separate male tests from their mass without breaking them and, therefore, also to count them exactly. In some cases I observed male larvae inhabiting their tests, and counted 8-14 larvae in a mass. Only 1 individual of the adult female was found beneath the female test and always in a narrow space between the dorsal portion of the female test and the mass of male tests. I do not agree with Green (1896) in his view that female and male insects found in the same test belong to the same generation. I am strongly inclined to believe that they are mother and sons [3.7.].

5. REMARKS ON THE SPECIES

5.1. *Conchaspis angraeci*

The newly collected specimens (Fig. 10) well agree with the previous ones [90ML-324 and -511]. However, the adult females collected from *Homalium*

[91ML-453] seem to have somewhat fewer multilocular disc pores than those from *Trigonostemon* (total on both sides, 20-30, mean 24.2, $n=20$ in 91ML-299 and -307 combined; 15-28, mean 22.7, $n=19$ in 91ML-453; also compare with Takagi, 1992, Table 3).

5.2. *Conchaspis buchananiae*

The specimens of the adult female from Sarawak [91ML-260] (Figs. 11 and 15) well agree with those from Malaya [90ML-239] in the total numbers of multilocular disc pores (Fig. 1) and tubular ducts (Table 3), and do not much differ in the length of the hind trochanter + femur (90-112 μm , mean about 99 μm , in 91ML-260, and 98-112 μm , mean about 104 μm , in 90ML-239). No closer agreement would be expected even for samples from the same locality and the same host plant. However, in the 2nd instar the tubular ducts are slightly more numerous in the sample from Sarawak (Table 4).

5.3. *Conchaspis vaccinii* and *C. garciniae*

C. vaccinii as understood in this paper is widely variable in the occurrence and development of the cicatrices of the head [3.1.], in the number of multilocular disc pores (Fig. 1), in the number of tubular ducts, and in the length of the hind trochanter + femur (Tables 5, 6 and 8).

Adult females possessing well-formed cicatrices on the head have been found together with those having no trace of the feature in the same colonies on Gg Jerai. *C. malesiana* and *C. vaccinii* can no longer be distinct forms. *C. garciniae* is also variable as to this feature, and cannot be distinguished from *C. vaccinii*, either, on the basis of the presence or absence of cicatrices on the head [3.1.]. Apparently *C. vaccinii* and *C. garciniae* are very close (Figs. 12, 13, 16 and 17), and their distinctness should be reexamined.

The examined samples of *C. vaccinii* and *C. garciniae* form an almost continuous series in the number of multilocular disc pores (Fig. 1) and are also nearly continuous in the number of tubular ducts and the length of hind trochanter + femur (Table 6). It seems that the numbers of the disc pores and ducts vary, to some degree, in correlation with the length of the hind trochanter + femur (Table 6), which is expected to correlate with the body size at full growth. Thus, *C. garciniae* may be thought to represent a mere fraction of the continuous series of forms, comprising larger individuals. However, there are still reasons for recognizing *C. garciniae* as a distinct species.

In my previous paper I showed that *C. vaccinii* and *C. garciniae* remarkably differed in the distribution pattern of multilocular disc pores in the submarginal, intermediate and submedian groups of the 3rd and 4th abdominal segments (Takagi, 1992, Fig. 1). *C. garciniae* was characterized by a strong concentration of disc pores in the submarginal groups. This tendency is also well displayed in the new samples from Gg Jerai [91ML-315, -351, and -392] (Fig. 2), which are, therefore, referred to *C. garciniae* in spite of the absence of cicatrices on the head in a great part of the examined specimens. The samples of *C. vaccinii* from Gg Santubong [91ML-256] and Gg Jerai [91ML-313, -341, and -390; and 91ML-391] have as many disc pores as *C. garciniae* (Fig. 1), yet their distribution patterns of disc pores are definitely of the *vaccinii* type (Fig. 2). Furthermore, it may not be meaningless that the samples from sympatric populations of these species (that is, the samples collected at

Kuantan and also those at Gg Jerai) significantly differ in the mean total number of disc pores (Fig. 1), and are considerably different in the total number of ducts and the hind trochanter+femur length (Tables 5-8). If we adopt the view that they belong to the same species, we must explain why the sympatric samples differ so remarkably.

The posteriormost ventral plates of the abdomen (belonging to the 7th segment) become gradually narrower anteriorly in *C. vaccinii*, while are abruptly attenuated on the mesal side at anterior third in *C. garciniae* (compare Figs. 16 and 17). The apparent basal segment of the adult female antenna (which corresponds to the 3rd and 4th segments of the 1st instar's antenna) is often enormously swollen in *C. garciniae* (compare Figs. 6 and 7), but sometimes this is also the case with *C. vaccinii*.

These species remarkably differ in the internal structure of the female test. In *C. garciniae* the intermediate zone of the dorsal portion is composed of vertical walls radiating from the centre (Figs. 32-35; Takagi, 1992, Figs. 64-66) [4.1.]. In *C. vaccinii* it is similar to the inner and outer zones and recognizable merely by its coarse texture (Takagi, 1992, Figs. 82-86; I have observed the same in 91ML-488). Apparently the adult females of these species behave differently in forming the test.

5.4. *Conchaspis socialis*

The specimens from Sarawak agree with the descriptions given by Green (1896) and Mamet (1952) considerably (Figs. 14, 18, and 19), but not in every detail. Their descriptions and drawings, however, contain such a misconception as the 'dorsal' tubular ducts [3.5.]. They state that the antennae of the adult female are 3-segmented, whereas in my observation the antennae are not distinctly segmented. But I doubt that this disagreement is real, because, in general, authors were not accurate in describing and drawing the antennae of *Conchaspis* species [3.3.]. (Needless to say, microscopes have been greatly improved since Green's time. In consideration of the power of microscopes in his time, Green's observation of *C. socialis*, made 100 years ago, is surprisingly detailed).

The tubular ducts are as follows in the specimens from Sarawak: 3-9 on metathorax, 4-10 on abd I, 4-9 on II, 3-7 on III, and 2-4 on IV; total on one side, 19-33, mean 26.4; total on both sides, 40-64 (based on 7 specimens). Multilocular disc pores occurring on abd I-III and at times also on IV, all in submarginal groups; 9-14 on I, 8-14 on II, 4-10 on III, and 0-2 on IV; total on one side, 23-35, mean 28.3; total on both sides, 48-65, mean 56.5 (based on 8 specimens). The specimens, then, agree with the redescription given by Mamet in the numbers of ducts; they do not with but are still close to the latter in the numbers of disc pores. This is noteworthy when the great distance between the localities—Sarawak and Sri Lanka—is taken into consideration.

This species shows a remarkable sexual dimorphism in the larval stage, the males and females of both instars obviously differing in the legs and antennae [3.7.]. In the 2nd instar the male tends to have more tubular ducts, but the difference is so small that, when both sexes are sampled together, the frequency distribution shows no indication of the mixed samples (Table 9).

6. KEY TO THE ASIAN SPECIES OF CONCHASPIS

Key to the families of Coccoidea : see Williams and Watson, 1990.

Key to the genera of Conchaspidae : see Williams, 1992.

1. Antennae with 6 segments; abdomen with a pair of long, especially outstanding setae towards the apex (ventrally on the margin of abd VI). First instar: 10
 - Antennae with fewer apparent segments (represented by sclerotized bands), or sclerotized throughout. 2
2. With multilocular disc pores; with a dermal invagination just posteriorly to hind coxa (or to mid and hind coxae each). Adult female: 3
 - Without multilocular disc pores; without dermal invagination. Second instar: 7
3. Dorsal spots of head with a sclerotized disc centrally; dermal invaginations present only posteriorly to hind coxae; dermal slits absent; submarginal dorsal bosses absent; multilocular disc pores occurring only in submarginal groups; claws with a denticle on plantar surface; derm becoming sclerotized throughout; antennae sclerotized throughout. *C. socialis*
 - Dorsal spots of head wholly membranous (central disc absent); derm not sclerotized throughout; antennae with sclerotized bands representing segments or fused segments; submarginal dorsal bosses present. 4
4. Without tubular ducts; dermal invaginations present only posteriorly to hind coxae; dermal slits absent; multilocular disc pores often occurring in all of submedian, intermediate and submarginal groups; claws with a small denticle on plantar surface; antennae with 4 apparent segments. *C. angraeci*
 - With tubular ducts; claws without denticle on plantar surface. 5
5. Dermal invaginations present only posteriorly to hind coxae; dermal slits absent; multilocular disc pores few (9-18 in total on both sides), yet often occurring in all of submedian, intermediate and submarginal groups; cicatrices absent laterally to dorsal spots of head; antennae with 4 apparent segments. *C. buchanae*
 - Dermal invaginations present posteriorly to mid and hind coxae; a pair of dermal slits present caudad of vulva; cicatrices present or absent laterally to dorsal spots of head; antennae with 3 apparent segments. 6
6. Posteriormost ventral plates of abdomen (abd VII) gradually narrowing anteriorly; multilocular disc pores usually occurring in all of submedian, intermediate and submarginal groups. *C. vaccinii* (= *C. malesiana*; ? = *C. hainanensis*)
 - Posteriormost ventral plates of abdomen (abd VII) abruptly attenuated on mesal side at anterior third; multilocular disc pores tending to concentrate in submarginal groups. *C. garciniae*
7. Tubular ducts absent; dermal slits rudimentary if present; antennae with 5 apparent segments; claws with a small denticle on plantar surface. *C. angraeci*
 - Tubular ducts present. 8
8. Claws with a denticle on plantar surface; submarginal dorsal bosses absent; a pair of dermal slits present; tubular ducts less than 20 in total on both sides. *C. socialis*
 - Claws without denticle; submarginal dorsal bosses present; 3 dermal slits present. 9
9. Antennae with 5 apparent segments; tubular ducts less than 30 in total on both sides. *C. buchanae*
 - Antennae with 4 apparent segments; tubular ducts more than 30 in total on both sides. *C. vaccinii*
10. Without disc pores; antennae not elaborately reticulate-annulate; claws with a small denticle on plantar surface. *C. garciniae*
 - With 3 disc pores pleurally on each side of abdomen (abd I-III). *C. angraeci*
11. Disc pores with 2 fissures meeting together at an angle to form a V; a pair of dermal slits present; claws with a denticle on plantar surface. *C. socialis*
 - Disc pores with 3 fissures meeting together at centre; 3 dermal slits present; antennae elaborately reticulate-annulate; claws without denticle. 12

12. Head without cicatrices dorsally near bases of antennae (though small obscure circles may be present). *C. buchanae*
- Head usually with a pair of cicatrices dorsally near bases of antennae (the cicatrix may sometimes be reduced to a small circle). *C. vaccinii*
C. garciniae

7. CONCLUDING REMARKS

My study in the family Conchaspidae has been limited to the 5 species, yet suffices for recognizing the importance of ontogeny for the systematics of this family. The antennae, for example, are subjected to the incorporation of their basal part into the head, the fusion of segments, the reduction of setae occurring on the terminal segment, and so on in the course of development from the 1st instar to the 2nd, and to the adult female. No doubt comparisons in ontogenetic changes will be essential in evaluating characters. Not only that. Rather, ontogeny should constitute the nucleus of systematics. Once we adopt 'the premise that the natural system of classifying forms is one based on the processes generating those forms' (there seems to be no good reason against this premise), we reasonably conclude that 'any taxon can be defined as a class of individuals sharing a common developmental field individuated to the same hierarchical level' (Ho and Saunders, 1994). Comparisons in developmental processes will lead to a sound recognition of taxa and their ranking. We do not know yet whether and how the process of embryonic development can contribute to conchaspidid systematics and coccoid systematics. We are not certain how the adult male can be incorporated in an ontogenetic approach, either. In conchaspids, however, the adult female and the larval instars have features whose characters can be traced through them. Fortunately, as far as my experience goes, it is usual rather than occasional to find larvae of both the 1st and 2nd instars and adult females all together in the same samples.

Functional morphology is also important. A remarkable sexual dimorphism has been found in the larval stage of *C. socialis*, and the possibility has been posed that in the 1st instar the sizes of the legs and antennae are sensitive to activity in dispersal. In all instars the sizes of these features should be meaningful from the viewpoint of behaviour. Some characters—the occurrence of dorsal spots, the apical opening of the anus, the ventropleural position of the tubular ducts—are apparently associated with the test forming behaviour and well characterize the genus *Conchaspis*. On the other hand, we are still ignorant about the function of the dermal slits, which are variable in occurrence and number among species and instars. We do not know the role of the dermal invaginations, and we cannot understand why they are limited to the adult female and why they occur in 2 pairs exceptionally in certain species. The multilocular disc pores of conchaspids have a peculiar structure, and produce wax-rings in the manner I called 'retroduction' (Takagi, 1992). In other coccoids, wax-rings are produced by other types of disc pores and in other manners. An inevitable question here is whether all these types of disc pores, while agreeing in producing wax-rings, have the same origin or have evolved independently.

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ERRATUM

Takagi, S. 1992. A contribution to conchaspidid systematics (Homoptera: Coccoidea). *Insecta Matsumurana New Series* 46: 1-71.

Page 8, Table 1, *C. vaccinii* bottom, '31-57' should be corrected to '35-57'.

TABLES

Table 1. Setae and dislike sensillum on the antennal segments of *Conchaspis*: basic pattern.

Segment	I	II	III	IV	V	VI
Seta (e)	2	2	0	1	1	8
Sensillum		+				

Comments :

- 1) The setae of the basal 1 or 2 segments will be dislocated onto the head in the 2nd instar and the adult female as a result of the incorporation of these segments into the head.
- 2) The seta occurring on segment V is always fleshy and often spatulate. It is often dislocated onto segment VI in the 2nd instar and the adult female.
- 3) The setae occurring on segment VI may be decreased and variable in number especially in the 2nd instar and the adult female.
- 4) Segments, especially III and IV, may be fused together in the adult female.
- 5) Minute invaginated setae, when present, are found on segment IV (or fused segments III+IV) and VI.

Table 2. Number of dermal slits.

Instar	<i>C. vaccinii</i> <i>C. garciniae</i>	<i>C. buchanae</i>	<i>C. socialis</i>	<i>C. angraeci</i>
First instar	3	3	2	2
Second instar	3	3	2	rudimentary
Adult female	2	0	0	0

Table 3. Total number of tubular ducts in *C. buchanae* adult females.

Sample	Total on both sides	Total on one side		
		Range	Mean \pm 2S.E.	<i>n</i>
91ML-260	33-84	16-42	26.6 \pm 1.6	26 \times 2
90ML-239	40-69	19-36	26.0 \pm 0.9	25 \times 2

Table 4. Frequency distribution of tubular ducts in *C. buchanae* 2nd instar larvae (91ML-260).

No. of ducts	0	1	2	3	4
Metathorax		22	12		
Abd I			9	22	3
II			6	28	
III			18	16	
IV		2	32		
V	33	1			
Total on both sides	19-28				
one side	9-14	mean \pm 2S.E. = 11.4 \pm 0.47			

n = 17 \times 2

Compare with Takagi, 1992, Table 1, data for *C. buchanae*, 90ML-239; total on one side, mean \pm 2S.E. = 9.0 \pm 0.22, *n* = 18 \times 2.

Table 5. Frequency distribution of tubular ducts in *C. vaccinii* 2nd instar larvae. 91ML-313, -341, -390 (Gg Jerai, on *Symplocos*)

No. of ducts	0	1	2	3	4	5	6	7	8	9	10
Metathorax					2	10	16	23	20	9	4
Abd I				1	3	12	19	28	15	3	3
Abd II				1	5	25	23	24	5	1	
Abd III			2	8	21	30	18	5			
Abd IV		5	70	9							

$n=42 \times 2$

91ML-488

No. of ducts	0	1	2	3	4	5	6	7	8	9	10
Metathorax				1	11	38	59	29	8		
Abd I				3	23	45	55	17	3		
II				7	35	70	29	5			
III			3	28	69	42	4				
IV	2	28	99	15	2						

$n=73 \times 2$

Table 6. Hind trochanter+femur length and approximate total number of tubular ducts in *C. vaccinii* and *C. garciniae* adult females.

Sample		Hind trochanter+femur length in μm (rounded mean in parentheses)	Approximate total number of tubular ducts (on both sides)
91ML-101	<i>Cv</i>	116-122 (119)	102, 113
91ML-136	<i>Ev</i>	132-152 (141)	124-164
Paratypes of <i>C. malesiana</i>	<i>Dv</i>	132-150 (142)	111
90ML-238, -311, -545	<i>Gv</i>	130-164 (146)	101-209
91ML-488	<i>Fv</i>	126-174 (151)	112-193
91ML-401	<i>Iv</i>	144-164 (153)	134-204
92SP-60	<i>Hv</i>	144-162 (155)	99-156
91ML-313, -341, -390	<i>Mv</i>	134-170 (155)	107-230
91ML-391	<i>Lv</i>	138-172 (155)	171-223
91ML-498	<i>Jv</i>	152-172 (165)	172-190
90ML-167, -186, -187, -295	<i>Ng</i>	156-192 (175)	230-306
91ML-256	<i>Kv</i>	152-200 (179)	148-237
91ML-315, -351, -392	<i>Og</i>	182-238 (202)	256-396

Samples are arranged in order of increasing hind trochanter+femur length. Symbols *Cv*-*Og* are in alphabetical order in Fig. 1, in which the samples are arranged in order of increasing mean total number of multilocular disc pores. The hind trochanter+femur length may have not always been adequately measured, and the values of the total number of tubular ducts are no more than approximations and are based on limited numbers of specimens in both the samples of *C. garciniae* and in some samples of *C. vaccinii* [2.7.]. Rank correlation coefficients (τ) calculated between the mean total number of disc pores and the mean hind trochanter+femur length and between the mean total number of disc pores and the median total number of tubular ducts are about 0.8.

Table 7. Frequency distribution of tubular ducts in *C. garciniae* 2nd instar larvae (91ML-315, -351, -392).

No. of ducts	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Metathorax										5	9	14	21	13	4	4
Abd I								6	9	23	18	9	3	2		
II						2	10	11	25	14	8					
III					3	13	27	20	5	2						
IV	1	2	36	28	3											

$n=35 \times 2$

Table 8. Total tubular ducts in *C. vaccinii* and *C. garciniae* 2nd instar larvae.
C. vaccinii

Sample	Total on both sides	Total on one side		
		Range	Mean \pm 2S.E.	<i>n</i>
91ML-488	33-58	14-29	22.3 \pm 0.52	73 \times 2
90ML-238, -311, -545	35-57	16-29	22.8 \pm 0.58	48 \times 2 + 1
91ML-136	37-56	18-30	24.1 \pm 1.24	13 \times 2
91ML-313, -341, -390	35-67	16-36	26.6 \pm 0.92	42 \times 2

C. garciniae

Sample	Total on both sides	Total on one side		
		Range	Mean \pm 2S.E.	<i>n</i>
90ML-167, -186, -187, -295	46-65	21-34	26.7 \pm 0.48	58 \times 2
91ML-315, -351, -392	63-94	30-49	38.0 \pm 0.97	35 \times 2

Table 9. Frequency distribution of tubular ducts in the 2nd instar *C. socialis*.

No. of ducts	Female			Male			Sexes combined		
	1	2	3	1	2	3	1	2	3
Abd. I		8			17	5		25	5
II		8			21	1		29	1
III	4	4			22		4	26	
IV	8			22			30		
Total on both sides	12-14			14-16			12-16		
Total on one side	6-7 (mean 6.5)			7-9 (mean 7.3)			6-9 (mean 7.1)		

$n=4 \times 2$

$n=11 \times 2$

$n=(4+11) \times 2$

PLATES

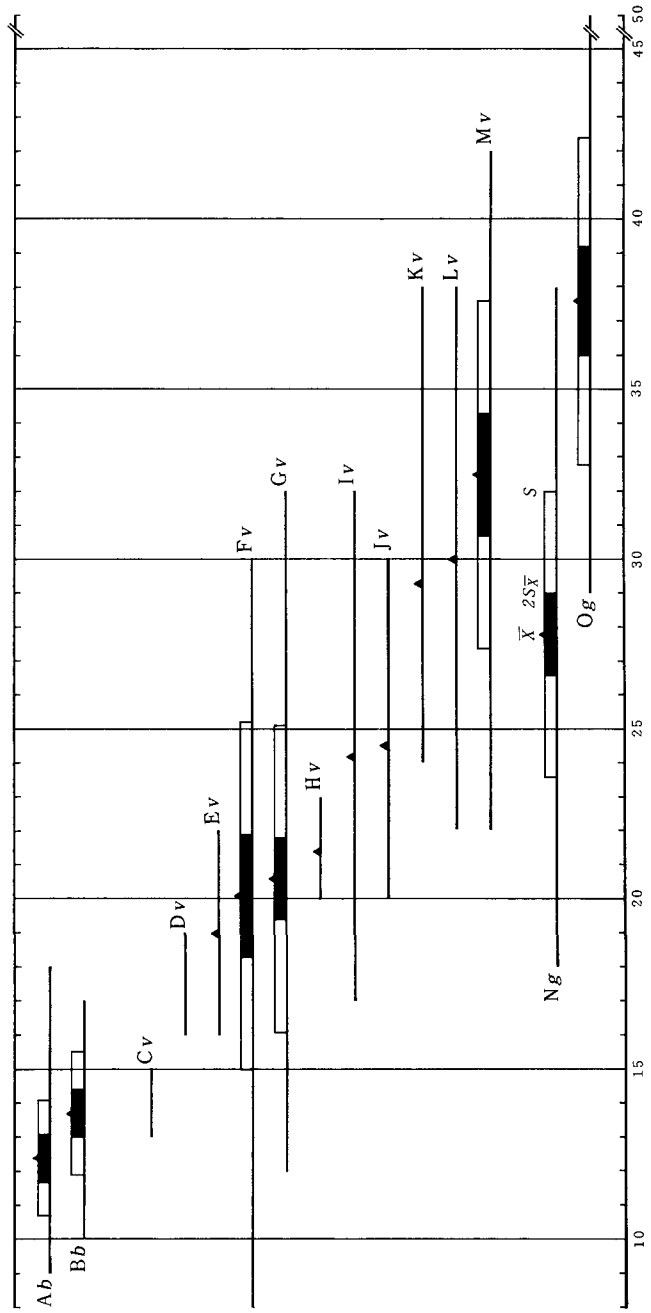


Fig. 1. Total number of multilocular disc pores. Complete Dice-grams are given for samples with $n \geq 25$ and show range, mean, and, on either side of mean, 2 standard errors and 1 standard deviation. Samples with fewer specimens are represented by range and mean or only by a line connecting the observed numbers.

C. buchananiae

Ab Gg Santubong, Sarawak, on *Bulbophyllum* [91ML-260] ($n=26$)

Bb Bt Bauk, Malaya, on *Buchanania* [90ML-239](25)

C. vaccinii

Cv TN Bako, Sarawak, on *Payena* [91ML-101](2)

Dv Bt Timah, Singapore, on a plant of Apocynaceae [paratypes of *C. malesiana*] (2)

Ev TN Bako, Sarawak, on *Willughbeia* [91ML-136] (6)

Fv HS Pantai Acheh, Pl Pinang, on *Urophyllum* [91ML-488](31)

Gv East Coast of Malay Peninsula (Bt Bauk, Kuantan and Desaru), on *Garcinia* and *Payena* [90ML-238, -311, and -545] (53)

Hv Bt Timah, Singapore, on *Elaterospermum* (?) [92SP-60](5)

Iv Bt Wang, Malaya, on *Urophyllum* [91ML-401](5)

Jv Bt Cendana, Pl Pinang, on *Urophyllum* [91ML-498](8)

Kv Gg Santubong, Sarawak, on *Mangifera* [91ML-256](8)

Lv Gg Jerai, Malaya, on *Planchonella* [91ML-391](12)

Mv Gg Jerai, Malaya, on *Symplocos* [91ML-313, -341, and -390](30)

C. garciniae

Ng Kuantan, Malaya, on *Garcinia* [90ML-167, -186, -187, and -295] (54)

Og Gg Jerai, Malaya, on *Garcinia* [91ML-315, -351, and -392] (40)

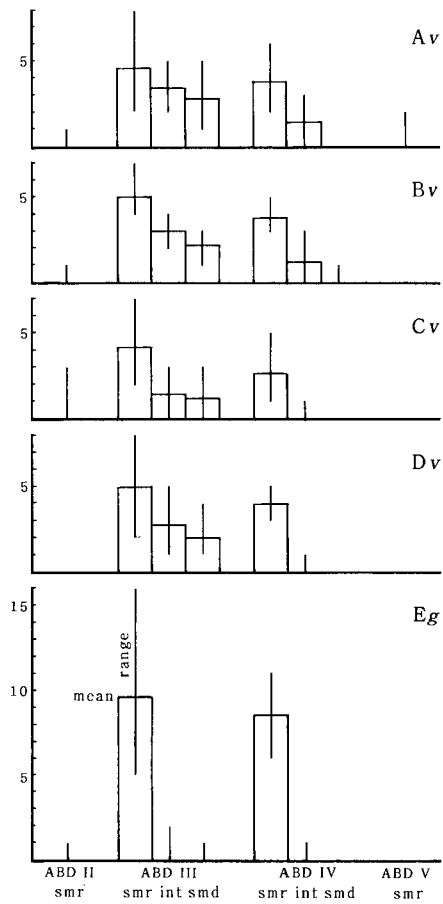


Fig. 2. Number of multilocular disc pores in each of the submarginal (smr), intermediate (int) and submedian (smd) groups on the 2nd to 5th abdominal segments in *C. vaccinii* (Av-Dv) and *C. garciniae* (Eg). Av: 91ML-313, -341, and -390 ($n=30 \times 2$); Bv: 91ML-391 (12×2); Cv: 91ML-488 (31×2); Dv: 91ML-256 (8×2); Eg: 91ML-315, -351, and -392 (40×2).

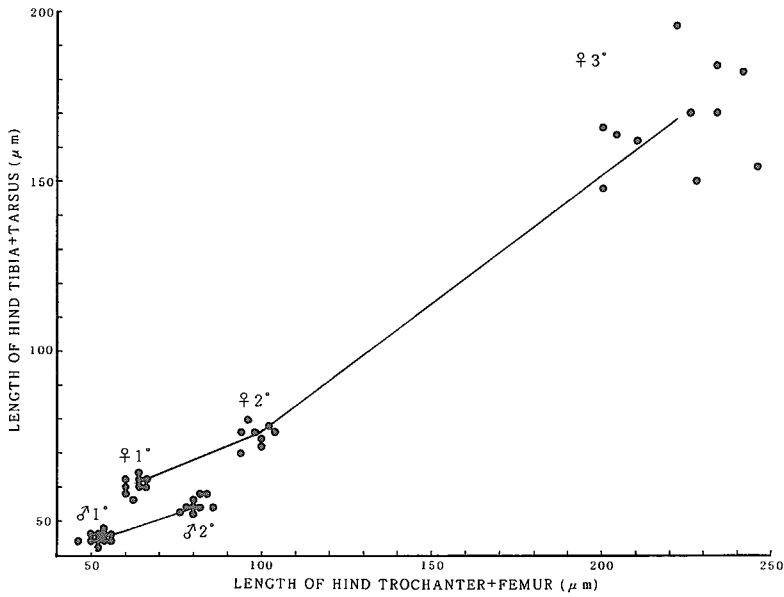


Fig. 3. Length of hind tibia+tarsus against length of hind trochanter+femur in larval instars and adult female of *C. socialis*. Sample sizes are as follows: 1st instar male, $n=9 \times 2+2$; 2nd instar male, 8×2 ; 1st instar female, 7×2 ; 2nd instar female, 4×2 ; adult female, $4 \times 2+3$.

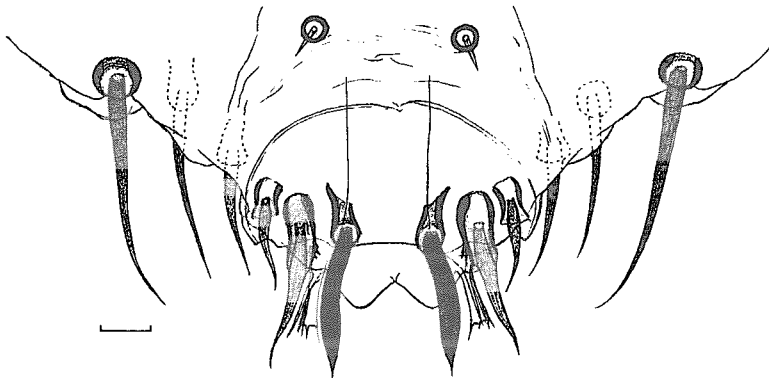


Fig. 4. *C. socialis*; adult female: apex of abdomen, dorsal view. Scale: $10 \mu\text{m}$.

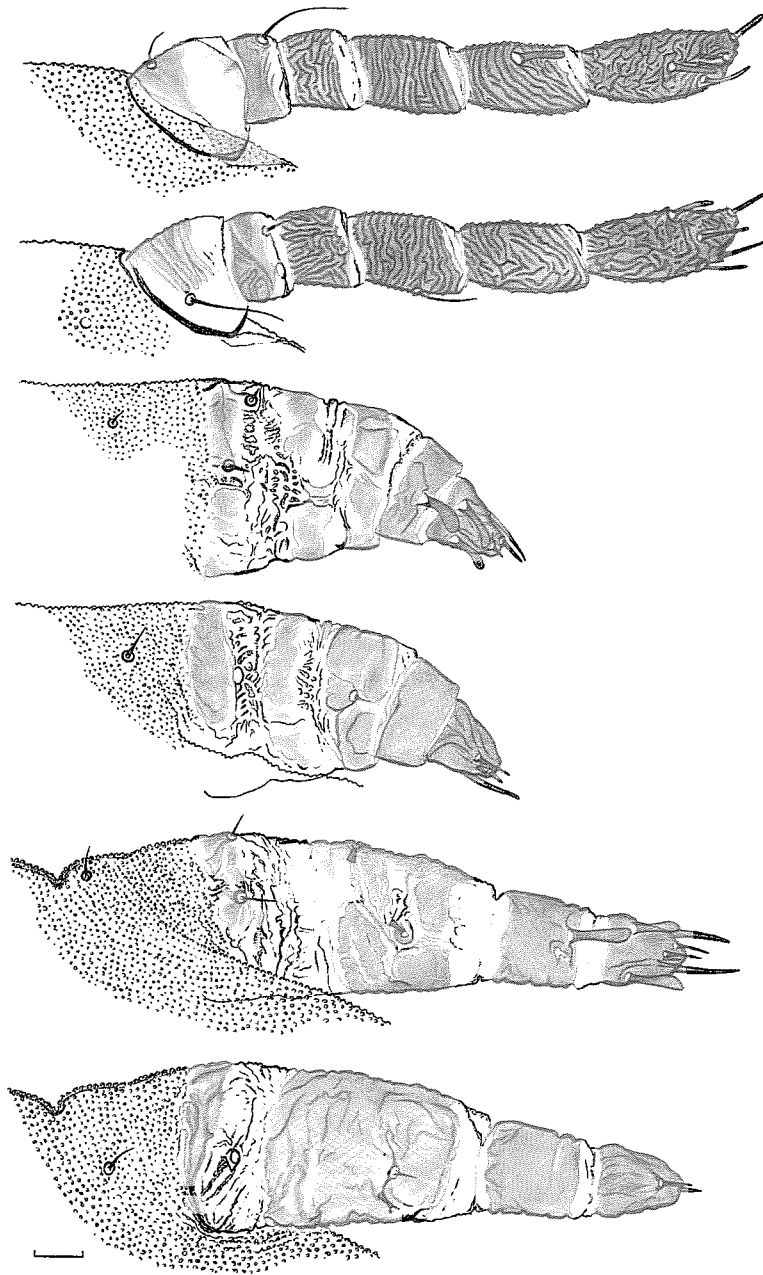


Fig. 5. *C. buchanaeiae*: antennae of 1st instar larva, 2nd instar larva and adult female (from top to bottom), ventral and dorsal views for each instar [91ML-260]. Scale: 10 μ m.

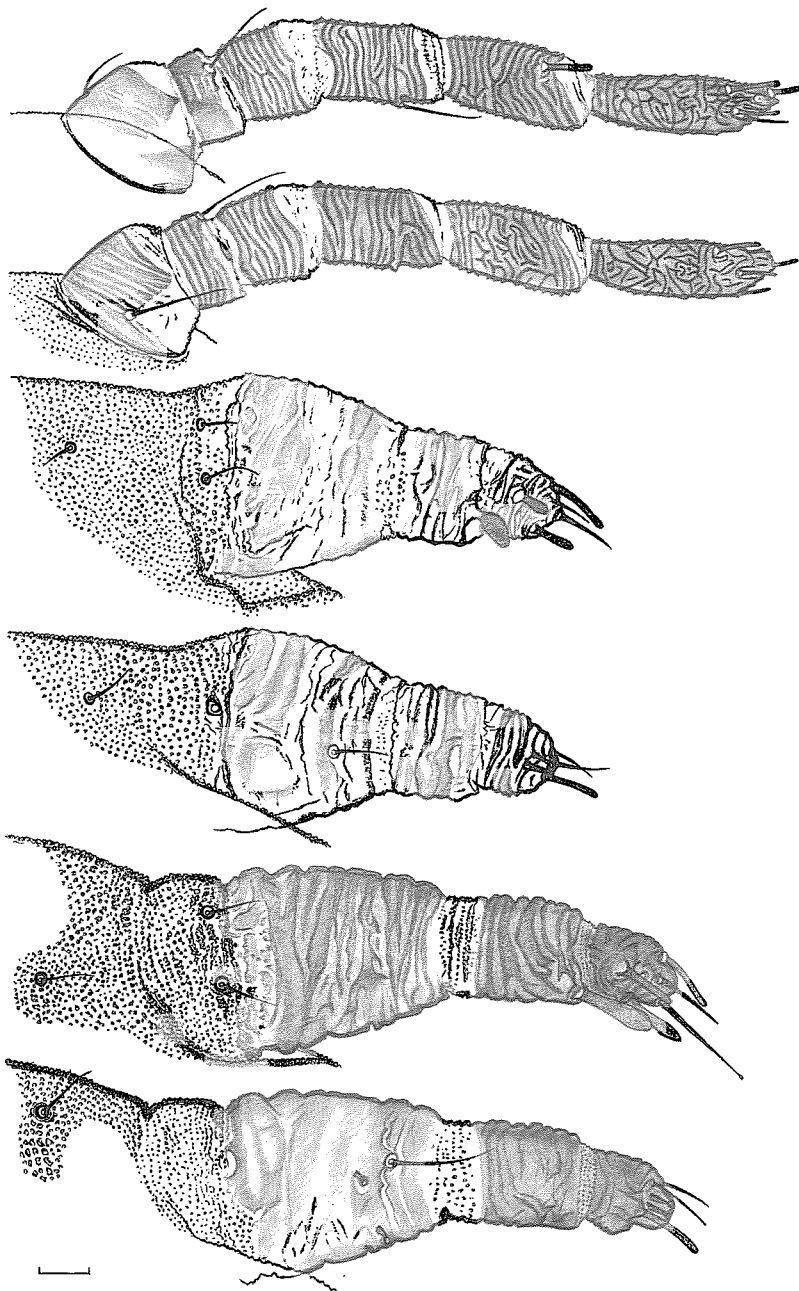


Fig. 6. *C. vaccinii* : antennae of 1st instar larva, 2nd instar larva and adult female (from top to bottom), ventral and dorsal views for each instar [91ML-488]. Scale : 10 μ m.

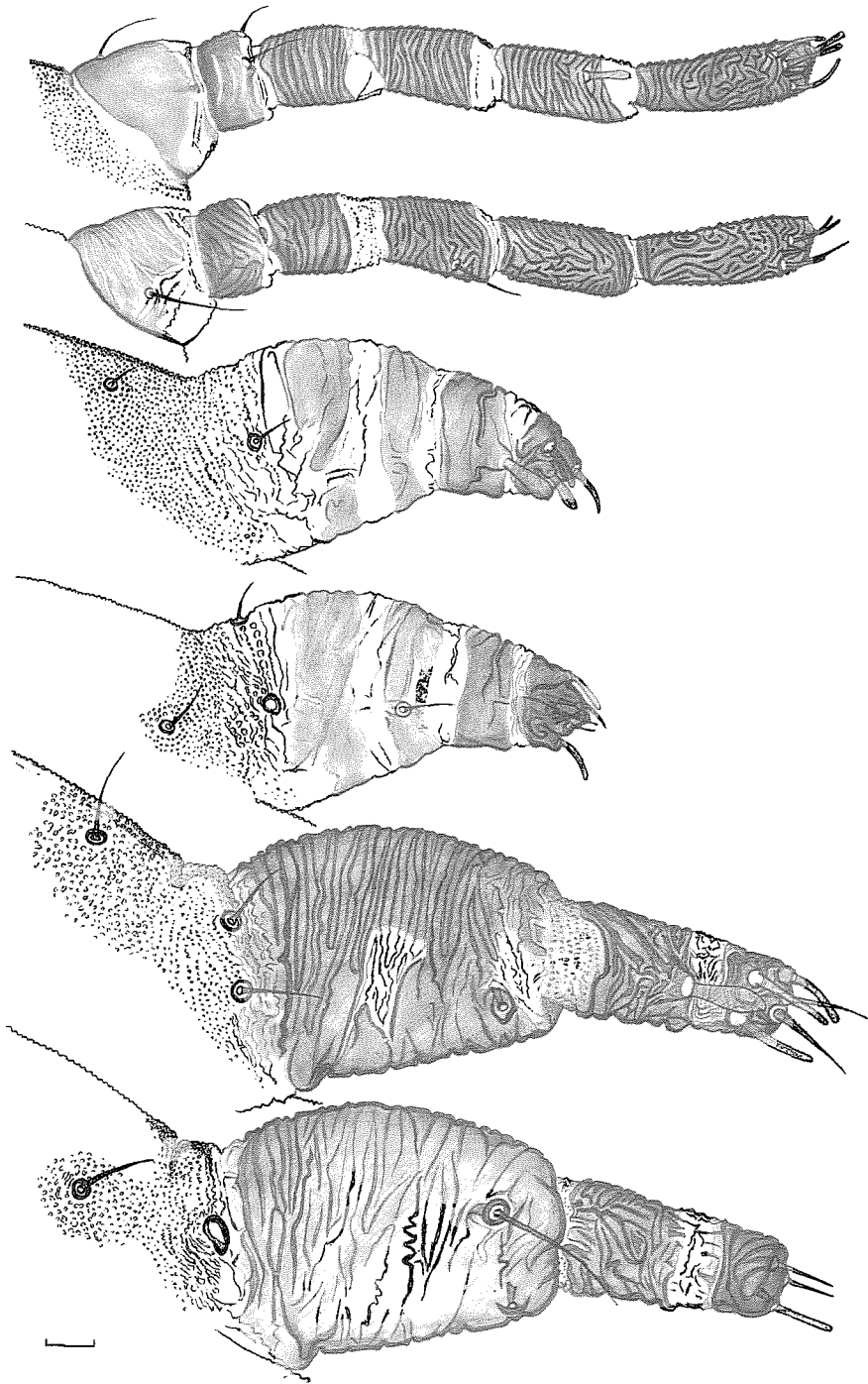


Fig. 7. *C. garciniae*: antennae of 1st instar larva, 2nd instar larva and adult female (from top to bottom), ventral and dorsal views for each instar [1st and 2nd instar larvae: 91ML-392; adult female: 91ML-351]. Scale: 10 μ m.

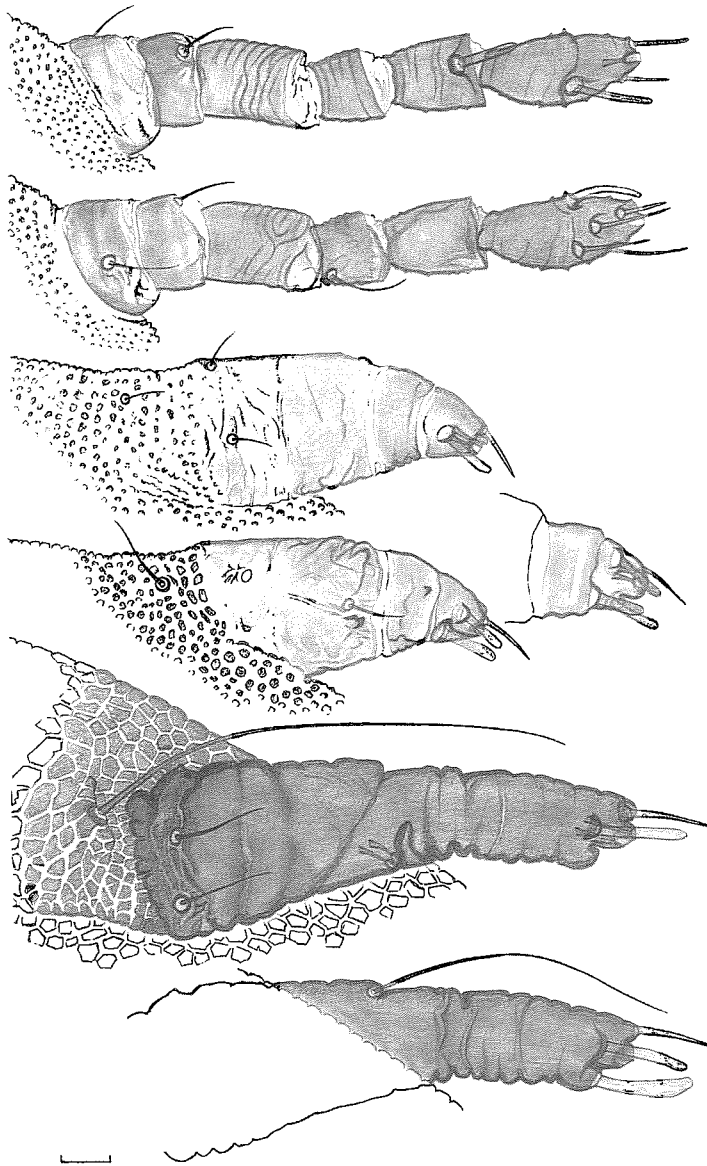


Fig. 8. *C. socialis*: antennae of 1st instar female, 2nd instar female and adult female (from top to bottom), ventral and dorsal views for each instar. The inserted drawing shows the terminal and penultimate segments of another 2nd instar specimen (the fleshy seta of the penultimate segment is not dislocated onto the terminal segment). Scale: 10 μ m.

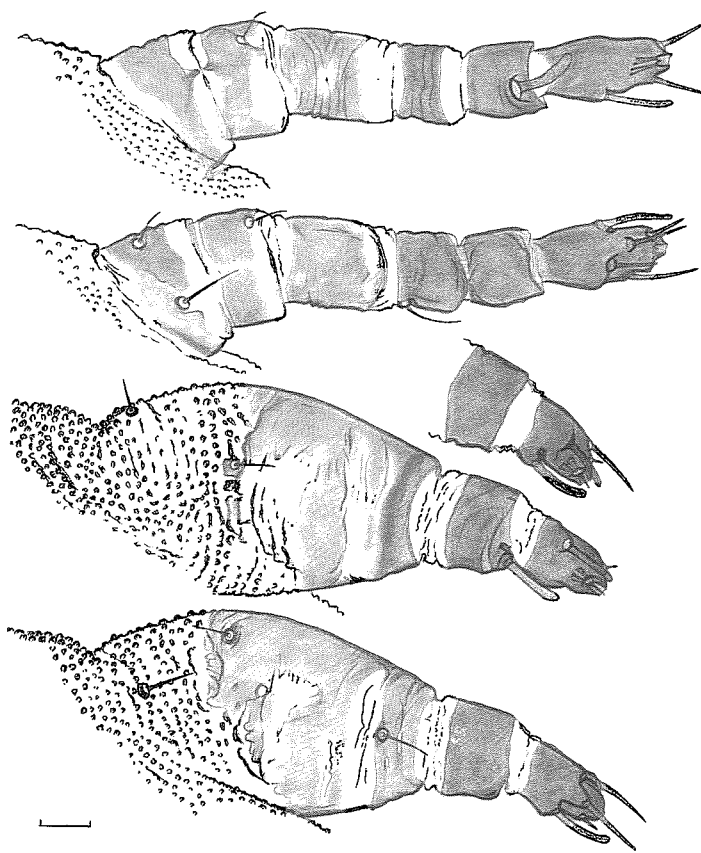


Fig. 9. *C. socialis* : antennae of 1st and 2nd instar males (from top to bottom), ventral and dorsal views for each instar. The inserted drawing shows the penultimate and terminal segments of another 2nd instar specimen (the fleshy seta of the penultimate segment is dislocated onto the terminal segment). Scale: 10 μ m.

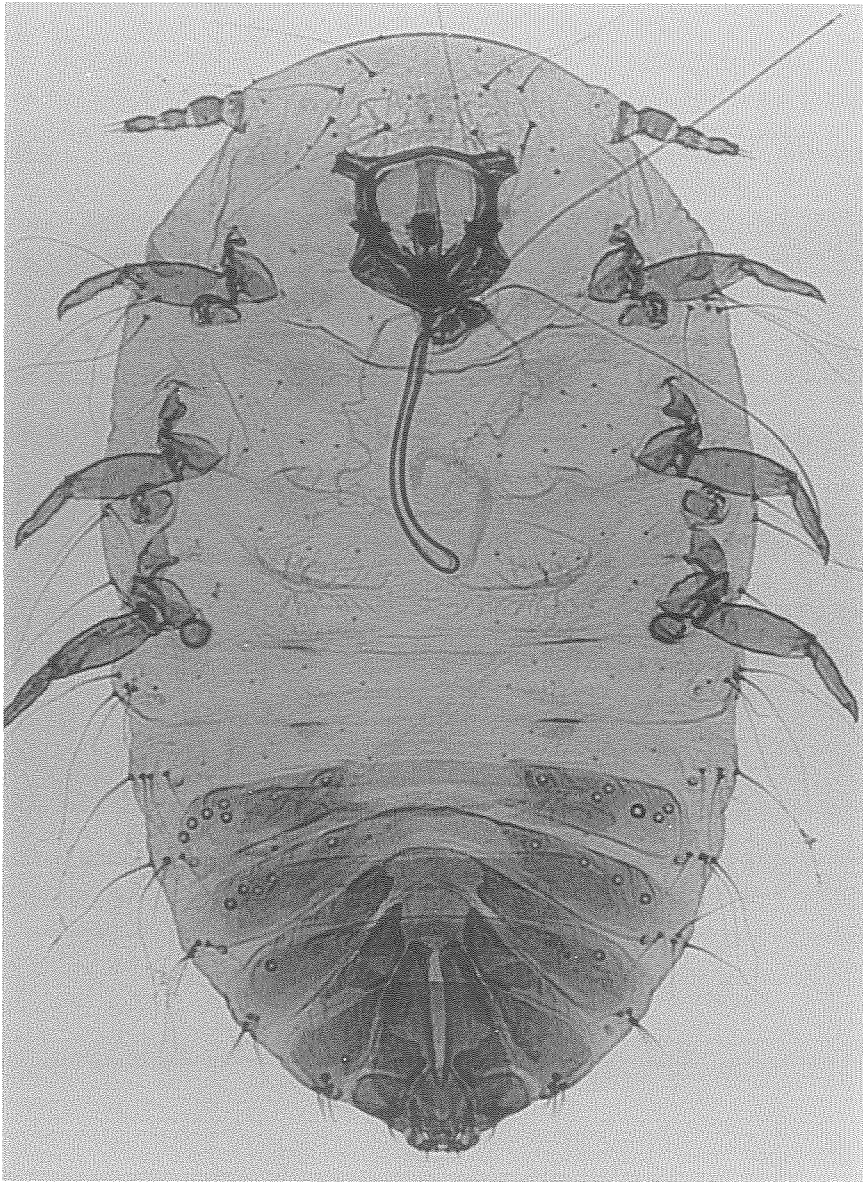


Fig. 10. *C. angraeci* : adult female ; nearly 1 mm long [91ML-307].

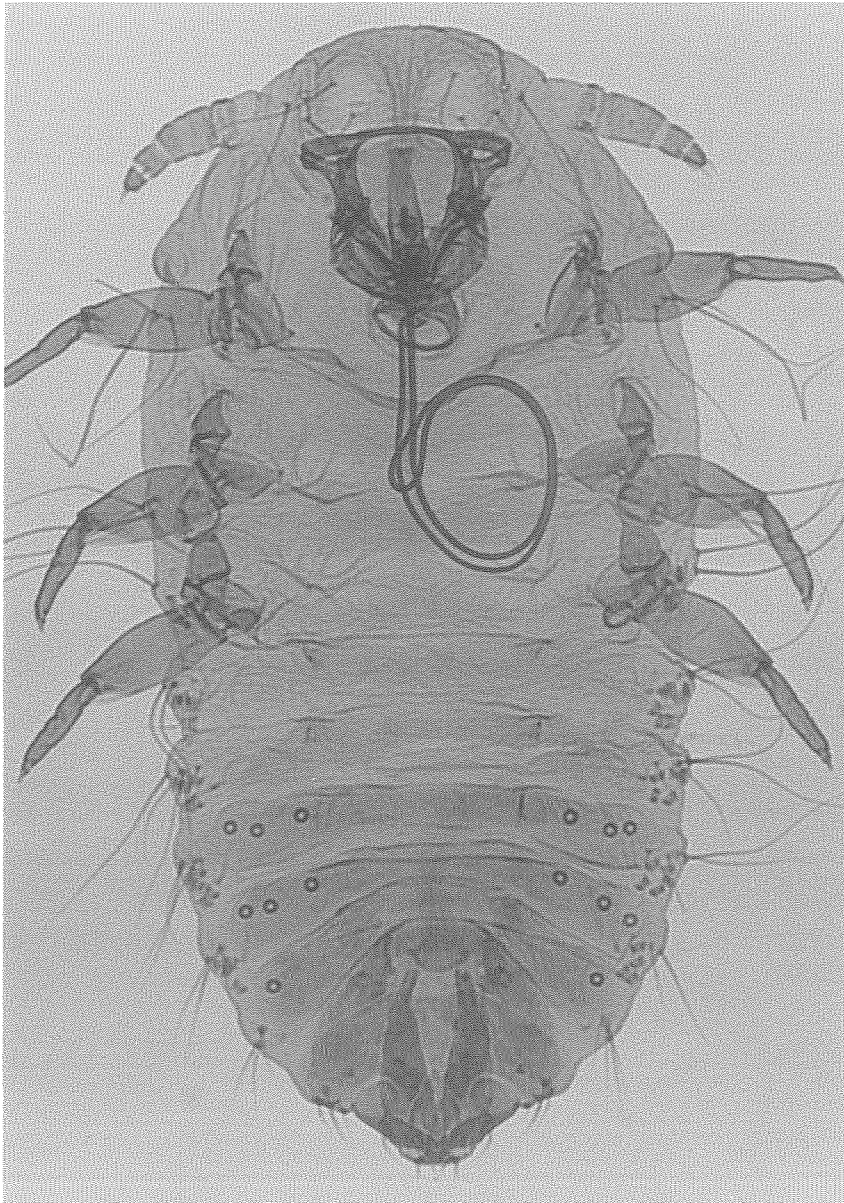


Fig. 11. *C. buchanae*: adult female; about 0.8 mm long [91ML-260].

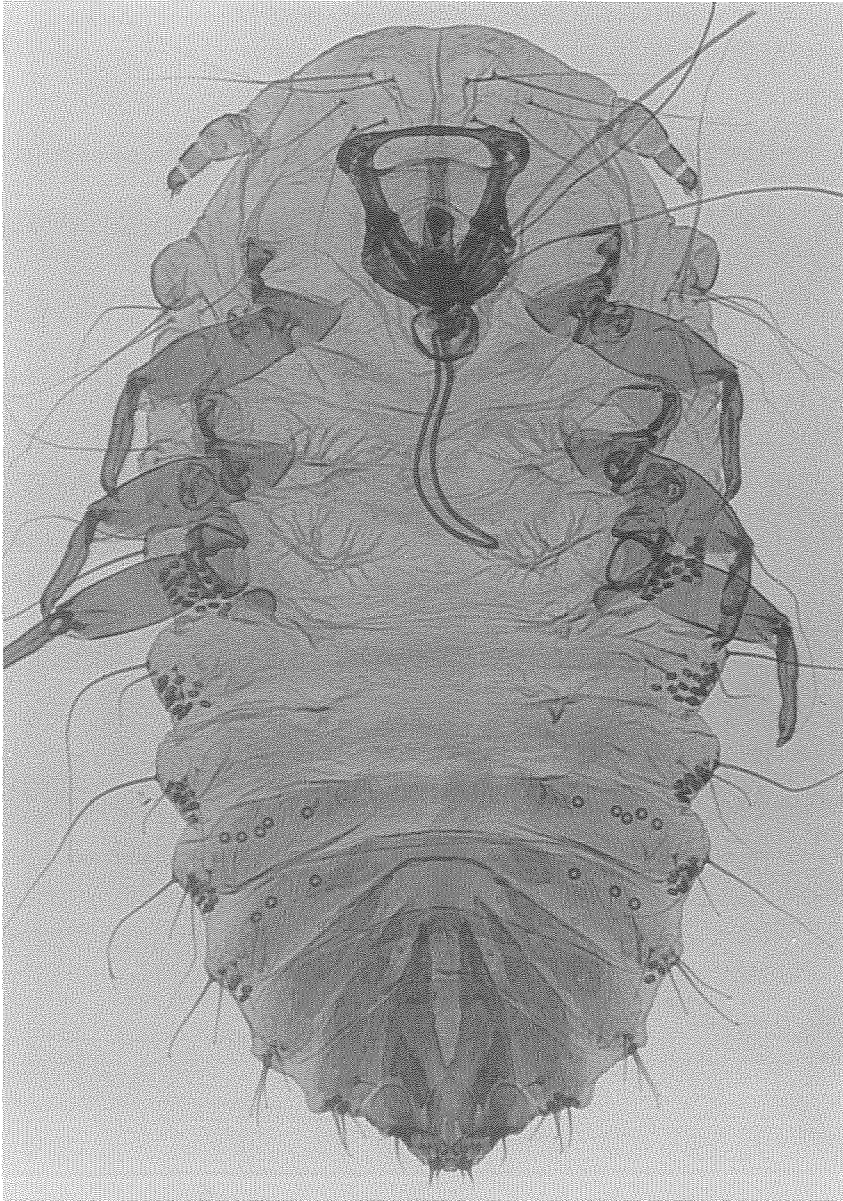


Fig. 12. *C. vaccinii*: young adult female; about 1 mm long [91ML-136].



Fig. 13. *C. garciniae*: young adult female; about 1.2 mm long [91ML-351].

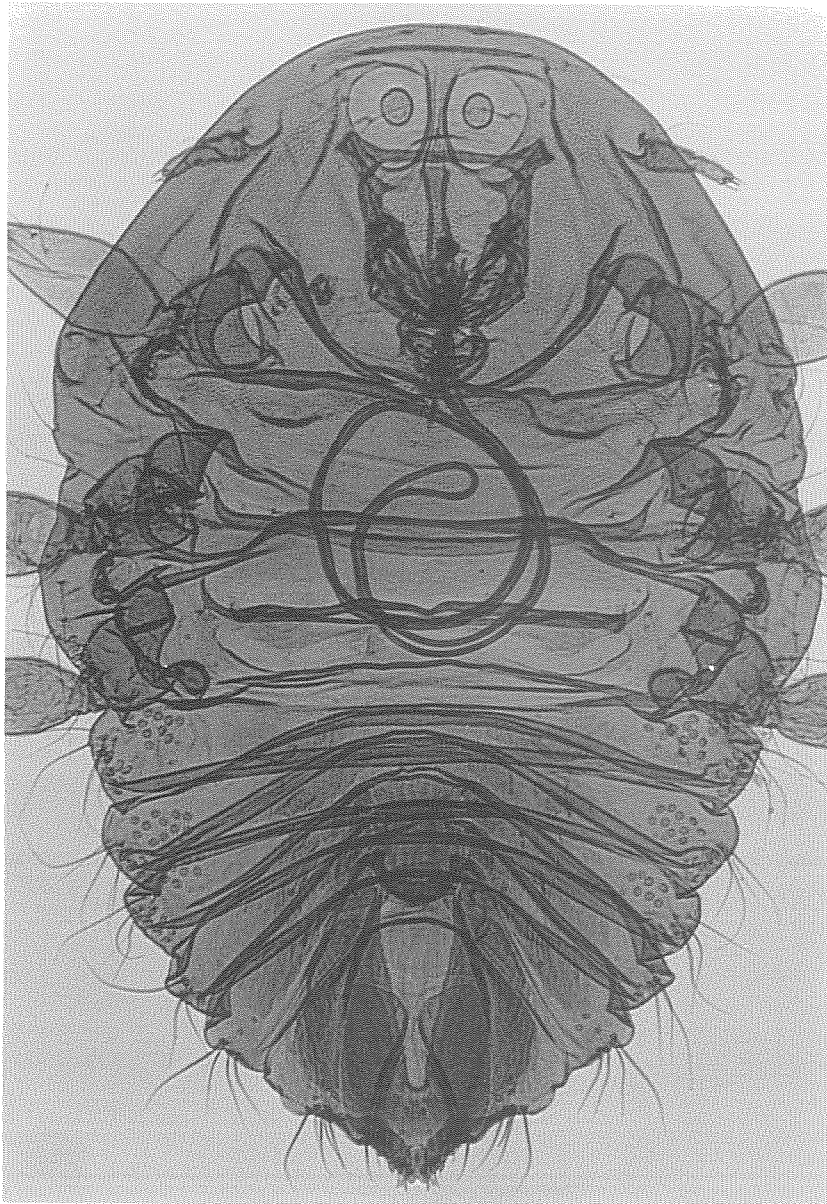


Fig. 14. *C. socialis* : young adult female ; about 1.2 mm long.

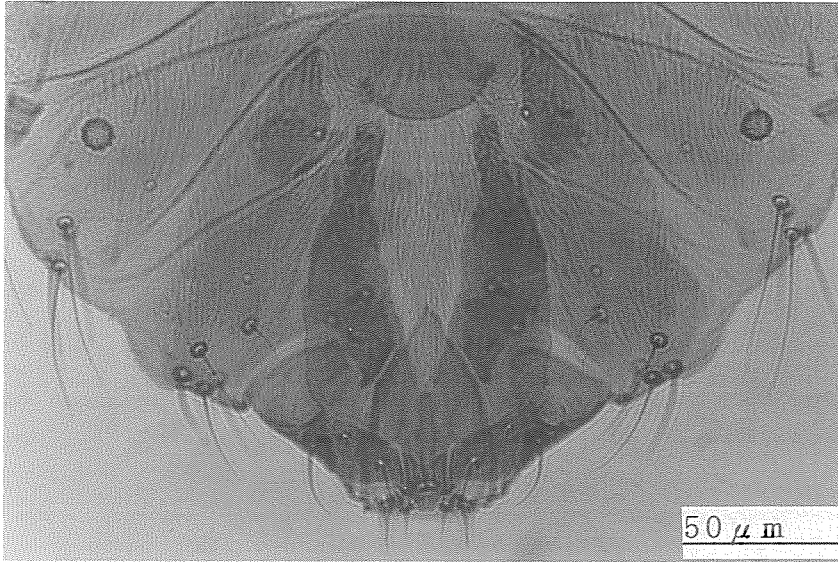


Fig. 15. *C. buchanaiae*: adult female, pygidium [91ML-260].

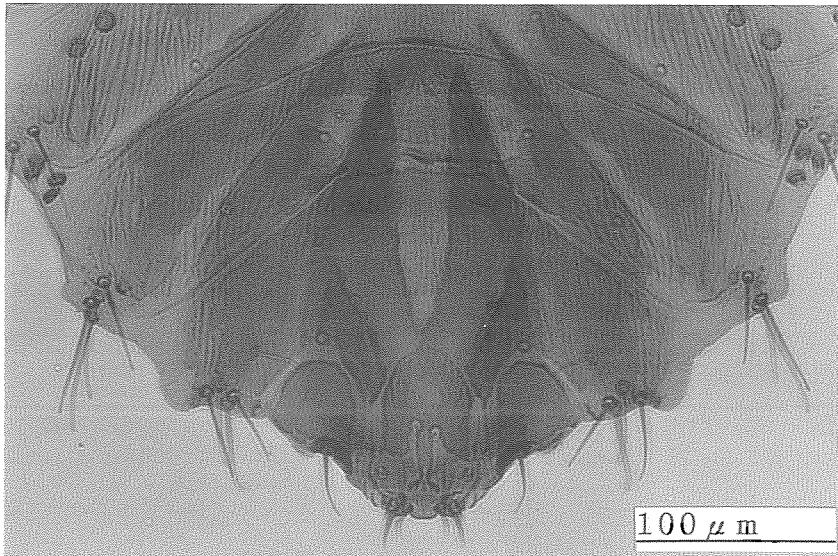


Fig. 16. *C. vaccinii*: adult female, pygidium [91ML-136].

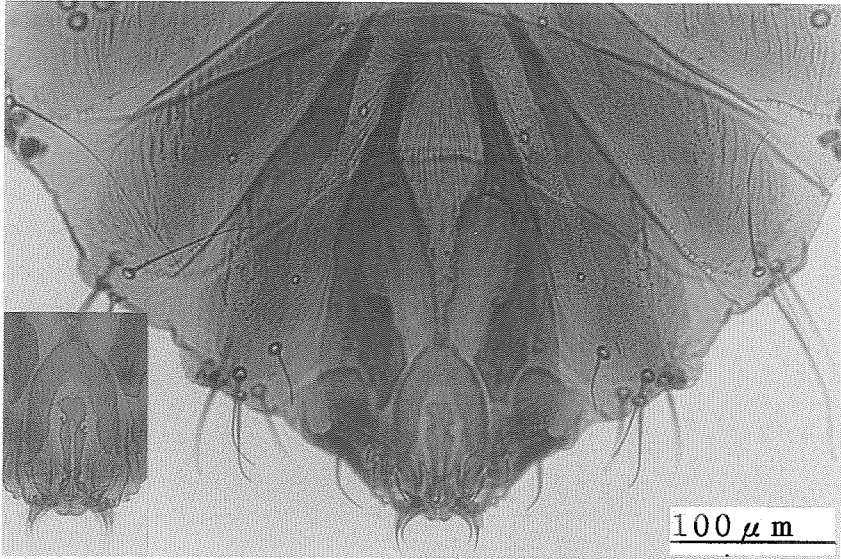


Fig. 17. *C. garciniae*: adult female, pygidium [91ML-315].

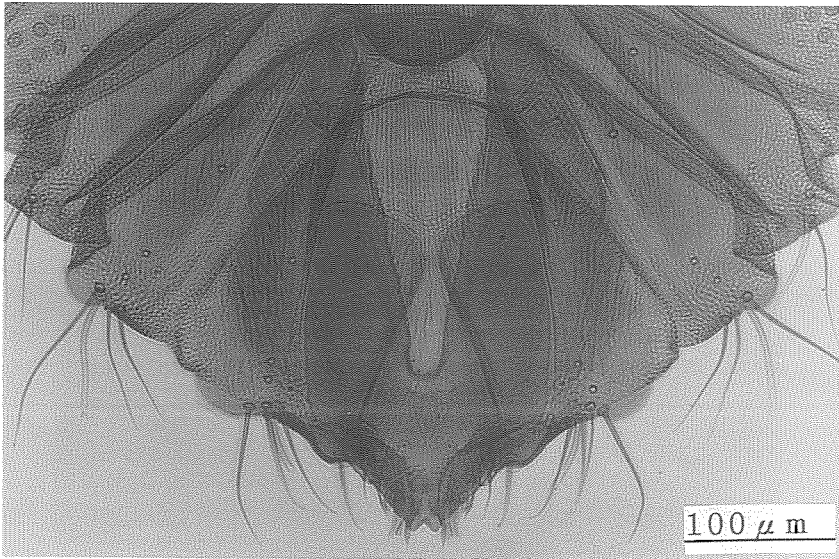


Fig. 18. *C. socialis*: adult female, pygidium.

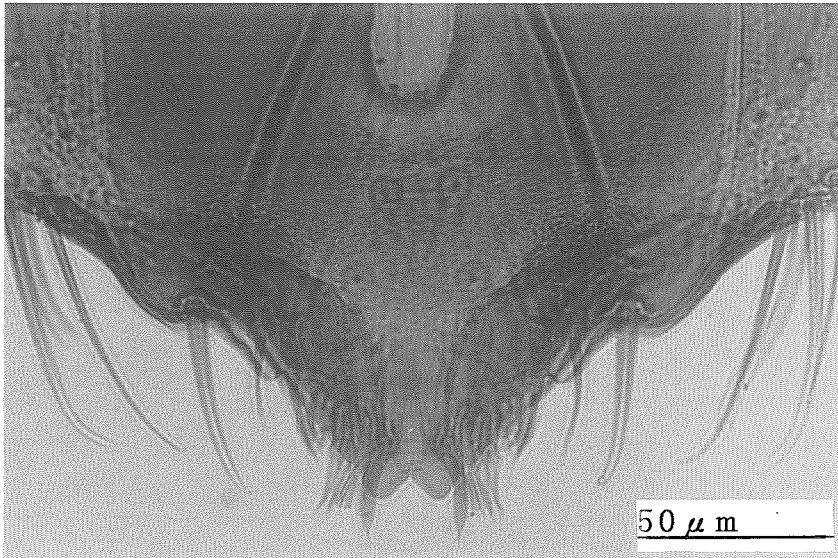


Fig. 19. Part of Fig. 18, showing apex of pygidium.

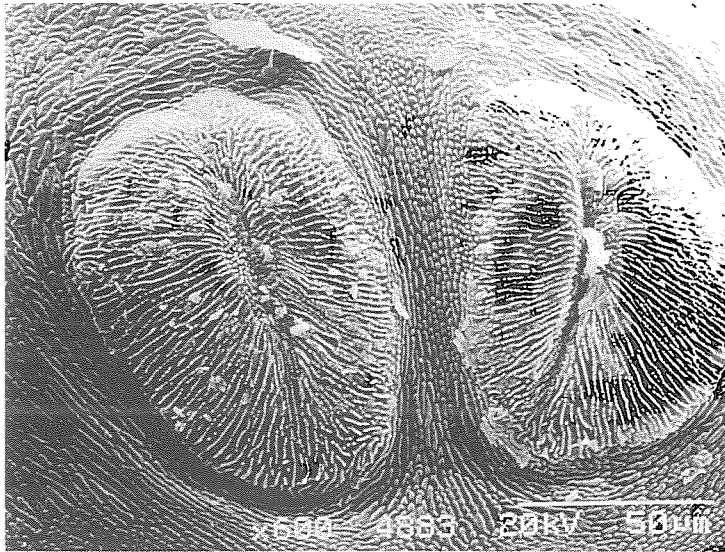


Fig. 20. *C. vaccinii*: adult female, swollen dorsal spots of head [91ML-488].

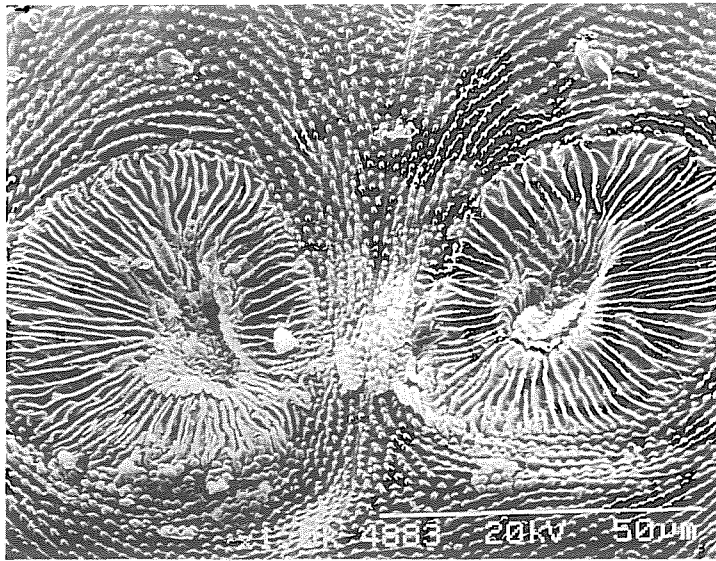


Fig. 21. *C. vaccinii*: adult female, flat dorsal spots of head [91ML-488].

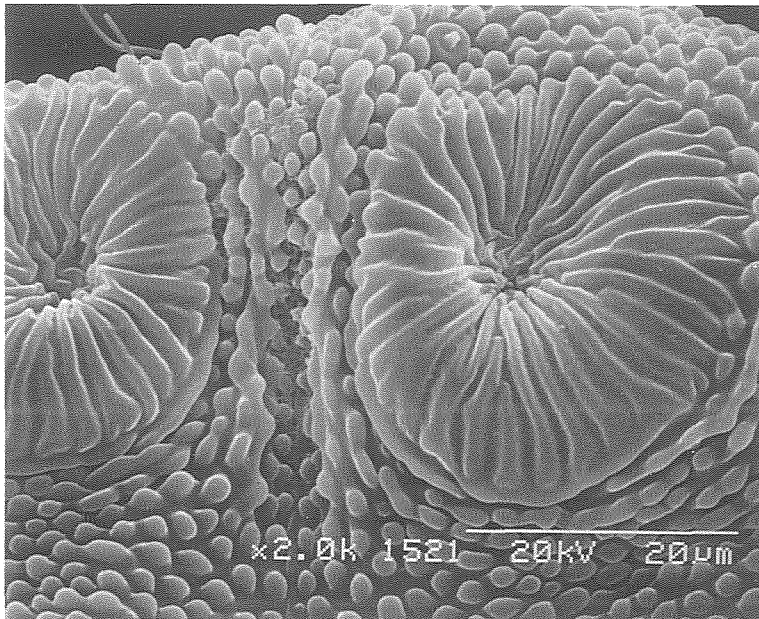


Fig. 22. *C. socialis*: 1st instar male, dorsal spots of head.

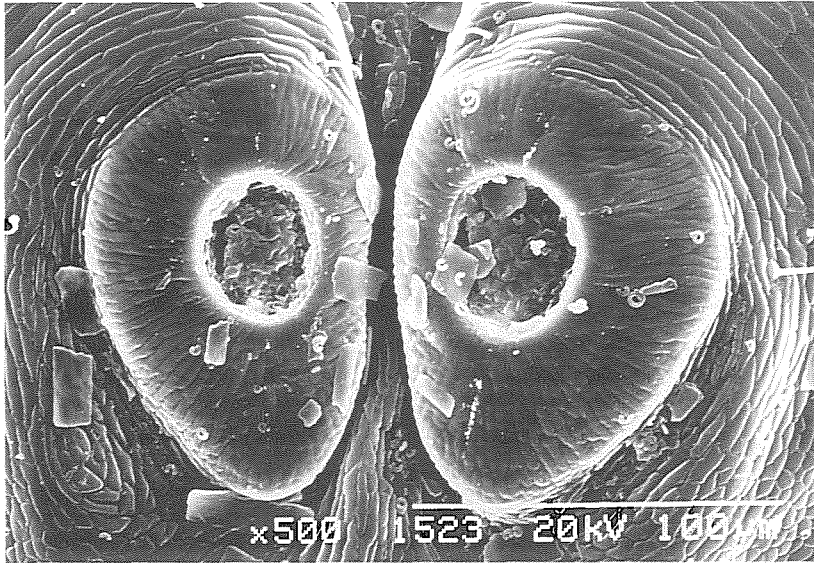


Fig. 23. *C. socialis* : adult female, dorsal spots of head.

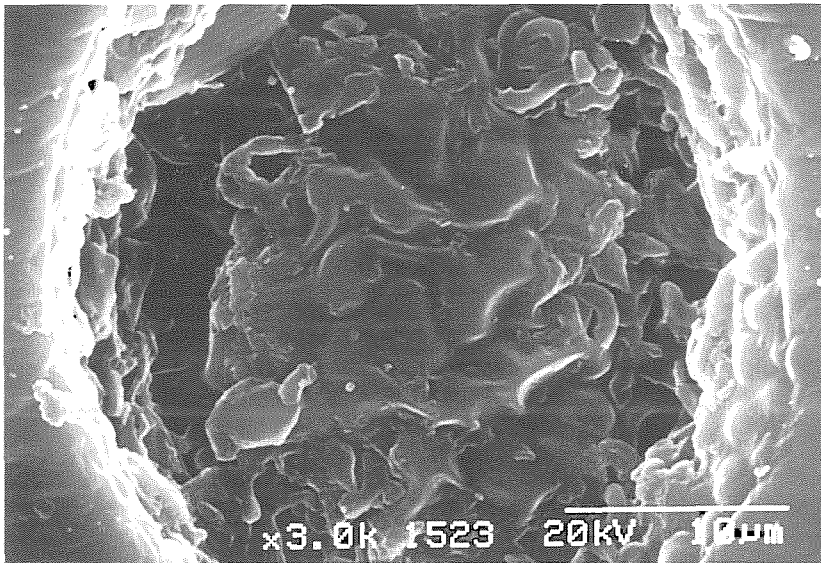


Fig. 24. Part of Fig. 23, showing centre of left dorsal spot.

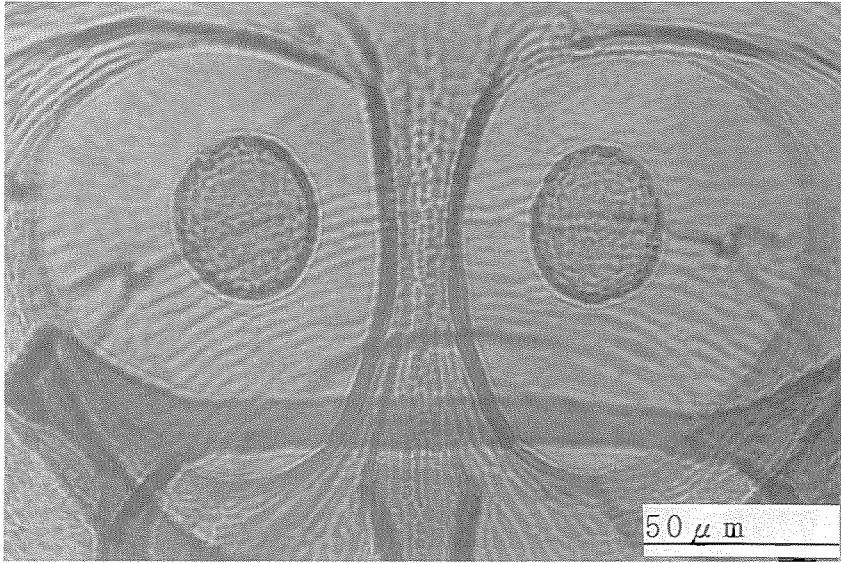


Fig. 25. *C. socialis* : adult female, dorsal spots of head in light microscopy.

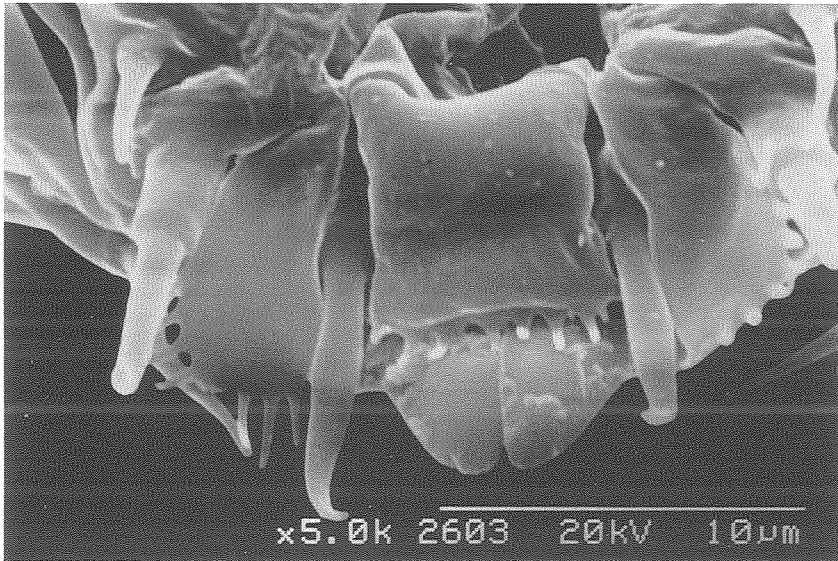


Fig. 26. *C. buchananiae* : adult female, apex of pygidium in dorsal view [91ML-260].

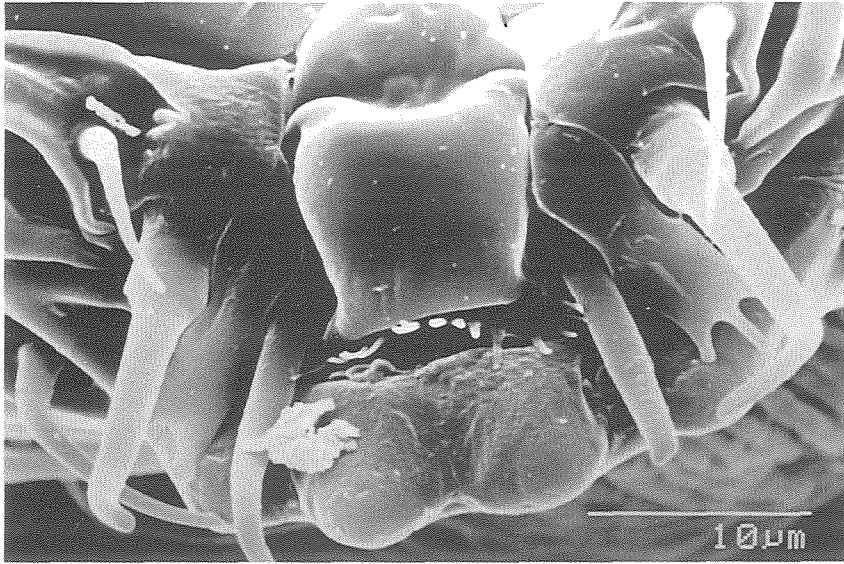


Fig. 27. *C. vaccinii*: adult female, apex of pygidium in posterodorsal view [92SP-60].

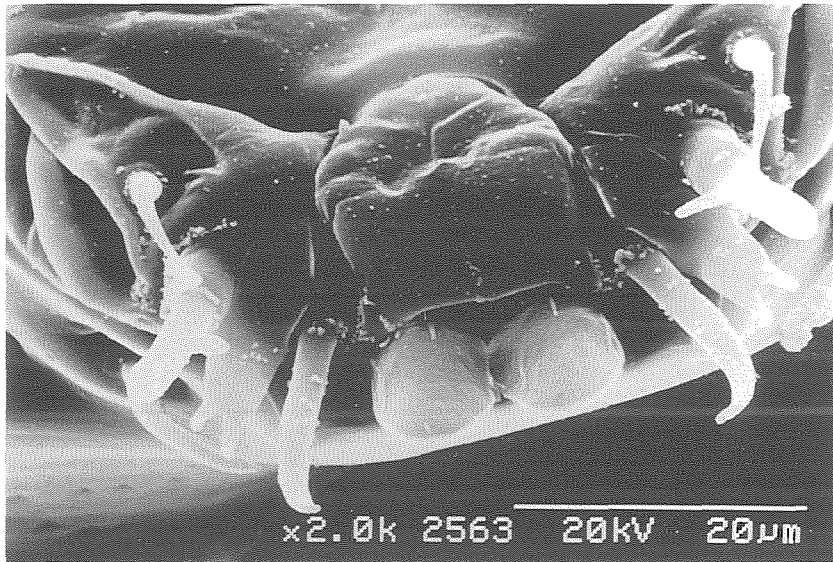


Fig. 28. *C. vaccinii*: adult female, apex of pygidium in posterodorsal view [91ML-256].

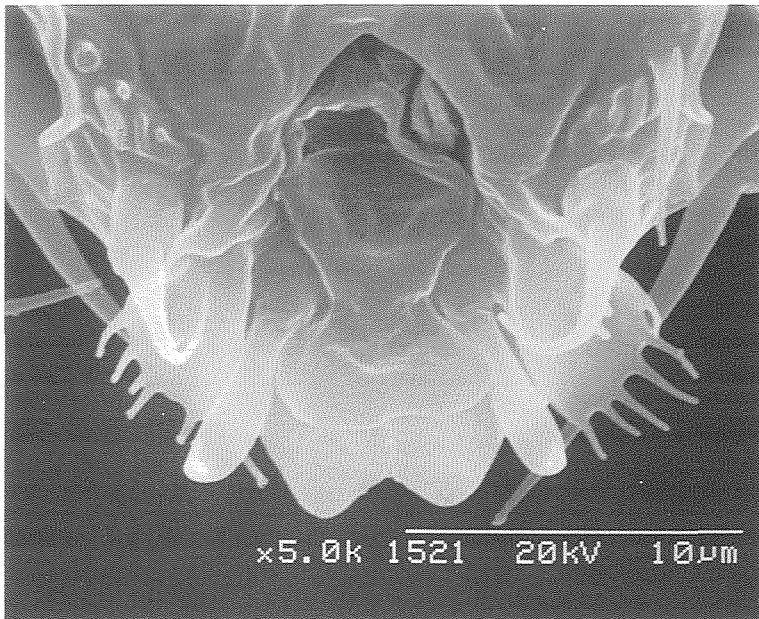


Fig. 29. *C. socialis* : 1st instar, apex of pygidium in dorsal view.

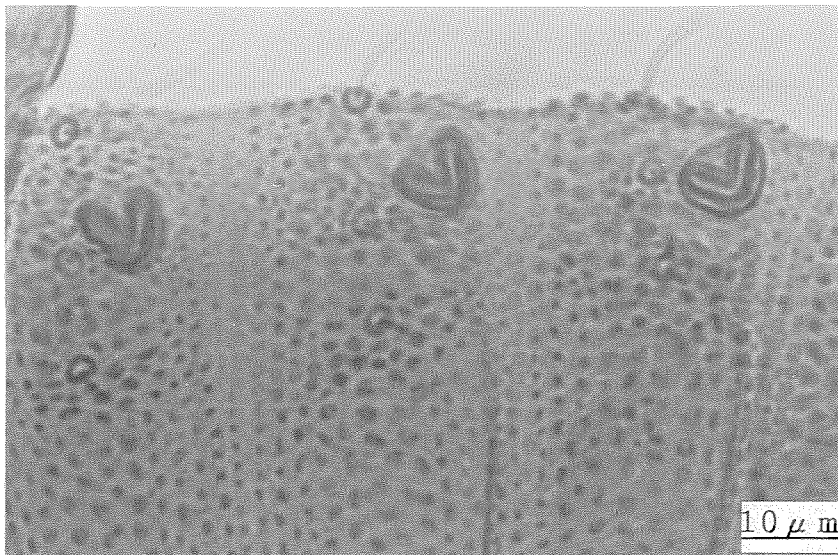


Fig. 30. *C. socialis* : 1st instar female, lateral side of abdomen showing 2-fissural disc pores.

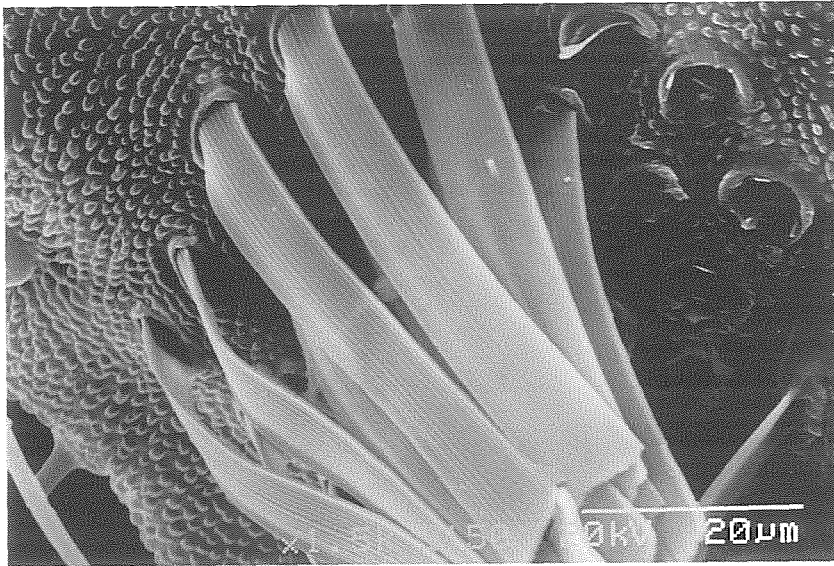


Fig. 31. *C. garciniae*: adult female, ventral surface of body with openings of tubular ducts secreting wax filaments [91ML-315].

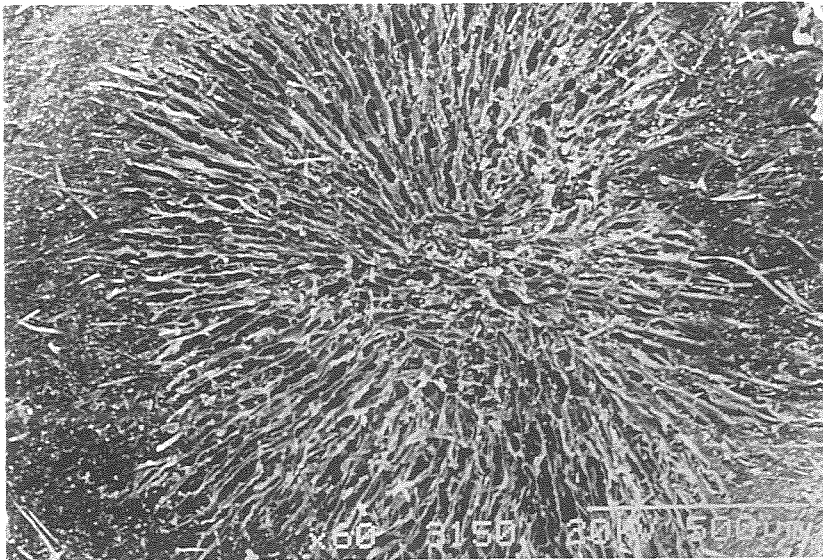


Fig. 32. *C. garciniae*: growing female test, inner surface showing a radiation of ridges [91ML-315].

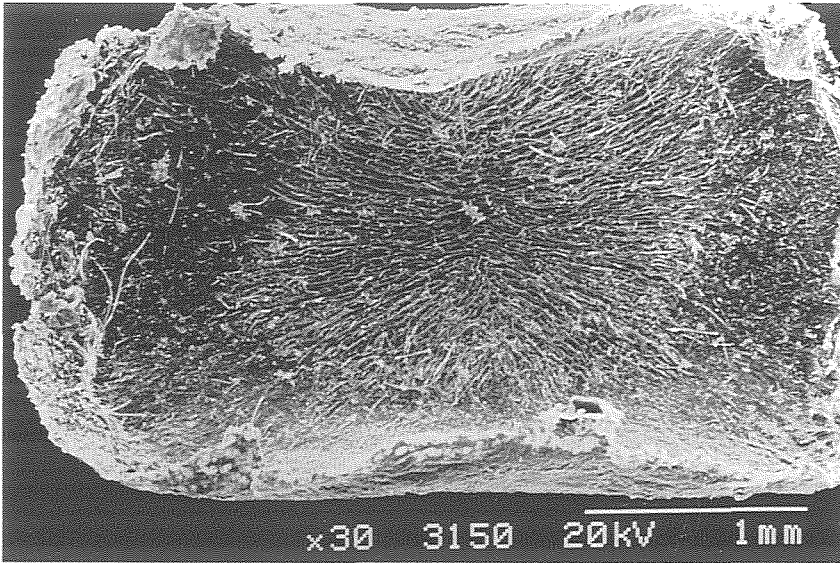


Fig. 33. *C. garciniae*: still growing female test, inner surface with ridges extending onto both sides [91ML-315].

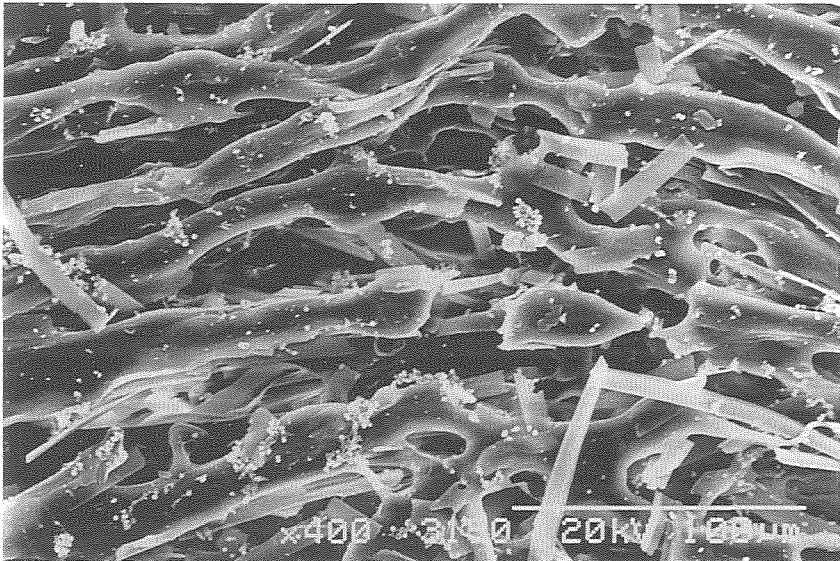


Fig. 34. *C. garciniae*: growing female test, ridges [91ML-315].

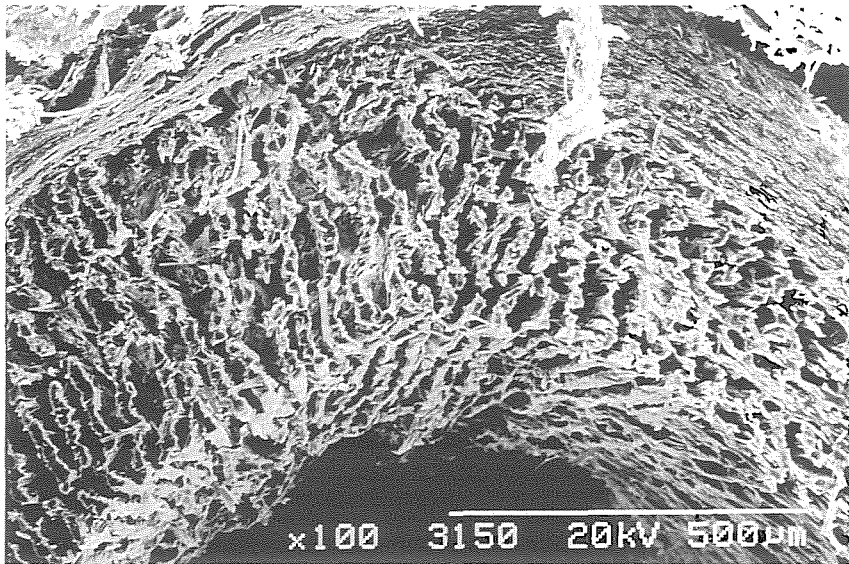


Fig. 35. *C. garciniae*: growing female test, cross-section [91ML-315].

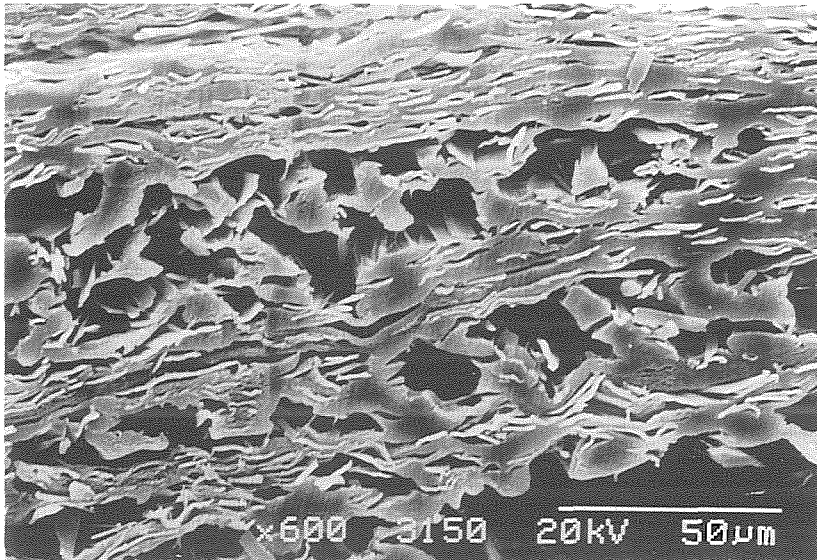


Fig. 36. Part of Fig. 35, showing the outer zone and the intermediate zone under construction.

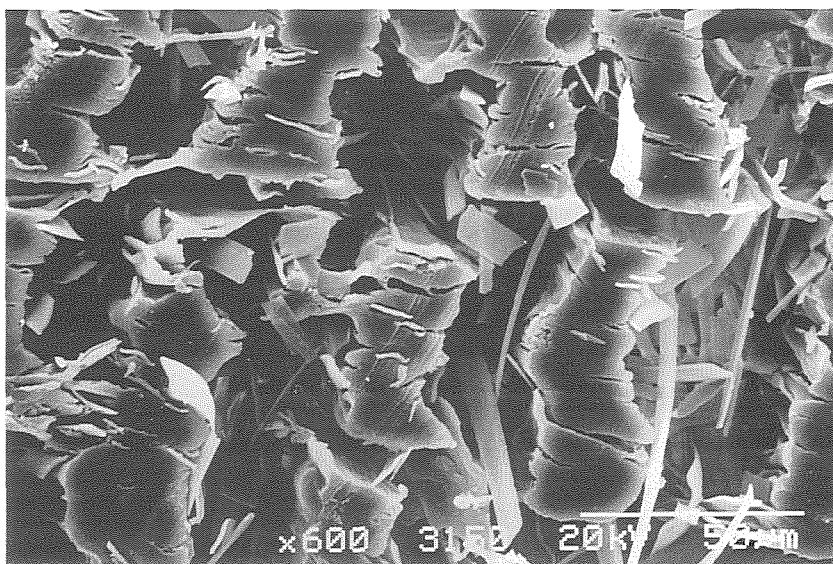


Fig. 37. Part of Fig. 35, showing the intermediate zone.

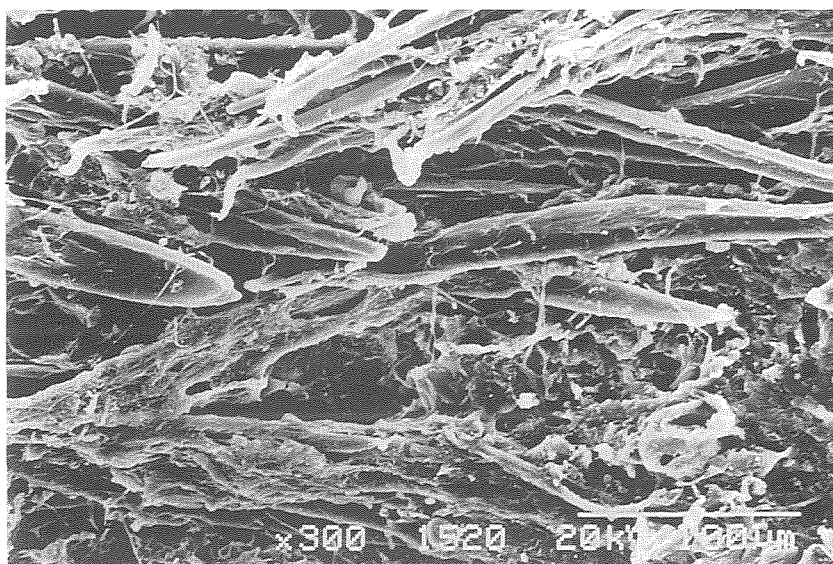


Fig. 38. *C. socialis*: female test, part of dorsal surface with bark filaments.

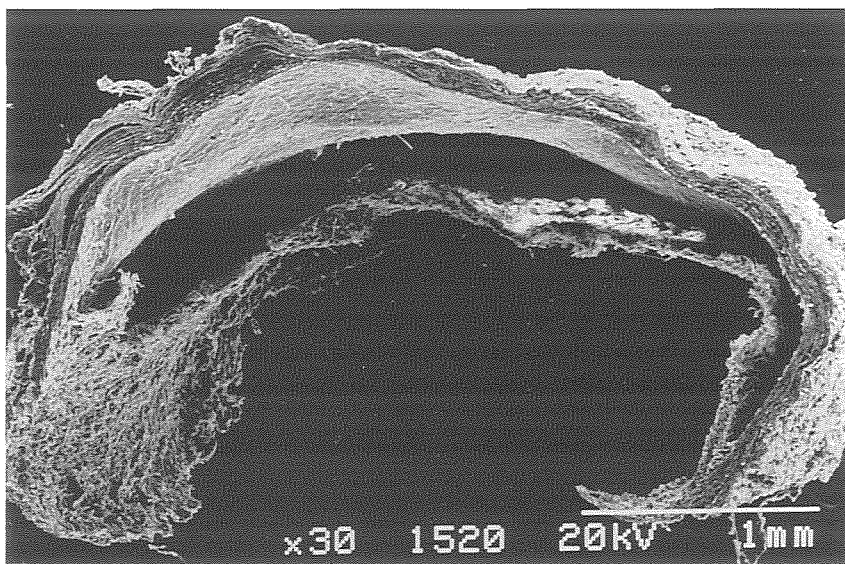


Fig. 39. *C. socialis* : female test, cross-section. (Tests were once moistened and, when detached from the bark, became revolute as shown here).

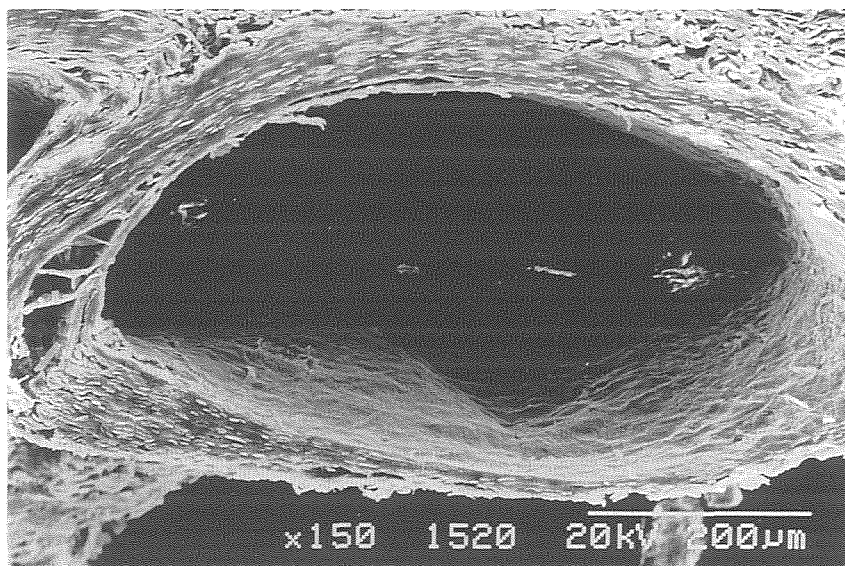


Fig. 40. *C. socialis* : male test, cross-section.

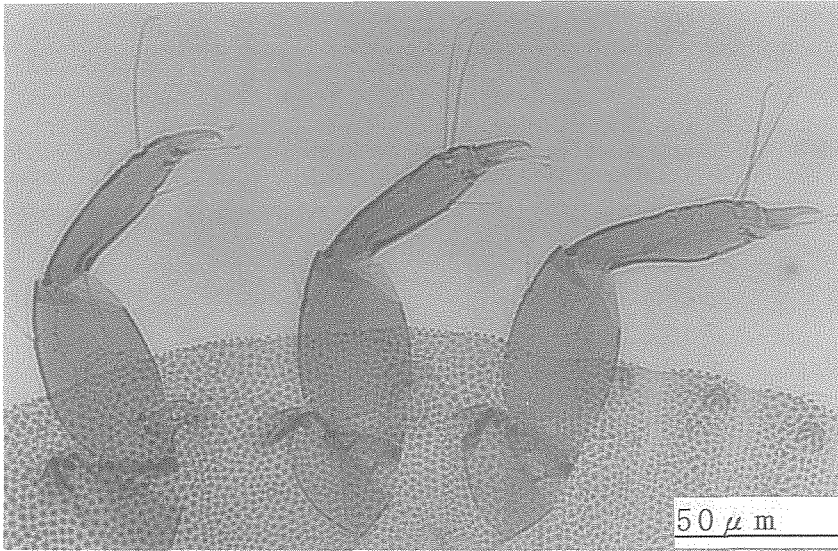


Fig. 41. *C. socialis* : 1st instar female, legs.



Fig. 42. *C. socialis* : 1st instar male, legs.