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**A DIASPIDINE SCALE INSECT IN CONVERGENCE TO
THE TRIBE LEPIDOSAPHEDINI (HOMOPTERA :
COCCOIDEA : DIASPIDIDAE)**

By SADAŌ TAKAGI

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Abstract

TAKAGI, S. 1989. A diaspidine scale insect in convergence to the tribe Lepidosaphedini (Homoptera : Coccoidea : Diaspididae). *Ins. matsum. n. s.* 42: 123-142, 22 figs.

Tamuraspis malloti (n.g., n. sp.), associated with *Mallotus* in Nepal, is described. SEM observations on the tests of the female and male are recorded. In the adult female this scale insect is very similar to some species of *Dactylaspis*, the subtribe Coccomytilina, the tribe Lepidosaphedini. However, the male test is of a felted nature and the second instar male possesses three pairs of enlarged modified ducts (which seem to be geminate-structured at the inner end) on the abdominal margin. This suggests that *T. malloti* belongs to the tribe Diaspidini, and that the similarity of the adult female to *Dactylaspis* is due to convergence. The Coccomytilina as currently composed may contain diaspidines in convergence.

Author's address. Entomological Institute, Faculty of Agriculture, Hokkaidō University, Sapporo, 060 Japan.

Contents. Introduction — *Tamuraspis malloti*, n. sp. — *Tamuraspis*, n.g. — SEM observations on the tests — Taxonomic position of *Tamuraspis malloti* — Further remarks.

INTRODUCTION

Diaspidid taxonomy has at times suffered much confusion caused by convergence in the adult female. For example, *Phenacaspis* as understood by authors has proved to be composed of species belonging to *Chionaspis* (Chionaspidina, Diaspidini) and *Pseudaulacaspis* (Fioriniina, Diaspidini). *Chionaspis* is supposed to have originated from *Narayanaspis*, which is primitive in comparison with *Chionaspis* in having non-zygotic median lobes (Takagi, 1985). The origin of *Pseudaulacaspis* is unknown, but may be traced back to another form with non-zygotic median lobes. The genus *Cameronaspis* (Chionaspidina) has recently been erected as a separation from *Africaspis* (which may belong to the Fioriniina) (Takagi, Tho and Khoo, 1988). In these cases the second instar males conspicuously differ between the confused forms and indicate the right taxonomic positions.

The scale insect described below may afford another remarkable example of convergence. So far as the adult female is concerned, it appears to be referable to the tribe Lepidosaphedini. The male test and the second instar male, however, strongly suggest that the species belongs to the Diaspidini.

On this occasion the tests of both sexes have been observed in a scanning electron microscope and the results are recorded. However, the test formation in this species and its phylogenetic significance, based on comparisons with other forms of the family, are beyond the scope of this paper.

DESCRIPTION

Tamuraspis malloti, n. sp.

Material examined. Collected by the River Tamur, on the way from Phidim, Mechi Zone, to Sankranti, Kosi Zone, Nepal, alt. 400-500 m., on *Mallotus philippinensis* [Euphorbiaceae], Nov. 13, 1983. Females occurring on the twigs and branches, and males on the undersurface of the leaves. Female test (Fig. 7) mytiliform, highly convex dorsally, thick, and dark brown; often covered wholly or partly with the epidermal tissue of the host plant. Male test (Fig. 21) white, felted and tricarinate. Nominiferous specimen [holotype] (adult female) deposited in the collection of the Entomological Institute, Hokkaido University.

Adult female (based on about 20 specimens) (Figs. 1-4). Body elongate, fusiform; at maturity attaining 2.3 mm in length at maximum and broadest across metathorax, with dorsal derm sclerotized extensively but not uniformly, remaining membranous along prepygidial intersegmental borders and on head; head disproportionately narrow; meso- and metathorax and 1st to 3rd abdominal segments weakly lobed laterally; pygidium broad, roundish marginally, irregularly and longitudinally striate on dorsal surface and densely striate-wrinkled on ventral surface. Pygidial lobes large and heavy, serrate, irregularly notched or almost entire; median lobes appressed together on most of their mesal margins, roundish apically, oblique and nearly straight on lateral margins, then a little constricted basally; 2nd lobe bilobulate, inner lobule appressed to median lobe, each lobule more or less triangular, somewhat smaller than median lobe; 3rd lobe also well developed, inner lobule as large as median lobe, roundish or somewhat triangular, outer lobule much smaller yet well represented; median lobe and lobules of second lobe each with a pair of

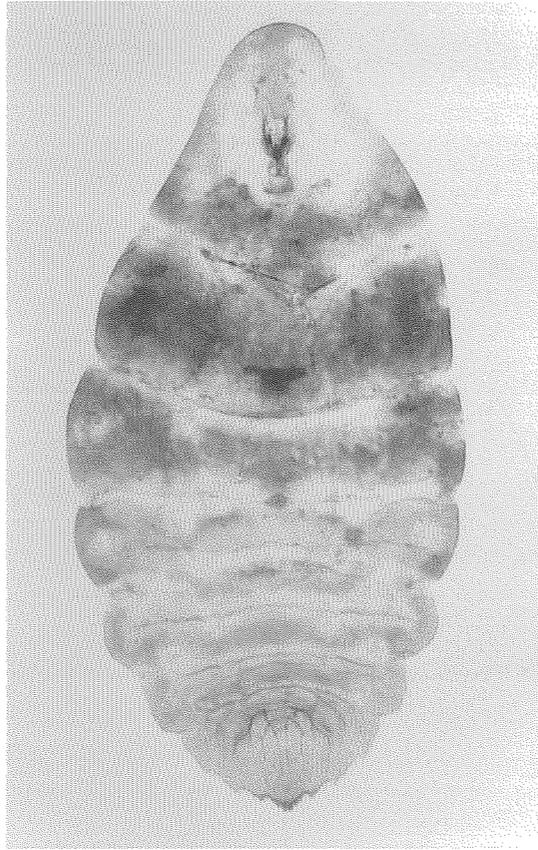


Fig. 1. Adult female, a full-grown individual.

paraphyses basally, these are slender, set close and parallel to each other, lobules of third lobe with basal paraphyses tending to be obscure. Three marginal processes on 5th abdominal segment, the lateral two may represent the 4th lobe; similar processes on 4th abdominal segment. Marginal gland spines membranous, absent between median lobes and also between median and second lobes (no spaces for gland spines at these positions owing to the lobes appressed together), 3-5 between 2nd and 3rd lobes, scarcely surpassing the lobes, 4-7 between 3rd and 4th lobes and also laterally to 4th lobe (on 5th abdominal segment), 3-6 on 4th abdominal segment, 2-6 on 3rd abdominal segment; 1-7 short gland spines posterolaterally to posterior spiracle (sometimes absent). Dorsal macroducts 2-barred, all small and slender, larger than ventral microducts on pygidium, as large as ventral macroducts on prepygidial segments, strewn over pygidium (on 5th to 8th abdominal segments), occurring in submedian and marginal-submarginal regions on 3rd and 4th abdominal segments and laterally on preceding segments as forward as mesothorax; ventral ducts abundant and strewn mainly in a broad lateral region on thoracic and prepygidial abdominal segments. Perivulvar disc pores absent. Spiracular disc pores trilocular; anterior spiracle with about 30-60 disc pores; posterior spiracle with

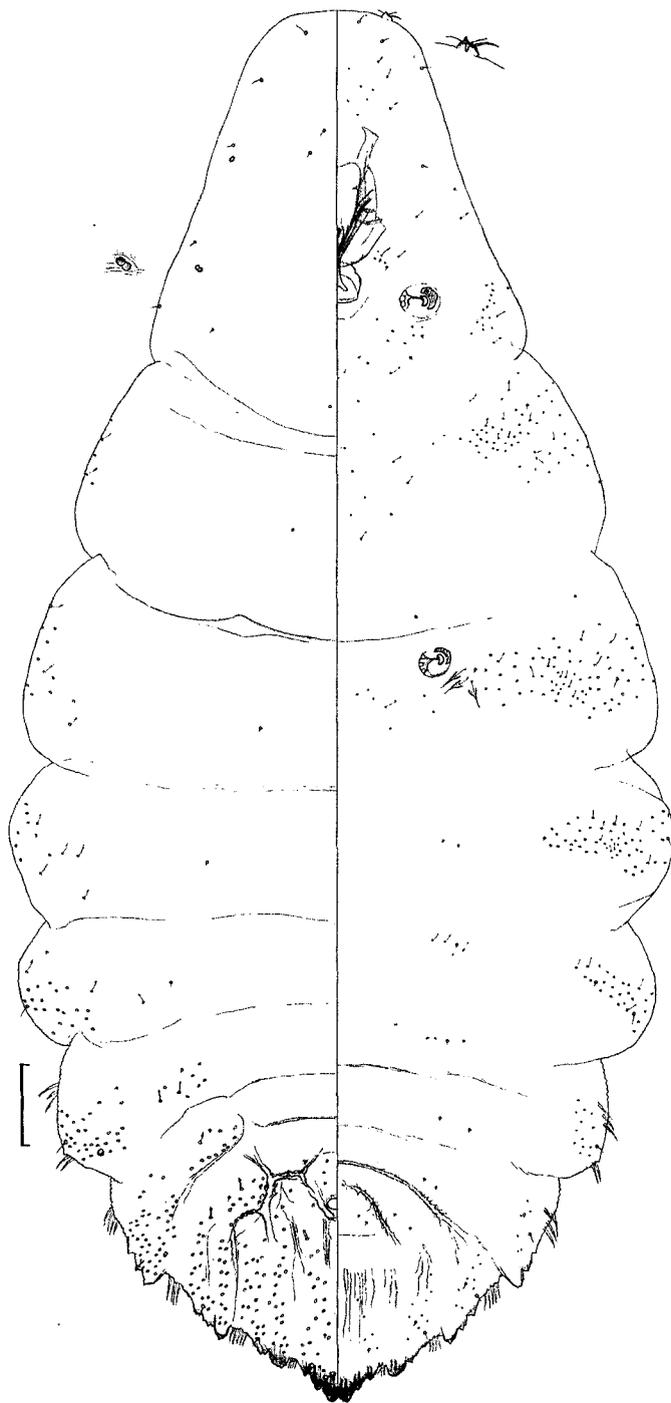


Fig. 2. Adult female, drawn from an immature individual (scale, 100 μ m).

about 10-20. Antenna usually with 1 short and 2 fine setae. Anus situated toward base of pygidium.

Second instar female (Fig. 5). Exuvial cast 0.80-0.96 mm in length, 1.5-2.3 times as long as wide; pygidial lobes nearly as in adult female; marginal gland spines 1 on 3rd to 7th abdominal segments each. Dorsal ducts small, occurring in submedian and marginal-submarginal series on 4th (or 5th) to 7th abdominal segments and in posterolateral corners of preceding segments as far forward as meta- or mesothorax, few in each series. Anus anterior to centre of pygidium.

Second instar male (based on 5 specimens) (Fig. 6). Body somewhat ovoid, membranous. Pygidial lobes well developed, sclerotized, broad and serrate; median lobes set close together, rounded; second lobe separated from median lobe by a narrow space, bilobulate, lobules somewhat smaller than median lobe; 3rd lobe similar to the second, but somewhat smaller. Abdominal margin anterior to 3rd lobe ragged with membranous processes as forward as 2nd segment. Gland spines, 5-8 posteriorly to anterior spiracle, 2-5 laterally to posterior spiracle, 1-3 (usually 2) submarginally on 1st abdominal segment, and 1 within margin on 2nd abdominal segment; small marginal gland spines occurring singly on 4th to 7th abdominal segments. Three large marginal ducts on each side of abdomen: 2 on base of abdomen, probably belonging to 2nd and 3rd segments, each opened at apex of a robust process, and 1 opened between bases of median lobe and inner lobule of second lobe (it seems that these ducts are geminate-structured at the inner end). Other ducts small, arranged across abdominal segments on dorsal and ventral surfaces and occurring laterally on thoracic segments. Anterior spiracle with 4-8 disc pores. Antenna with 3 short and 2 minute setae.

First instar (based on male and female exuvial casts) (Fig. 5). Antennae 5-segmented, terminal segment about as long as the 2nd to 4th combined. A pair of enlarged dorsal ducts on head. Anus situated marginally. Laterally to caudal seta a small conical process, accompanied laterally by a smaller, serrate process; further laterally, beyond a space, a much smaller conical process.

Tamuraspis, n.g.

Nominifer [type-species]: *Tamuraspis malloti*, n. sp.

Because this genus is represented by the above species alone, it may provisionally be described as follows:

Adult female fusiform; pygidium remarkably striate on both surfaces; pygidial lobes large and heavy; median lobes appressed together, but not zygotic; lateral lobes bilobulate; second lobe set close to median lobe; marginal gland spines present on pygidium, but no gland spines (no spaces for gland spines) between median lobes and between median and second lobes; macroducts 2-barred, all small in size, strewn over dorsal surface of pygidium; no differentiated marginal macroducts present; no spurs or other marginal prominences on prepygidial abdomen; spiracular disc pores trilocular; antenna with more than 1 seta; anus situated toward base of pygidium. Male test felted.



Fig. 3. Adult female: pygidium, dorsal surface, drawn from an immature individual (scale, 50 μ m).

SEM observations on the tests

Dried material was kept in a humid atmosphere (with creosote in a vial) for some days. After the insect bodies within the tests absorbed enough moisture to become plump, the material was dehydrated in alcohol, dried in a Hitachi HCP-2 critical point dryer, and coated with gold in a Hitachi E101 ion sputter. Observations and photography were made in a Hitachi S-2100A scanning electron microscope.

It has generally been held, though may not be well backed by chemical analyses, that the tests of the Diaspididae are made of wax. The present observations have revealed that the tests are a structure rather than a uniform film, being composed of



Fig. 4. Adult female: pygidium, ventral surface, drawn from the same individual with Fig. 3.

entangled threads of wax. In the female test these threads may be largely divided into "filaments" and "ribbons".

The completed female test shows dorsally a growing pattern composed of transverse ridges, which are especially developed in the posterior region of the test (Fig. 7). At a higher magnification the dorsal surface is thickly covered with wax filaments, which are rather irregularly entangled in the anterior region (Fig. 8) but arranged predominantly transversely in the ridged region (Fig. 9). At places broader runs of wax or wax ribbons appear and are more or less fused together (Fig. 9, right third). The test ends with a mass of wax probably originated from fused wax threads, with wax filaments running along the margin (Figs. 10 & 11). The inner surface is covered by wax ribbons, which tend to run transversely especially in

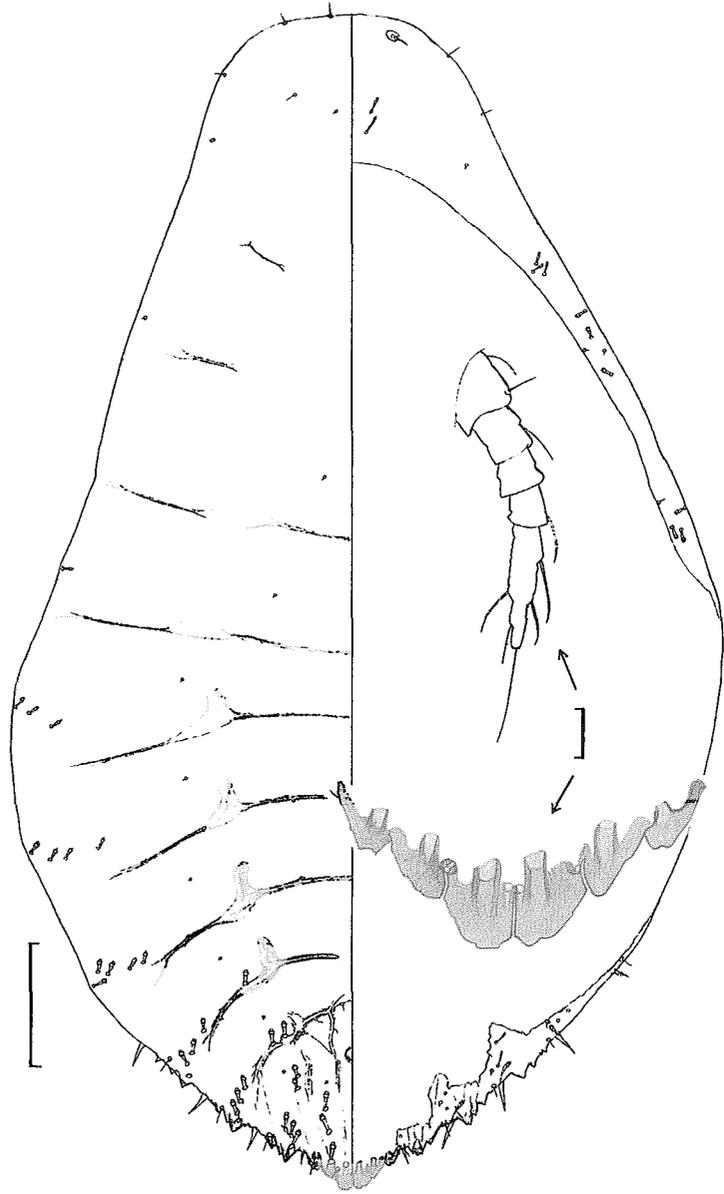


Fig. 5. Second instar female: exuvial cast (scale, 100 μm) and its pygidial lobes (scale, 10 μm). First instar female: exuvial cast, antenna.

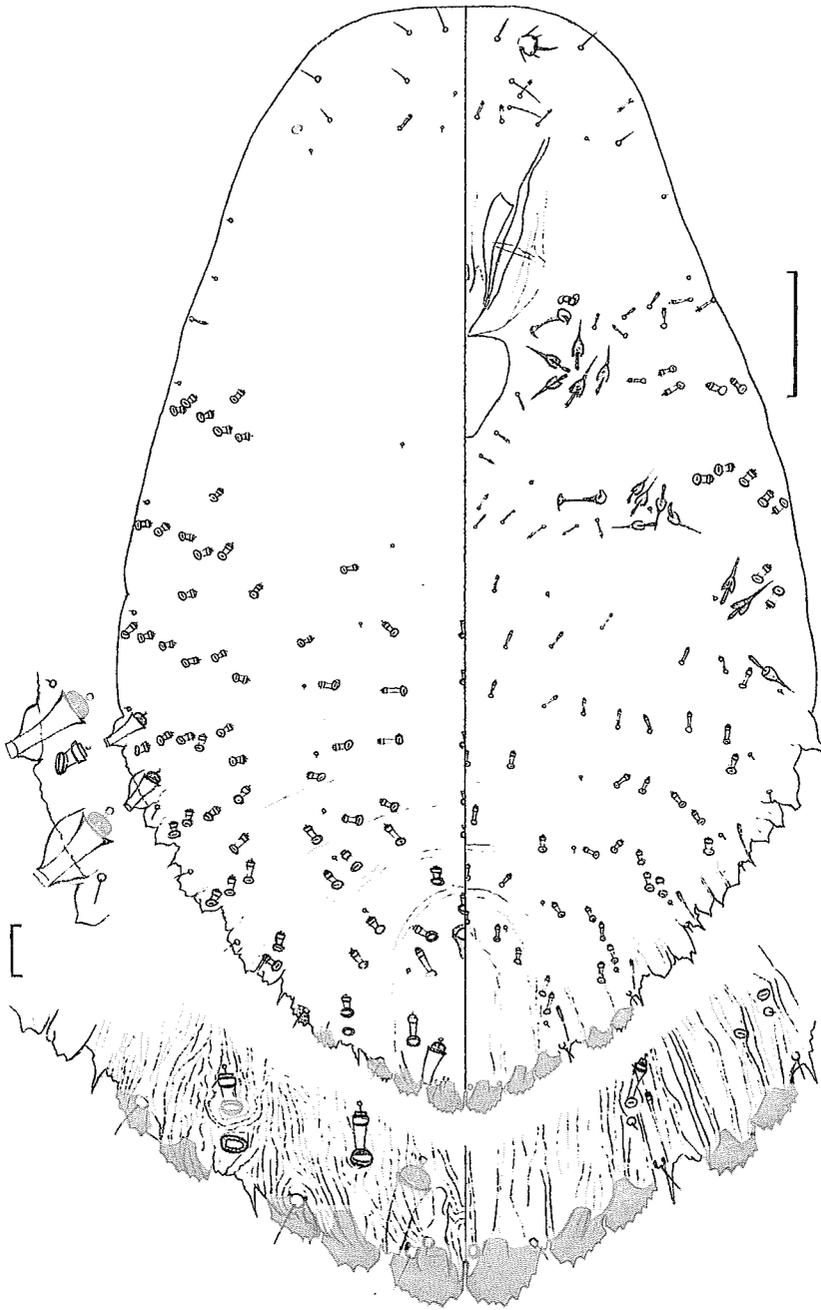


Fig. 6. Second instar male: body (scale, $50\ \mu\text{m}$); pygidial margin and enlarged macroducts (scale, $10\ \mu\text{m}$).

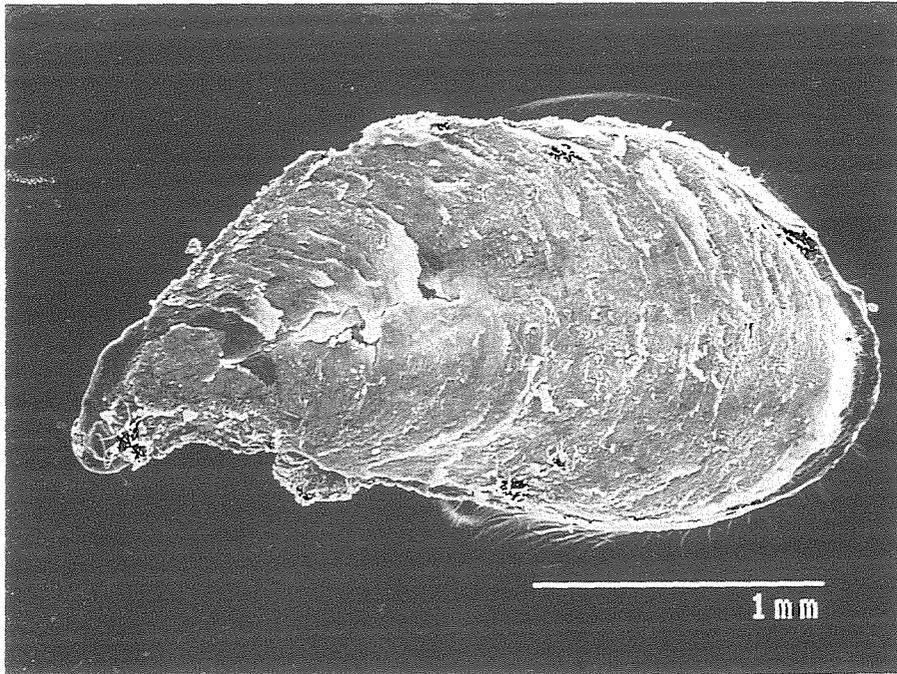


Fig. 7. Female test : dorsal view.

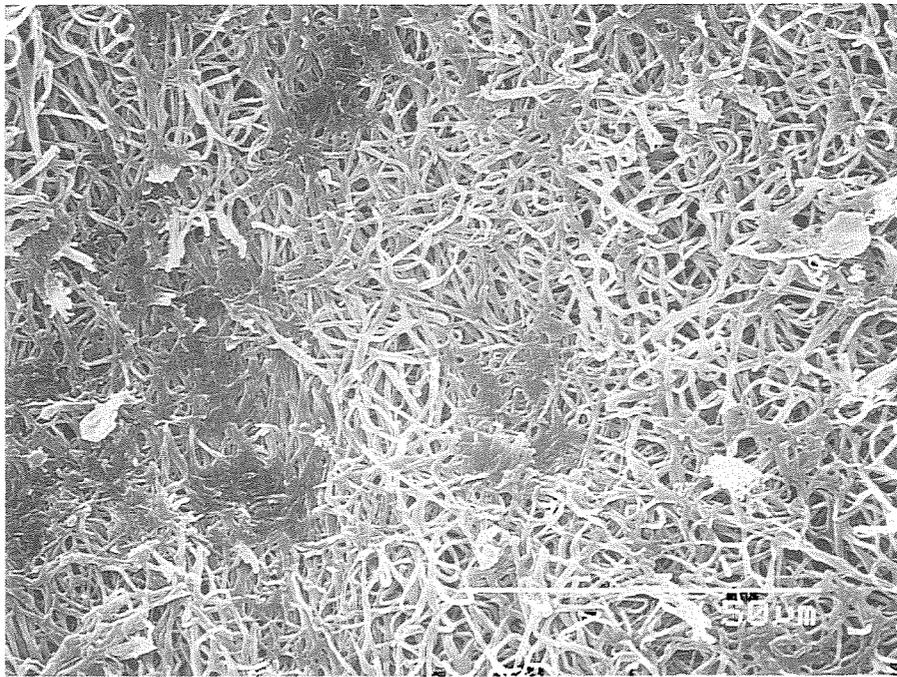


Fig. 8. Female test : dorsal surface in anterior region (anterior direction of the test is on the left side of the figure [same for all the succeeding figures]).

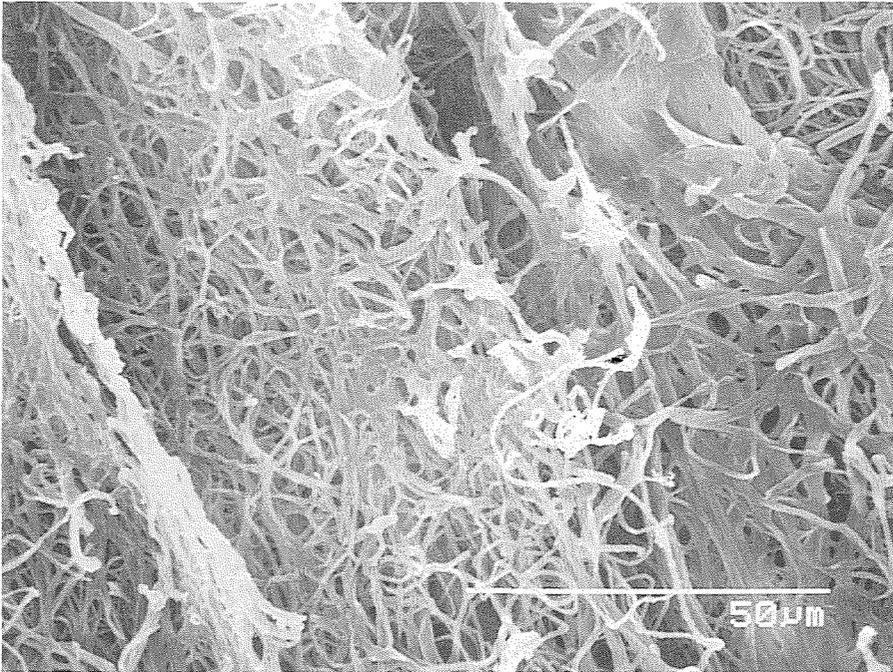


Fig. 9. Female test : dorsal surface in posterior region.

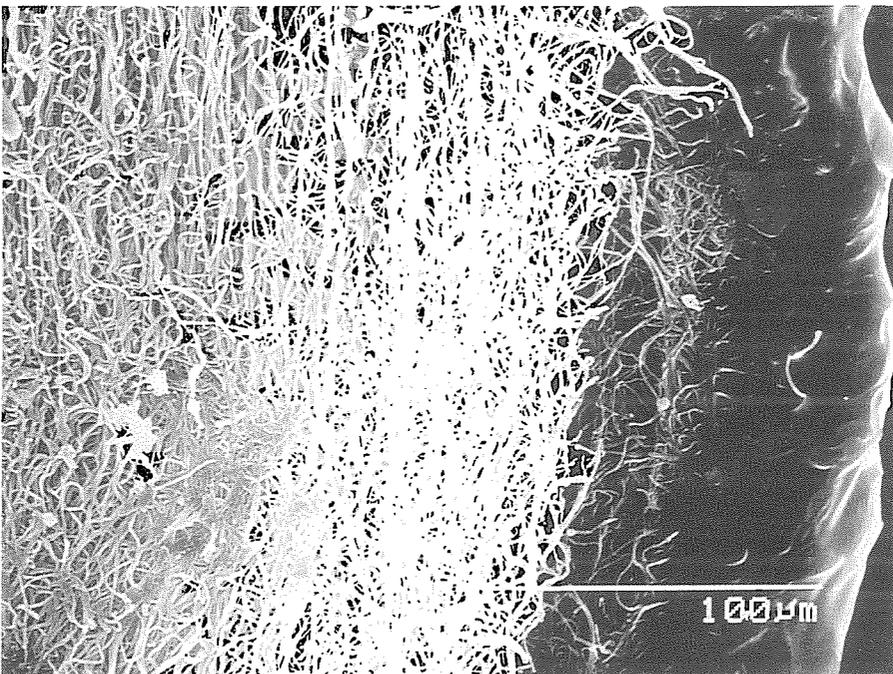


Fig. 10. Female test : posterior end, dorsal view.

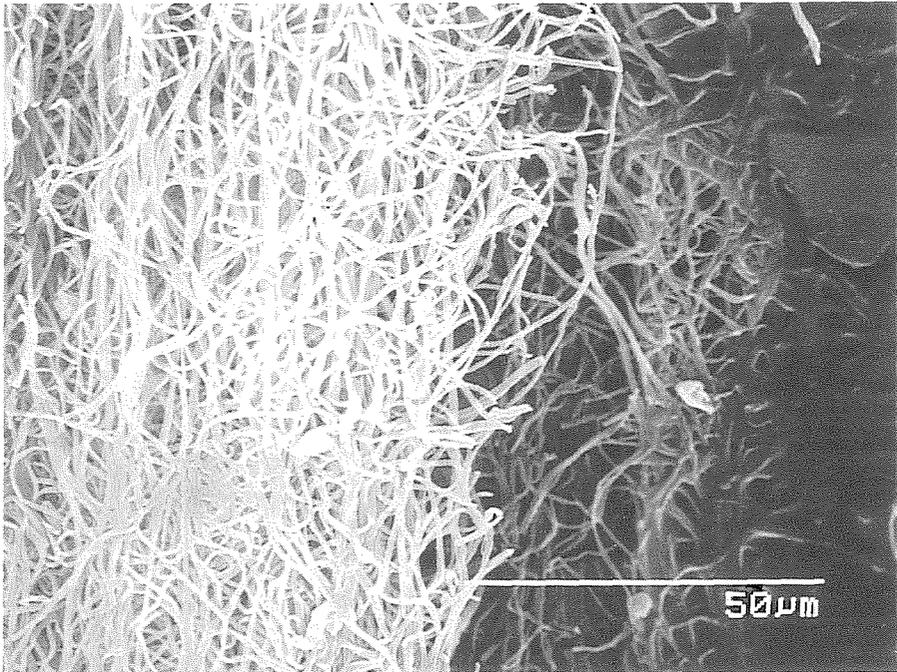


Fig. 11. Part of Fig.10 enlarged.

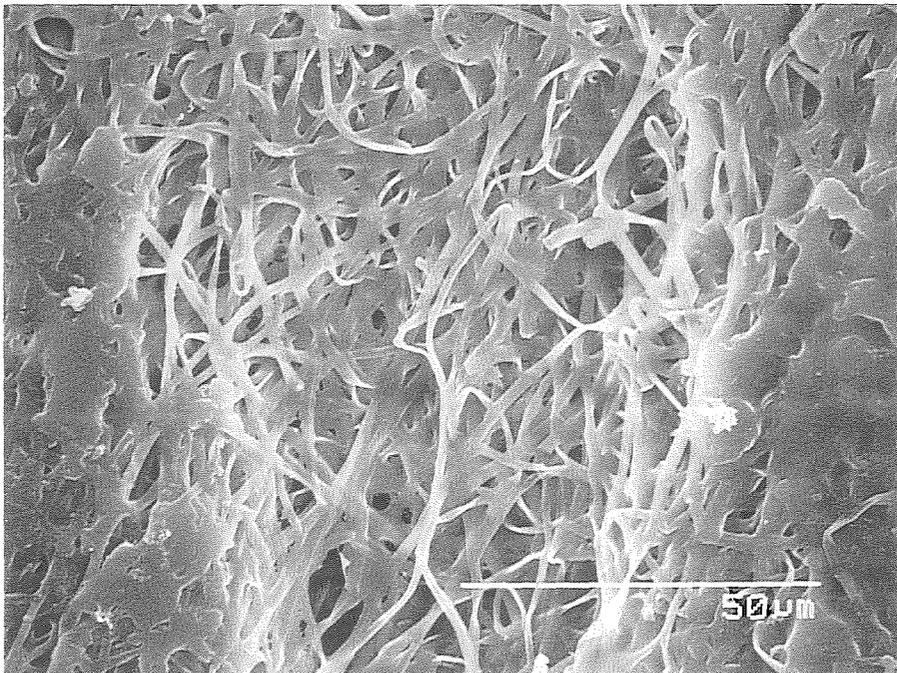


Fig. 12. Female test : inner surface of dorsal portion, anterior region.

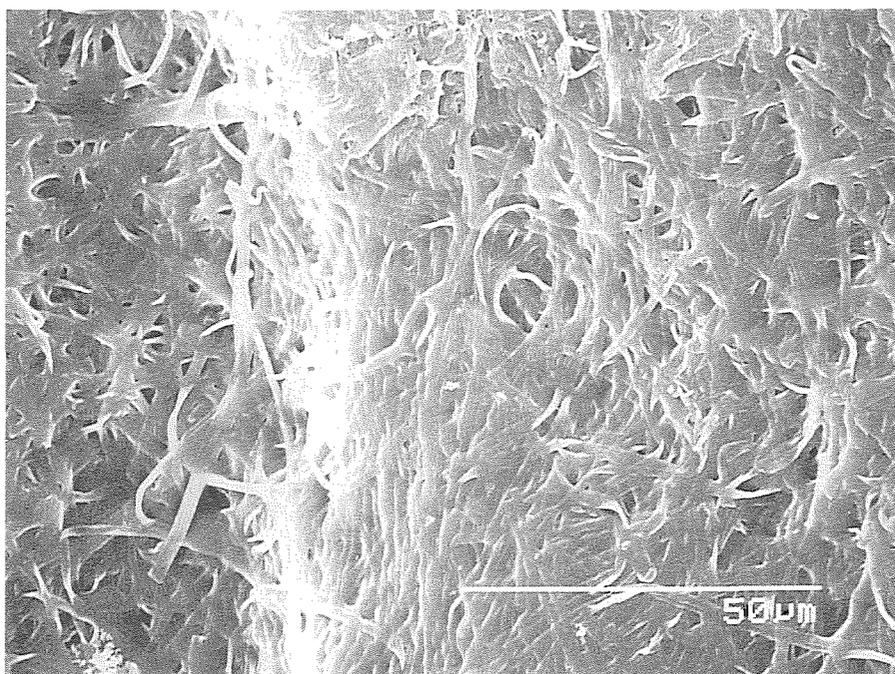


Fig. 13. Female test : inner surface of dorsal portion, posterior region.

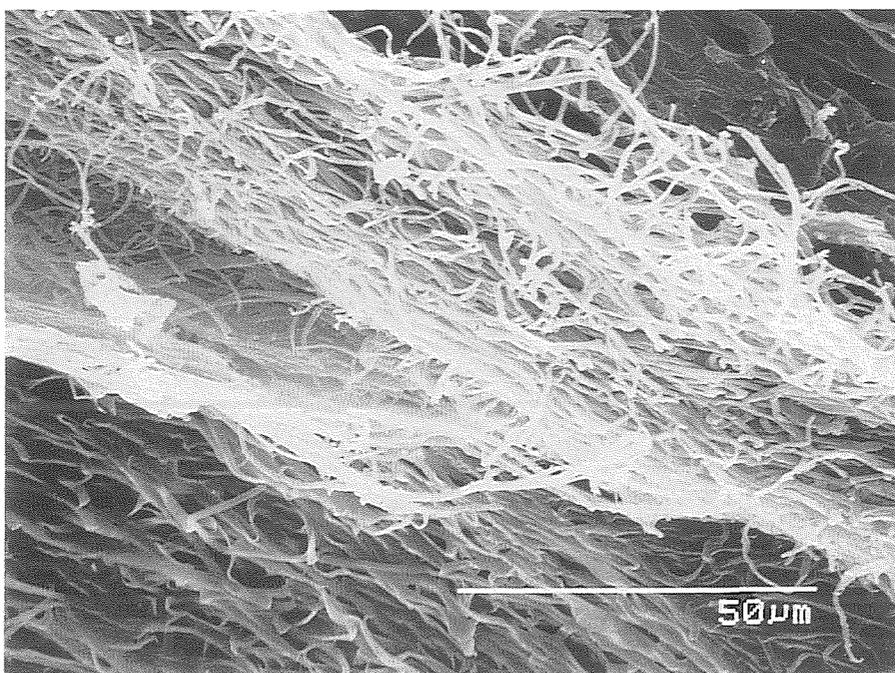


Fig. 14. Female test : inner surface of dorsal portion, posterolateral margin.

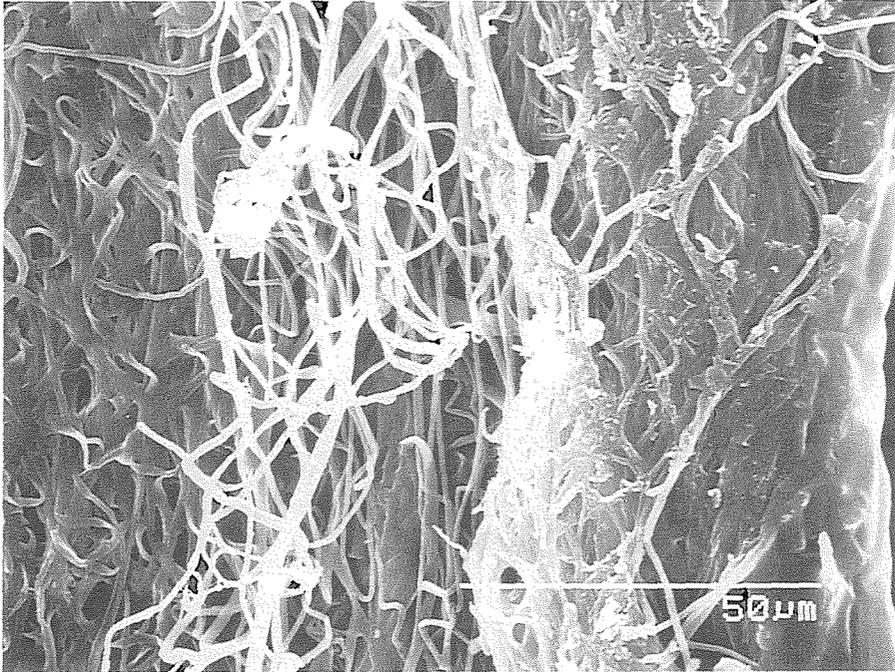


Fig. 15. Female test : inner surface of dorsal portion, near posterior end.

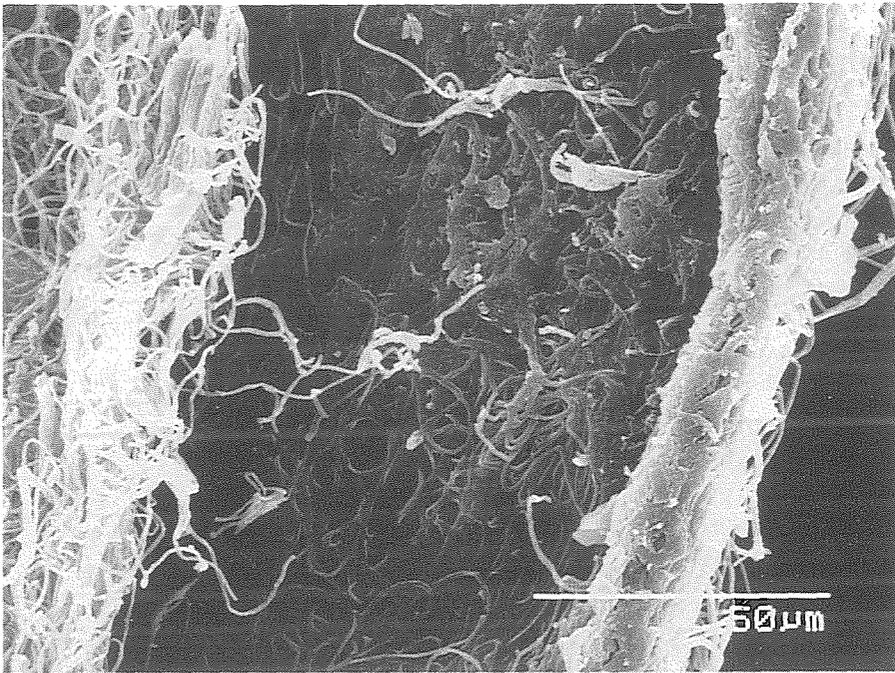


Fig. 16. Female test : ventral view, slit between dorsal and ventral portions at posterior end.

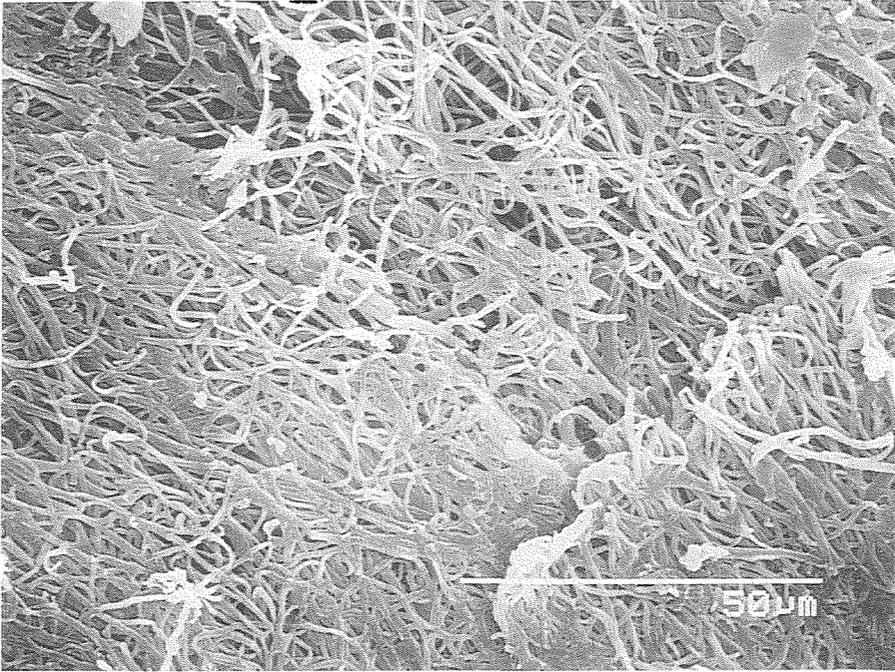


Fig. 17. Female test : outer surface of ventral portion in central region.

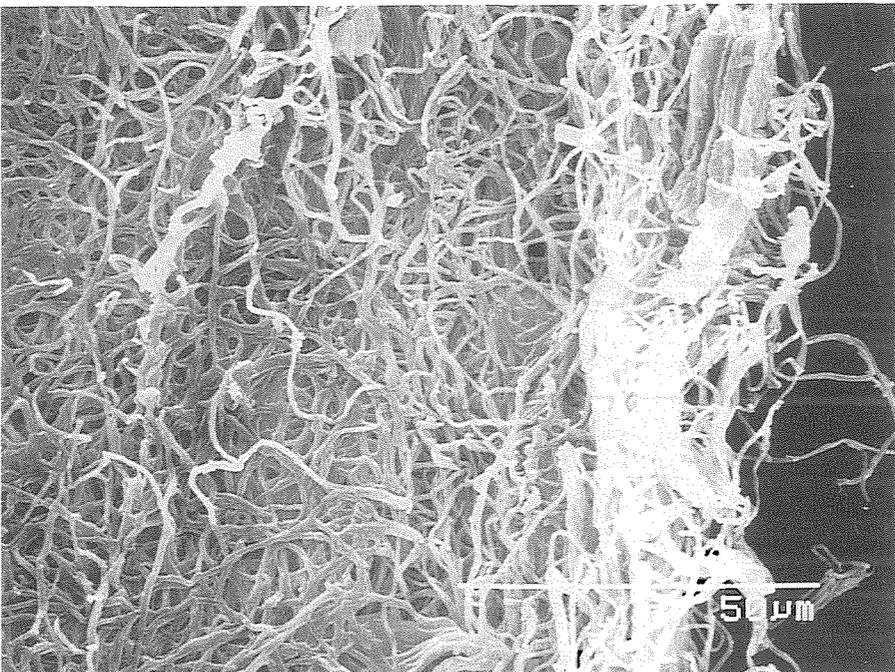


Fig. 18. Female test : outer surface of ventral portion, posterior end.

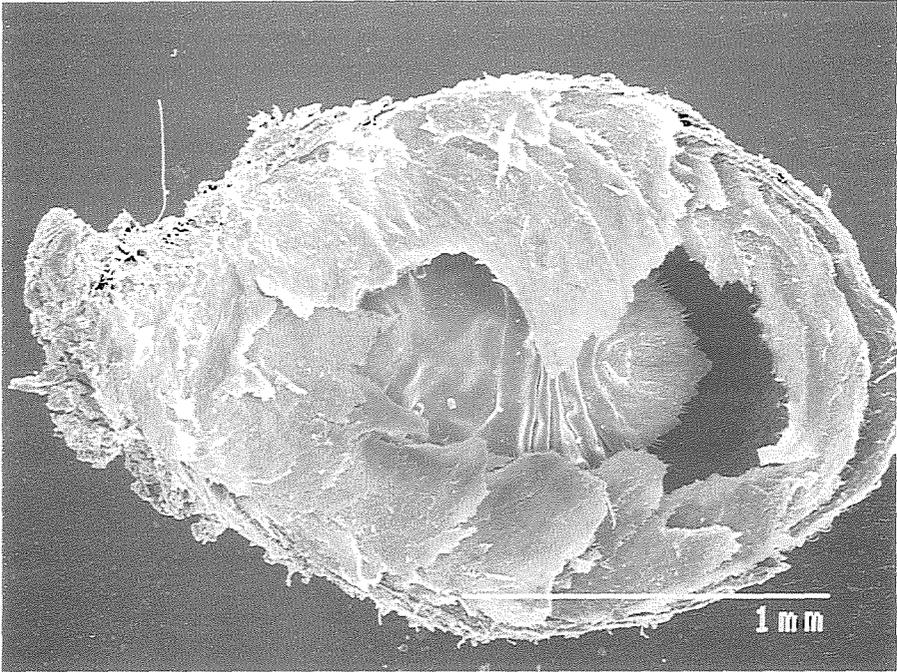


Fig. 19. Female testis : ventral view (ventral portion of the testis is partly removed).

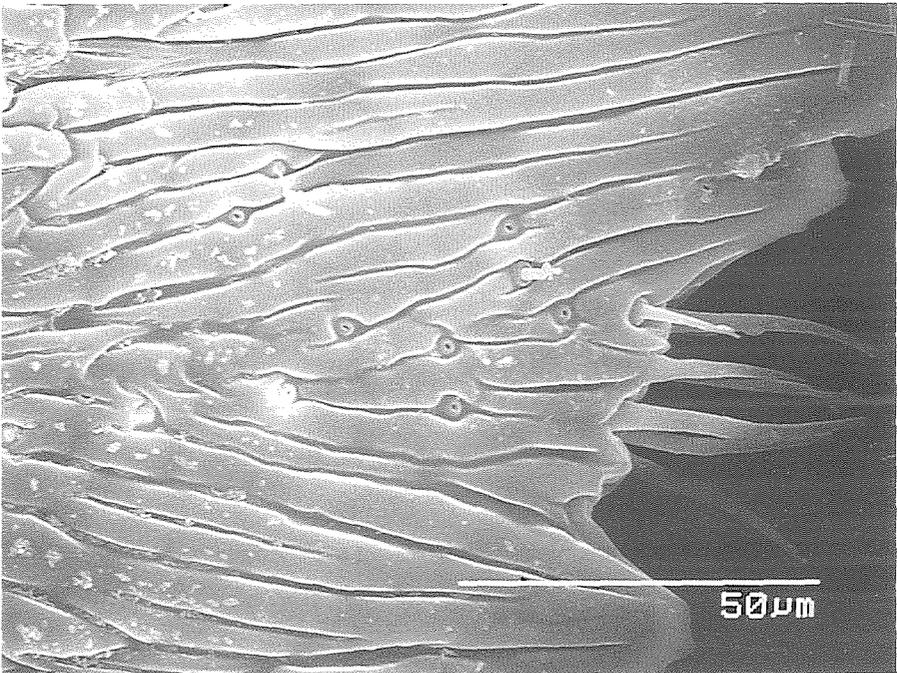


Fig. 20. Adult female : part of pygidium, ventral surface.

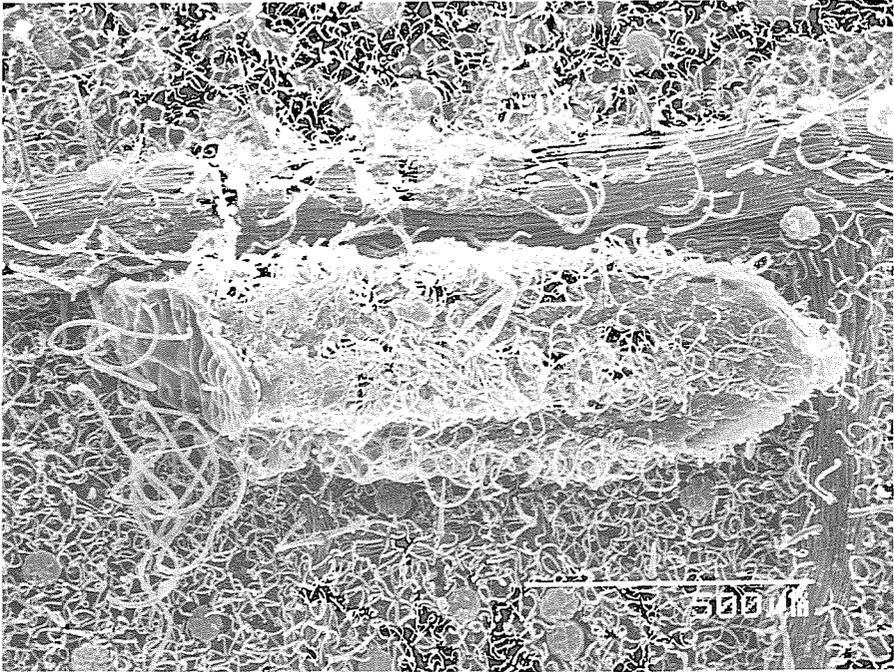


Fig. 21. Male test : dorsal view.

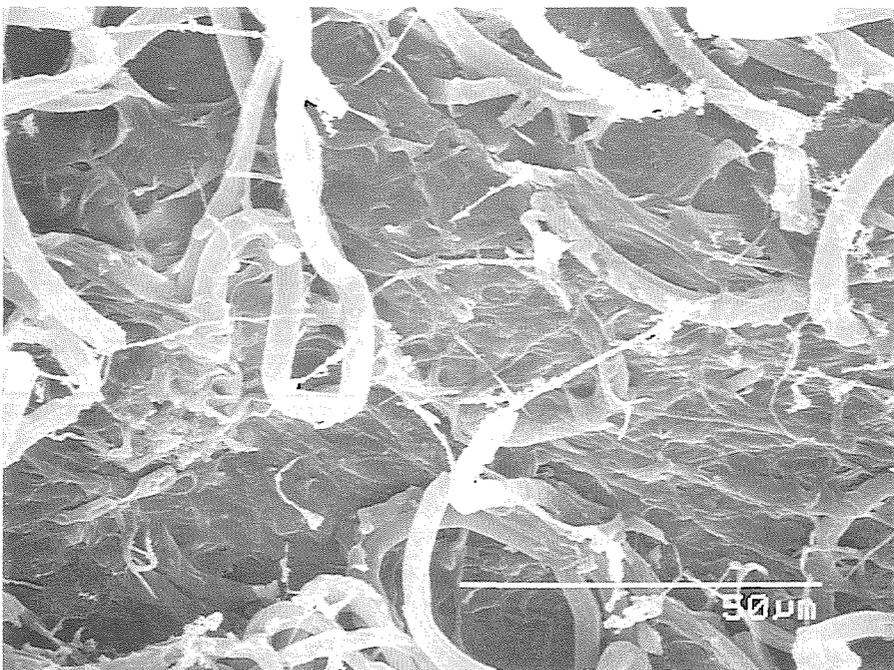


Fig. 22. Male test : dorsal view, part, showing interspace between carinae.

the posterior region of the test (Figs. 12 & 13). There are on the lateral sides of the inner surface many wax filaments forming a loose bundle and running along the margin of the test (Fig. 14); filaments are also found along the posterior margin of the test (Fig. 15).

The ventral portion of the test is well developed, leaving a slit against the dorsal portion along the posterior margin of the test (Fig. 16) (thus the insect body is entirely enclosed within the test). On the outer surface it is covered by entangled wax filaments, which, however, show some predominant direction in running (Figs. 17 and 18).

The wax ribbons composing the dorsal portion of the test may have been discharged from the dorsal ducts. On the other hand, it may not be easy to distinguish wax filaments according to their supposed origins, the smaller ducts (occurring ventrally on the pygidium and laterally on the prepygidial segments) and the gland spines (Figs. 2-4 & 20). However, a great part of the wax filaments, especially in the dorsal portion, may have originated from the gland spines.

The female test completed is much larger than the insect body (Fig. 19), and this, combined with the observations given above, postulates some movement of the insect in forming the test.

The male test appears felted and tricarinate under a dissecting microscope. At a higher magnification the carinae are composed of curved wax threads (Fig. 21), and this makes the test felted in appearance. Undoubtedly the carinae correspond to the enlarged marginal ducts in position. The interspaces between the carinae are rather smooth (Fig. 22).

TAXONOMIC POSITION OF TAMURASPIS MALLOTI

In the adult female this scale insect appears to be close to some species belonging to the American genus *Dactylaspis* (studied by Ferris, 1937, 1938, 1942), but is definitely different from them in lacking spurs or cylindrical processes on prepygidial abdominal segments. These processes are characteristic of the Lepidosaphedini, yet are often absent in the tribe. It seems unquestionable, therefore, that *Tamuraspis malloti* belongs to the tribe Lepidosaphedini and to the subtribe Coccomytilina.

The subtribe Coccomytilina was erected by Borchsenius (1965, 1966). It differs from the Lepidosaphedina in lacking 'mégapores' (the term according to Balachowsky, 1954), which uniquely characterize the subtribe Lepidosaphedina. Otherwise these subtribes, as represented by their nominiferous genera, *Lepidosaphes* and *Coccomytilus*, are very close to each other (*Coccomytilus convexus*, the nominifer of the genus, was studied by Ferris, 1941). In the tribe Lepidosaphedini the test of the male looks the same in texture with that of the female, being coriaceous in many species; in accord with this, the sexual difference in the external features is, so far as known, not conspicuous in the second instar.

In *Tamuraspis malloti* the test of the male is quite different from that of the female. It is of a felted nature and tricarinate as in many Diaspidini. The second instar male is commonly characterized with the adult and second instar females in having well-developed lobes, but otherwise remarkably different from them. It is especially noteworthy in possessing enlarged marginal ducts at positions where

modified ducts (cuplike ducts) are found in the second instar males of some chionaspine scale insects. Thus the male strongly suggests that *T. malloti* belongs to the tribe Diaspidini and is related with chionaspidines. There may be some doubt whether the male insects here are really conspecific with the females. But they agree in the antennae and other features of the first instar, and the well-developed pygidial lobes of the second instar male correspond to those of the second instar and adult females. It seems very certain, therefore, that the male insects are correctly paired with the females. On the other hand, such remarkable lobes may be unusual for a chionaspine second instar male, but we have still only meagre knowledge about phenotypic manifestation in this stage.

The view is adopted that *Tamuraspis malloti* belongs to the Diaspidini. On the other hand, there seems no doubt that *Dactylaspis* is a lepidosaphedine genus, having spurs or cylindrical processes on the prepygidial abdomen. Accordingly the resemblance of *Tamuraspis* to *Dactylaspis* in the adult female should be superficial and due to convergence. In fact, these genera are conspicuously different in the antennae of the first instar.

What is the background of this remarkable case of convergence? The female test of *Tamuraspis malloti* is usually covered by the epidermal tissue of the host plant. In *Dactylaspis crotonis*, too, the females are "covered with bark tissue in such a manner as to be distinguishable with difficulty" (Ferris, 1942), and *T. malloti* is more closely similar to *D. crotonis* than to any other species of *Dactylaspis* in the state of the pygidial lobes. In these species the heavy and almost continuous median and second lobes are apparently associated with their habit of burrowing in the bark. This agreement alone is, however, far from an explanation for the case.

FURTHER REMARKS

In concluding this paper I would like to point out the possibility that the Coccomytilina as currently composed may include foreign forms (diaspidines) in convergence. If no material of the male were available, I would take *Tamuraspis malloti* for a coccomytiline with little doubt. Borchsenius (1966) referred 12 genera and 26 species to the subtribe, but some of them may be doubted as to their given position. So far as I am aware, none of the species referred to the subtribe has yet been examined for the second instar male. However, when species in question are parthenogenetic, is there any way to find their right positions? In this connection *Howardia* has generally been referred to the tribe Diaspidini, but it should be a coccomytiline genus, having prepygidial spurs in the adult female. Unfortunately, no support may be expected for this view from the second instar male, because the male has been unknown for either of the two species of the genus (Williams & Watson, 1988).

The case of convergence reported in this paper is concerned with the tribes Diaspidini and Lepidosaphedini, and the two cases mentioned at the beginning are both with the subtribes Chionaspidina and Fioriniina, the tribe Diaspidini. In all these cases the counterparts are remotely related and the second instar males are different enough to show the right positions of the forms in question. However, if convergence takes place between closer forms (for example, within the subtribe Chionaspidina), is it possible to recognize the phenomenon at all?

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