The Natural History of Brochosomes in *Yakuza gaunga* (Hemiptera, Auchenorrhyncha, Cicadellidae, Typhlocybinae, Erythroneurini).

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Abstract

Pictures of body parts of the leafhopper *Yakuza gaunga* covered with brochosomes are shown. The emphasis is on the difference in the amount of the excretion applied by the insect on different body regions and structures which facilitate the process. In the studied insect, only males deposit thick layers of brochosomes on the frontoclypeus and on the anteclypeus.

Key words: Hemiptera, Typhlocybinae, SEM, brochosomes, male behaviour.

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Introduction

The particular behavior of insects of the superfamily Membracoidea to use the product of excretion for coating the body surface has been long known (STOREY & NICHOLS 1937). It has been well established that the functioning component of the excretion fluid is solid microgranules, later called brochosomes, which are produced by specialized regions of the Malpighian tubules. SMITH & LITTAU (1960) gave review of study of the brochosomes as well as detailed original studies in electron microscopy of the excretory organs, complete with the histochemical tests. They found that the micro-granules contain lipid and protein. VIDANO & ARZONE (1984) observed the behaviour of insects very similar to the subject of the present study in the same superfamily, distributing the excretion over their body surfaces. These observations are helpful in arranging the pictographic material obtained recently on *Yakuza gaunga* from Myanmar. Initially this study was focused on the difference between the male and female characters of the brochosome coat on the frontoclypeus because only the male accumulates great quantities of the excretion on its face. It was also interesting to look at the brochosome coat on other cuticular surfaces. Later not only the brochosome coat but also cuticular outgrowths that help packing the powdered material on the otherwise smooth surface were investigated as well as the spiny armour of the prothoracic and metathoracic legs which serve as tools in the process of coating.

Material and Methods

A small sample of insects collected from a forest in Myanmar, subsequently killed by cyanide vapour and air dried was sputter coated with 25 nm gold and observed using a Cambridge 250T scanning electron microscope (SEM) and a Hitachi SEM. One male and one female were subsequently boiled in KOH, to remove all the brochosome coating from the cuticular surfaces then dehydrated in a series of ethanol, critically point dried and observed with SEM. Dissecting light microscope pictures were taken to show the colour and texture of the whole insects.

Results

The photographs are arranged to illustrate the presumed fate of the brochosomes from their liberation at the end of the anal tube to the final deposition. VIDANO & ARZONE (1984) observed that the brochosomes are initially collected by the hind tibiae and first deposited on the wax-field at the costal margin of the forewing, which is a storage site. From this accumulation, analogous to compact powder, the insect spreads the loose material all over the body using mostly the hind legs and works on anterior surfaces (including the face) with the fore legs.

The brochosomes contained in droplets of excretion leave the gut through the anus situated among sclerites on the posterior surface of segment 11 (Figs 7, 8) which is similar in both sexes (Figs 9, 10). Subsequently the brochosomes are collected by the hind legs (Figs 11, 12) and deposited on the wax-field on the fore wing (Figs 1, 4, 13, 14). Figure 15 shows accumulation of brochosomes on the wax-field close to the costal margin which is adorned with thickly packed cuticular outgrowths (Fig. 18). Figures 17-20 show the main surface of the wax-field cleared of brochosomes and filled with ridges (Fig. 19), but relatively smooth, with occasional sensilla (Fig. 21). This allows the thick layer of brochosomes to be packed (similarly to the pollen in pollen basket of the honey bee) as the surrounding area and remaining part of the fore wing is rough with short cuticular outgrowths (Fig. 22). The brochosomes are also incidentally gathered in masses on areas which are close to the places of their distribution: e.g. pygofer lobe (Fig. 6); paramere (Figs 29, 30); ventral side of wax-field (Fig. 23); costal margin of hind wing (Fig. 24); apical part of hind wing (Figs 25, 26); and margin of fore wing at caudo-dorsal angle (Figs 25, 27, 28). The whole surface of the body becomes coated by a thin layer of brochosomes subsequently taken from the wax-field and deposited in the final destination by the hind legs, or on the anterior part of the body by the fore legs (Figs 31, 32). The middle legs do not have the specialized setae on the tibiae (Fig. 33) and do not become as involved in brochosome distribution. There is accumulation of brochosomes on the lateral lobe of the pronotum (Figs 34, 35) which is covered with prominent cuticular outgrowths (Figs 35, 36). This part of the pronotum together with the dorsal side of the fore wing (Fig. 37) form a water protecting roof over the rest of the body. The ventral side of the fore wing hosts considerably less brochosomes (Fig. 38). Also the hind wing has a coating with only sparsely distributed brochosomes (Figs 39, 40). A male, contrary to a female, (Fig. 1) paints its face with a thick layer of brochosomes (Figs 2-5) apparently by using its fore legs (Figs 41, 42). This is a behavioural feature of the male, not a structural feature since the male frontoclypeus (Fig. 43) is only slightly more convex than that of the female (Fig. 34) and the cuticular sculpture facilitating better adherence of the brochosome coating on frontoclypeus (Figs 45, 46) is not considerably richer than that of a female (Figs 47, 48).

Discussion

The function of the brochosome coat was believed to be a protective layer against desiccation of these delicate insects by augmenting the waterproof properties of the integument. Where the water elements prove to be excessive, the brochosome coat acts as an anti-wetting agent in addition to the cuticular wax.

The pictures obtained in this study support the hypothesis that the brochosome coat is protection against excess loss of water. On the side of the body (Fig. 34) an unexpected accumulation of material on the specialized surface of lateral lobe of pronotum (Fig. 36) is visible. This part of the body together with the wings may function like a roof over the remaining parts of the insect (Figs 1, 4). Figures 37 to 40 show the difference in the brochosome layers between the fore and hind wings and between their dorsal and ventral surfaces supporting the well known property of hydrophoby particularly of the upper surfaces. They show that the ventral surface hosts considerably less microgranules than the dorsal surface of the fore wing and that the amount of brochosomes on the ventral surface of the fore wing is comparable to that on dorsal surface of the hind wing. The brochosomes contain mainly lipid material, justifying the difference in affiliation of these surfaces to water. The margins of the wings which host considerable numbers brochosomes (Figures 23, 27) also consequently change their affiliation to water. The function of protecting against desiccation seems to be obvious by analogy with desert insects and other organisms, which coat themselves with dust. The insects of the superfamily Membracoidea are more active in higher temperatures. Typhlocybinae (almost without exception) die of dehydration very fast when devoid of the opportunity to replenish body fluids, so that any increase in protection against water loss is very important. Brochosomes may also aid cleaning of the body surface by the insect in a process analogous to „sand bathing."

One observation difficult to explain on this basis is the behaviour of males and deposition of the brochosomes on their face in *Yakuza gaunga*. This behaviour is expressed also by several other species of this genus. DAY (1993) mentioned the function of brochosomes as carriers of pheromones. The author suggested that the brochosomes might function as vectors of aggregation pheromones and also sex pheromones. There is no direct evidence that Typhocybinae do produce any pheromone including sex pheromones. On the other hand the production of pheromones has been proven in various groups of Rhynchota. The alarm pheromones originally described in social Hymenoptera and Isoptera were later discovered in non-social but gregarious insects such as aphids. Among the closer relatives of Typhlocybinae, the alarm pheromones were found in Membracidae (NAULT et al. 1974). The sex pheromones are known in Heteropotera (THISTLEWOOD et al. 1989) and, as in most cases, these were produced by females. In cases where the sex pheromones are produced, they provide a method of communication triggering mating behaviour. In Membracoidea, like most of Auchenorryncha, communication for mating behaviour is realized by sound production. Acoustic behaviour in these insects (including Typhlocybinae) is already broadly accepted as the only known way of communication. This does not exclude of course the existence of other methods of communication, for example through pheromones, although that possibility has not yet been listed.

The present example of male *Yakuza* behaviour involving brochosomes (that may possibly be carriers of pheromones) so different from that of the female behaviour, suggests that this superficially morphological effect may be a way of sending chemical or at least visual information related to reproduction.

The immature male has a black to dark grey face and only after some time and labour does it achieve the white shining coat of brochosomes (Figs 2, 3). The female face always retains its natural colours with a light brochosome coating as on most parts of its body.

In one sample of another species of *Yakuza*, all the males were found without prominent brochosome deposits on the face suggesting that they were immature. Perhaps in this species there is a long period of maturation of adult males needed for accumulating facial brochosomes and eventually saturating them with pheromones increasing the chance of finding a mate. All these speculations could be investigated by taking a species of the genus *Yakuza* easy to breed on potted Araceae plants, some species of which are food crops.

Zusammenfassung

Die Verteilung von Brochosomen auf verschiedenen Körperteilen der Kleinzikade *Yakuza gaunga* wird anhand von Fotos dargestellt. Die Männchen dieser Art deponieren - im Gegensatz zu den Weibchen - eine mächtige Schicht von Brochosomen auch an Fronto- und Anteclypeus.

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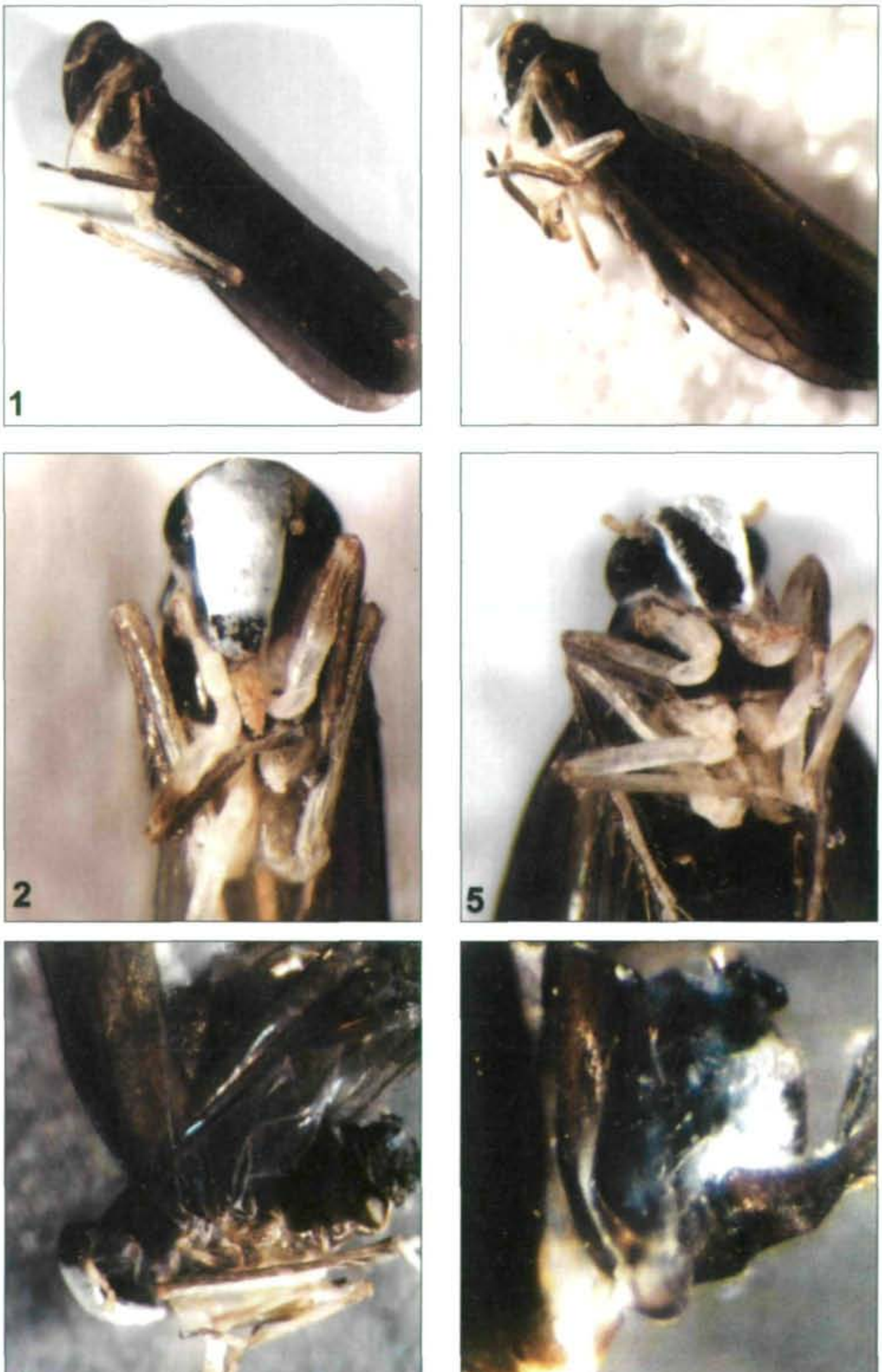
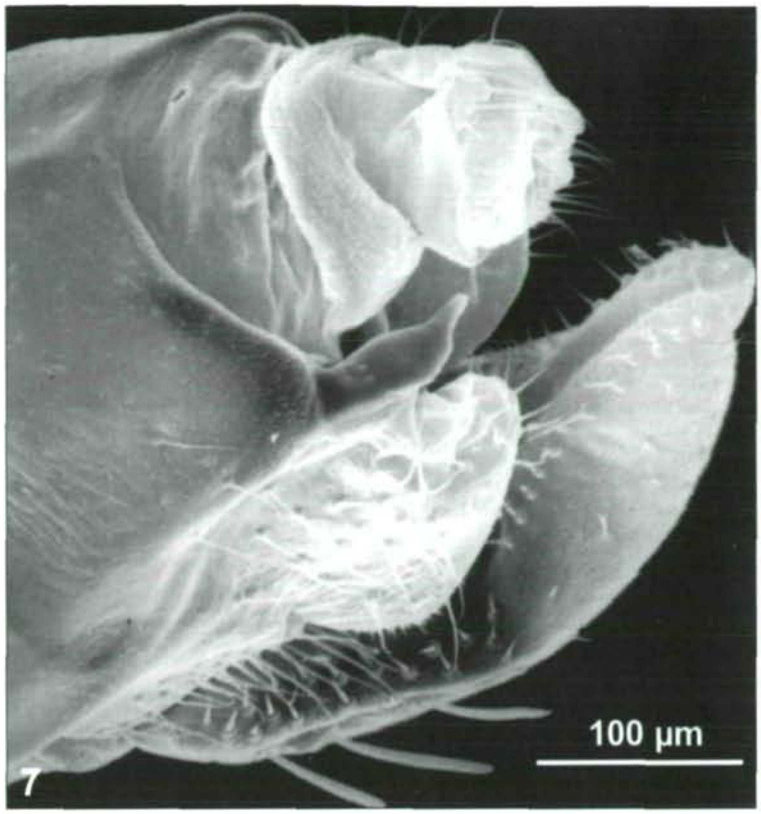
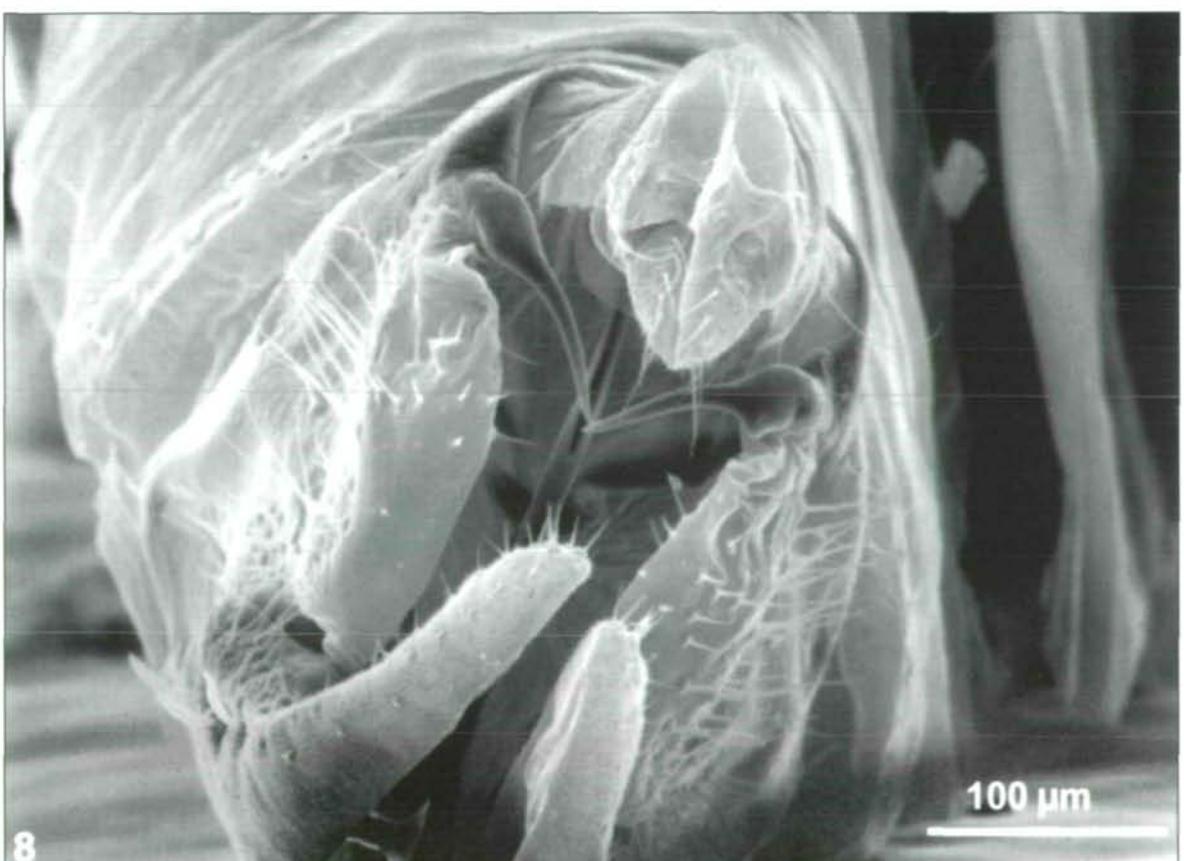
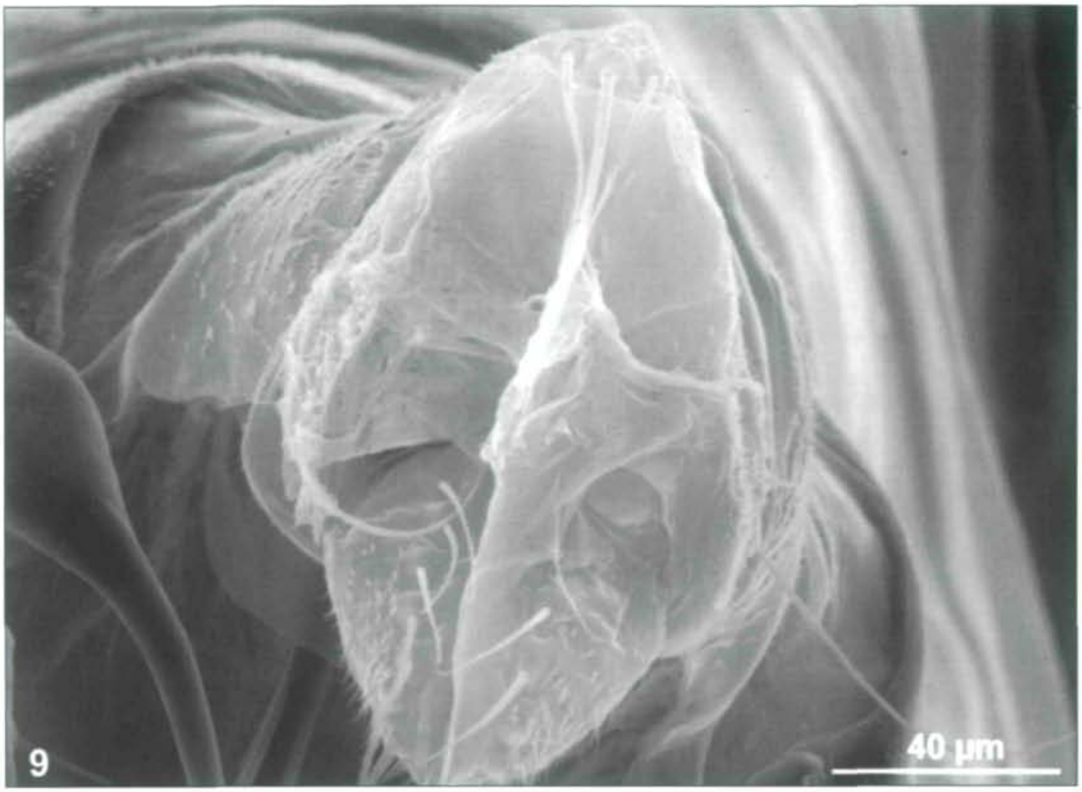


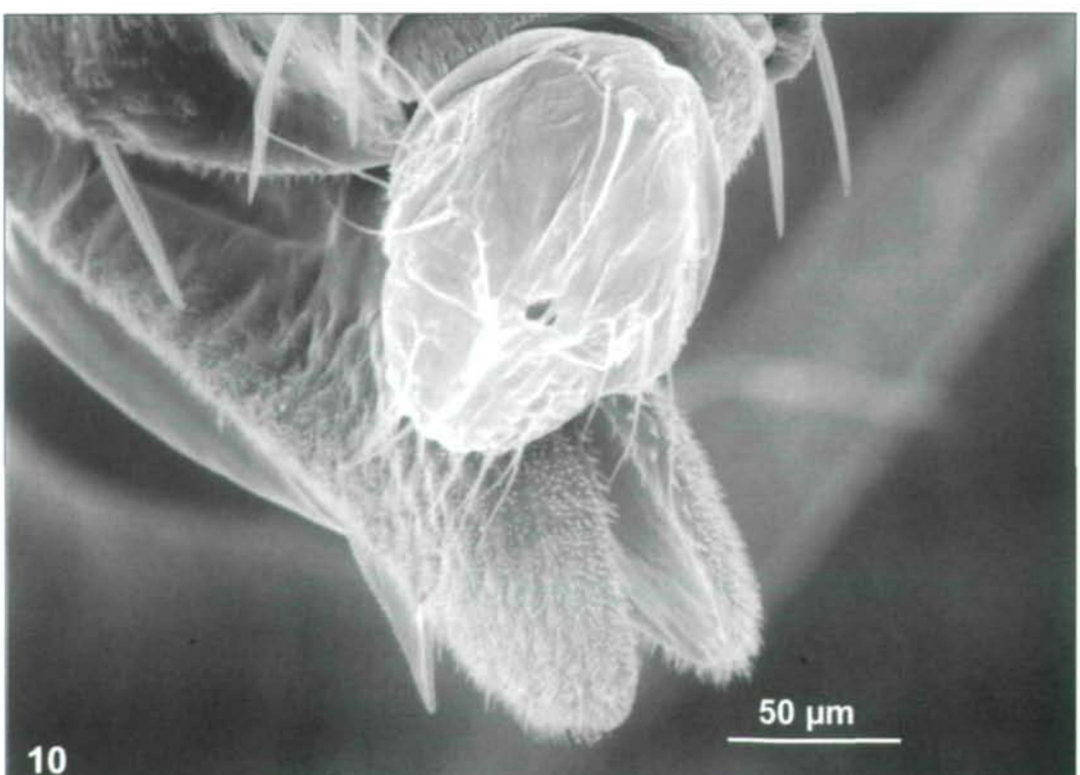
Figs 1-6:
Habitus of *Yakuza gaunga*, female, lateral view (1); same, male, ventral side, complete coating of fronto-clypeus (2); same male, lateral view, brochosome coating on face complete (3); same, male, lateral view (4); same male ventral side, part of brochosome coating on right side of face pealed off (5); same, male terminalia, brochosomes accumulated on ventral region of pygofer lobe (6).

Figs 7-8:
Yakuza gaunga, male terminalia cleared of brochosomes, dorso-lateral view (7); same, caudal view (8).



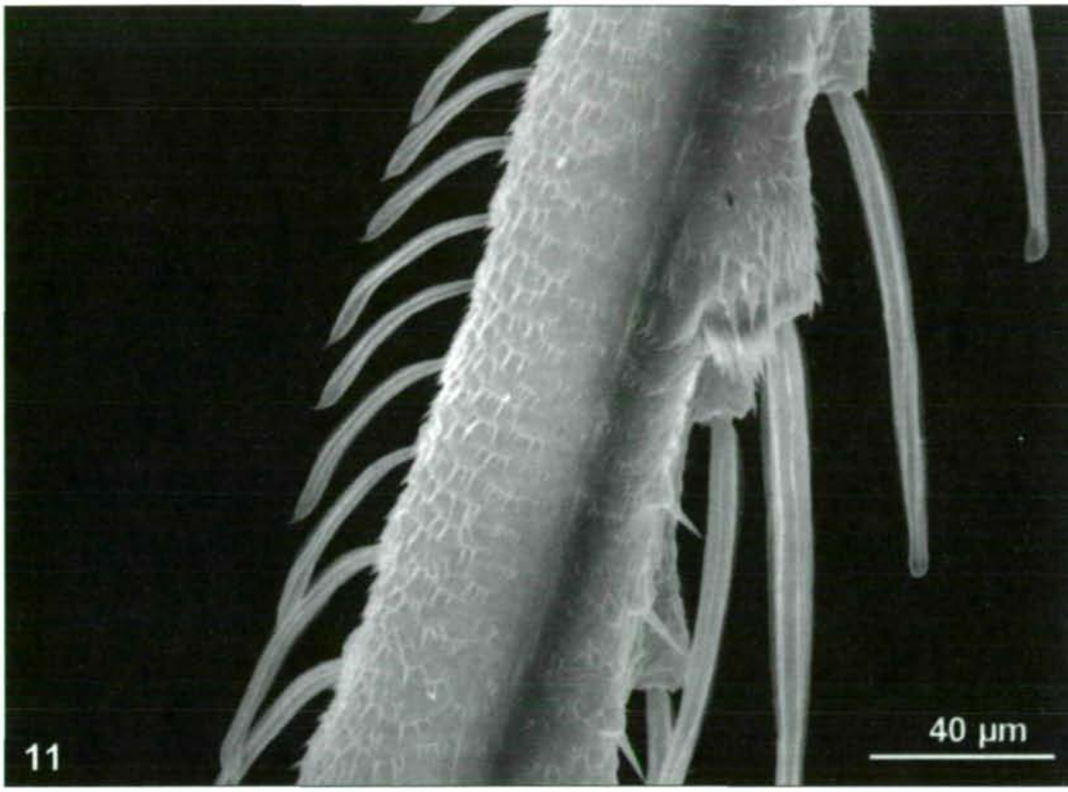


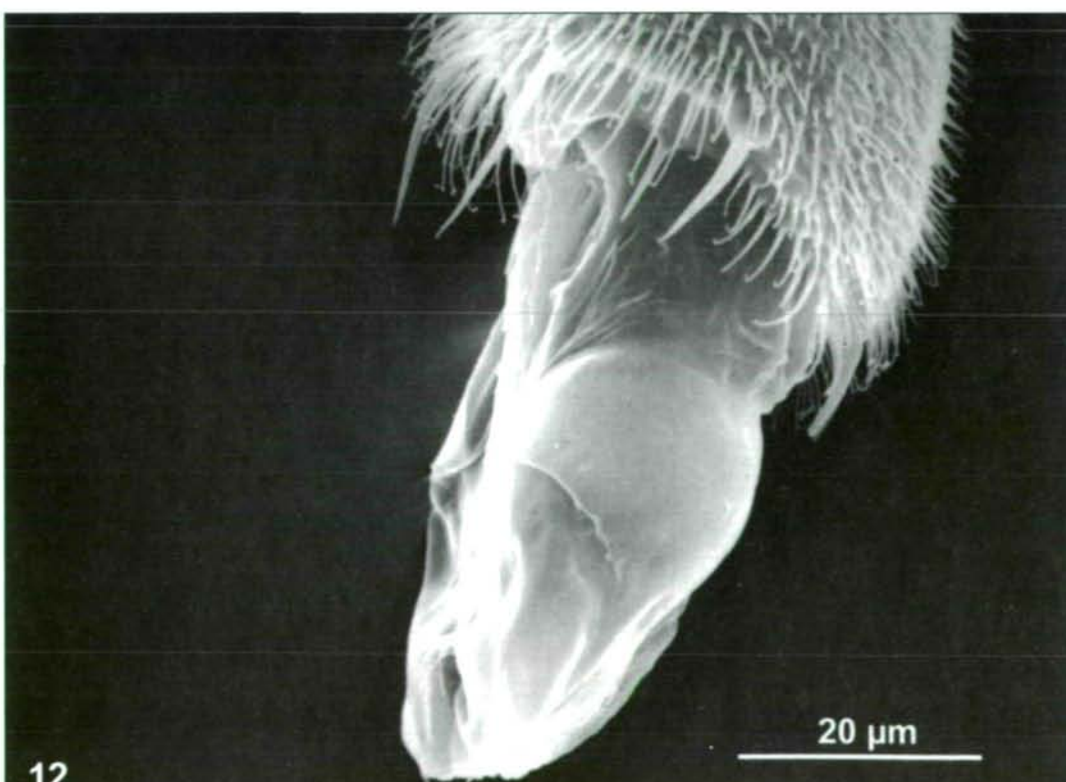


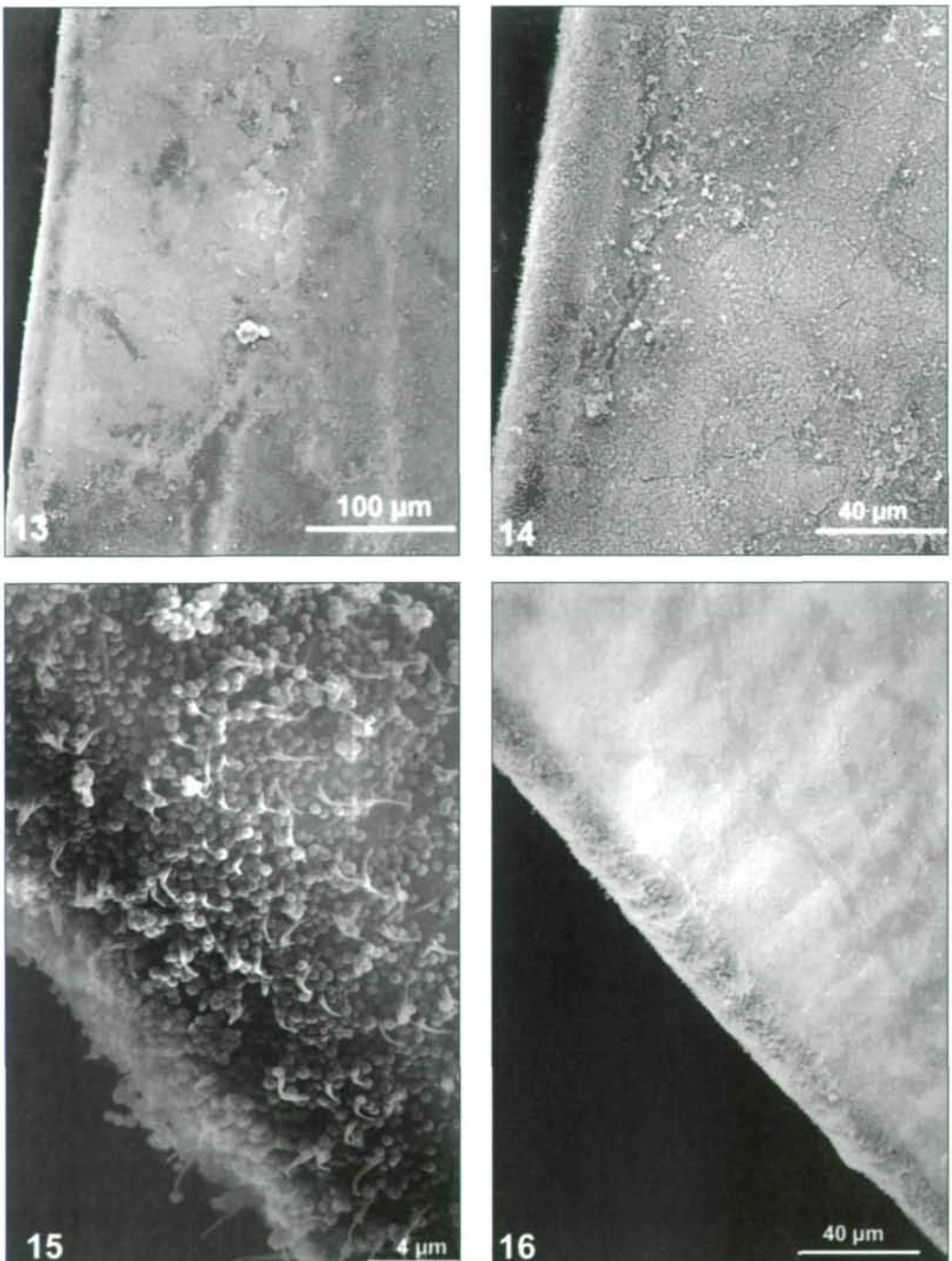


Figs 9-10:
segment 11 of male cleared of brochosomes, caudal view (9); same of female (10).

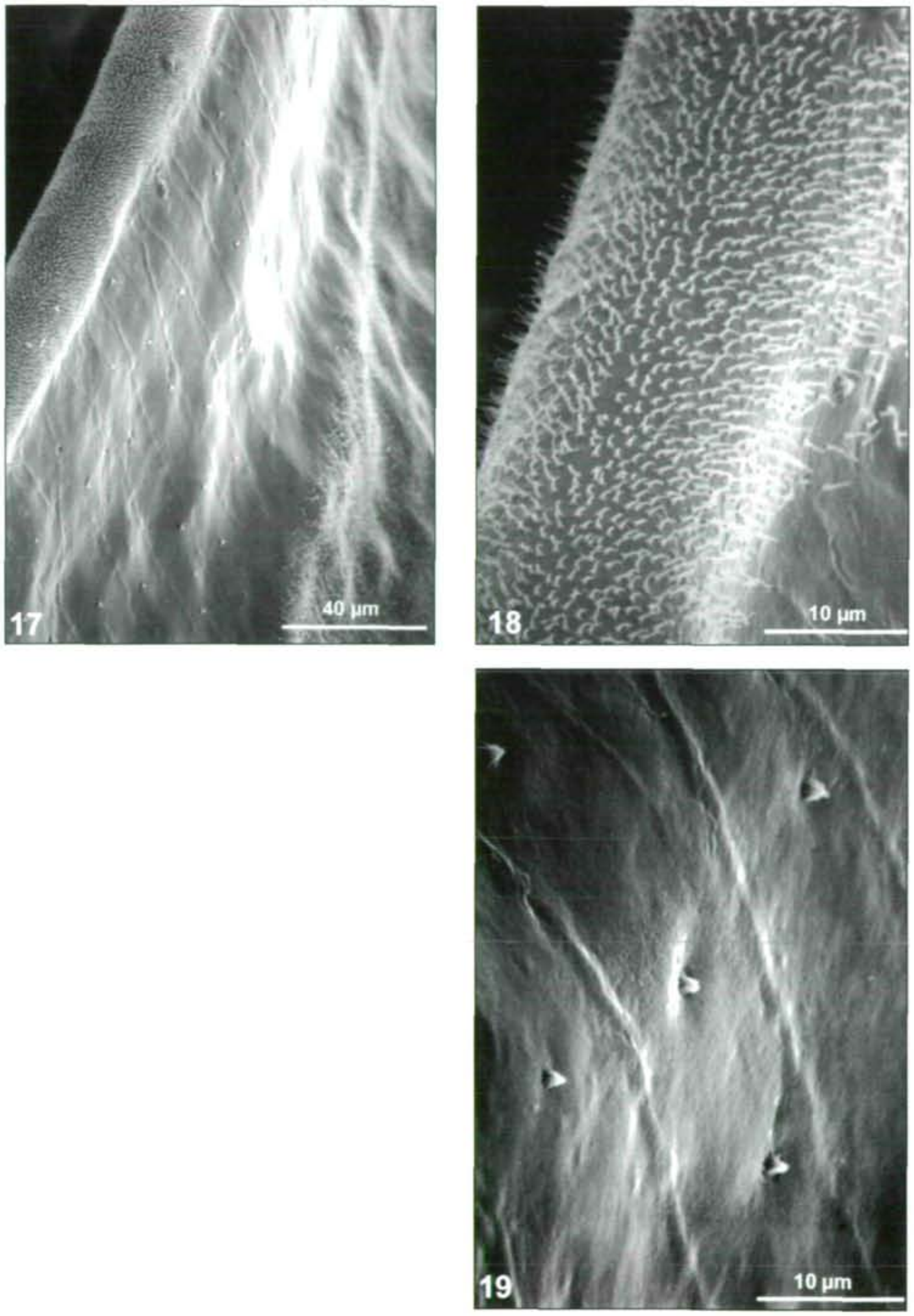
Figs 11-12:
hind tibia cleared of brochosomes (11); meso and metatarsus of hind leg cleared of brochosomes (12).



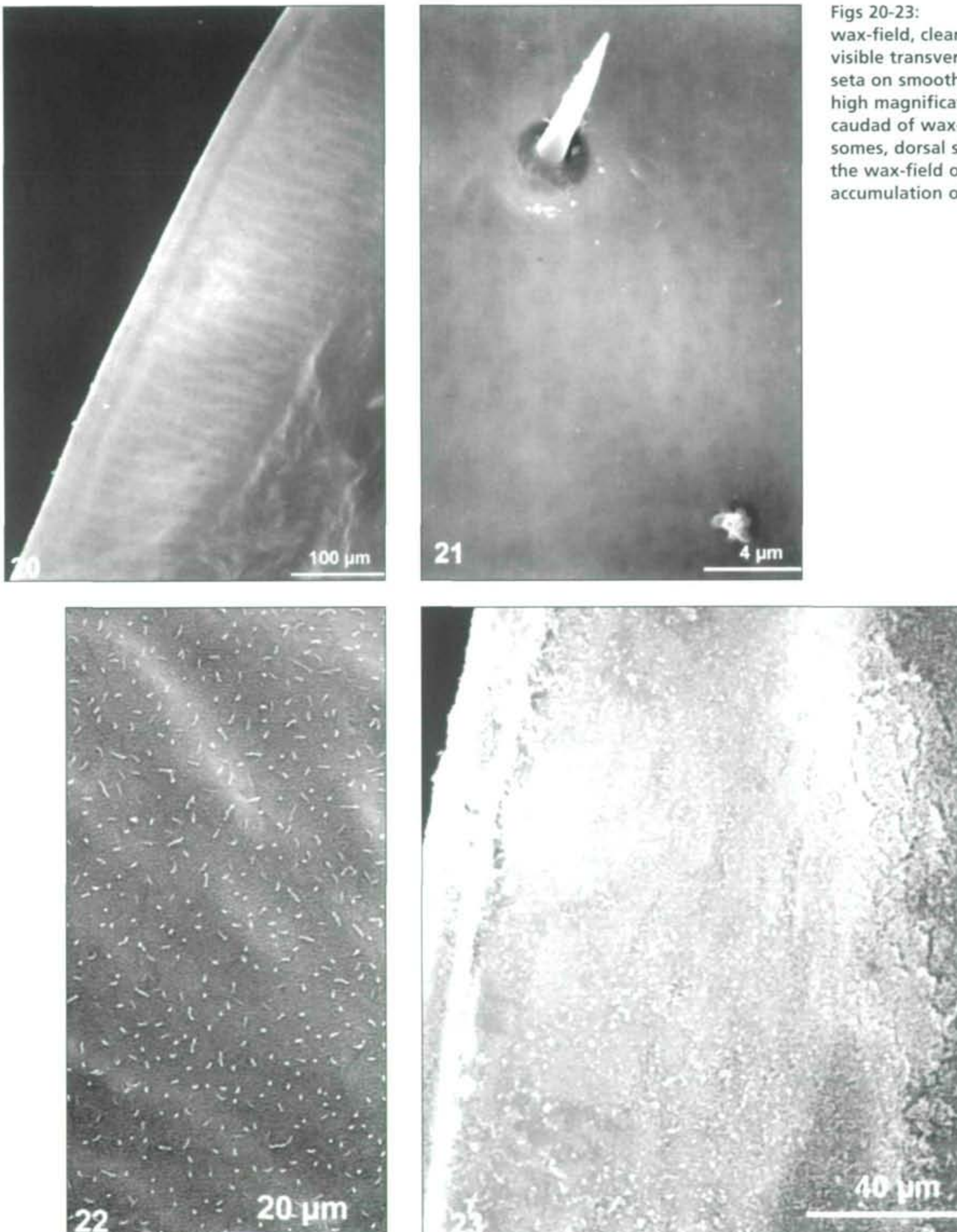




Figs 13-16:
wax-field on fore wing covered with brochosomes (13); same, higher magnification, thick coat of brochosomes (14); costal margin of fore wing coated with brochosomes, higher magnification (15); wax-field on fore wing slightly covered with brochosomes (16).

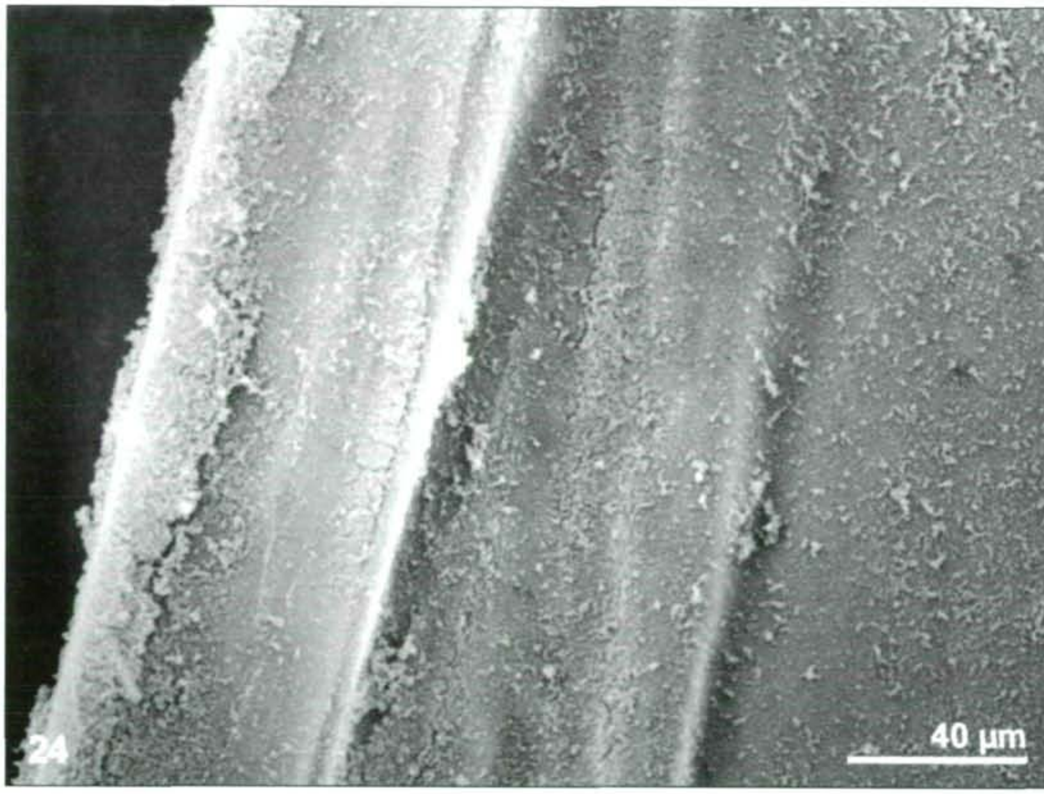


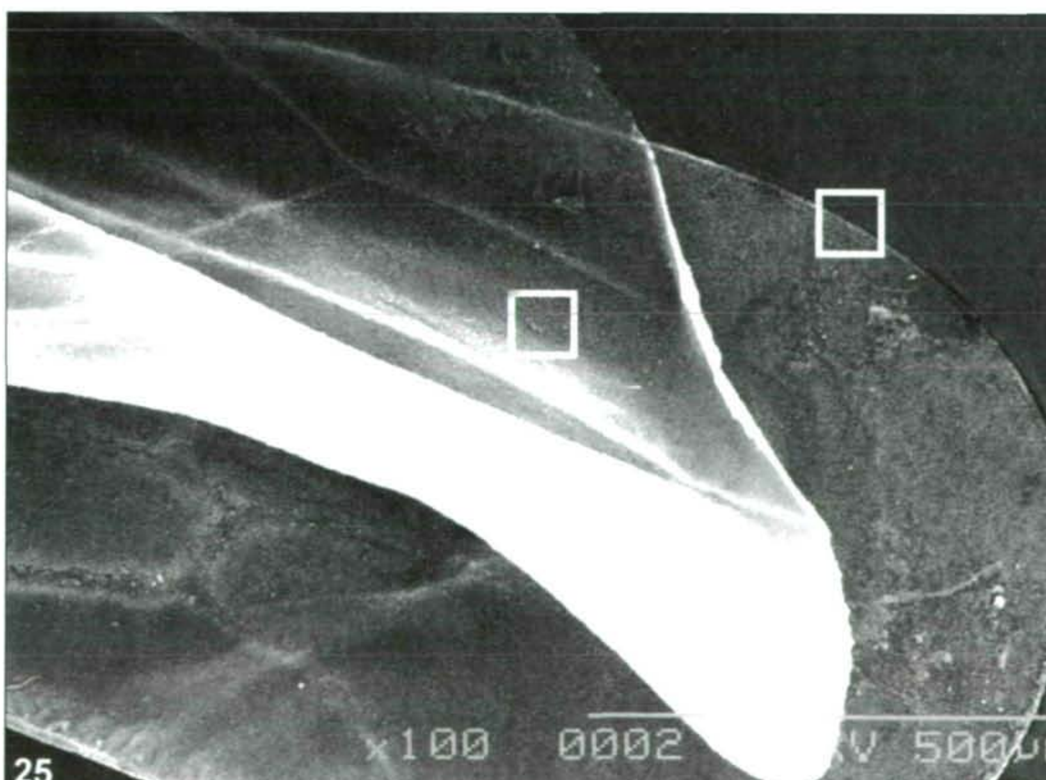
Figs 17-19:
wax-field on fore wing cleared of brochosomes (17); same, costal margin, higher magnification (18); same, ridges across the wax-field (19).

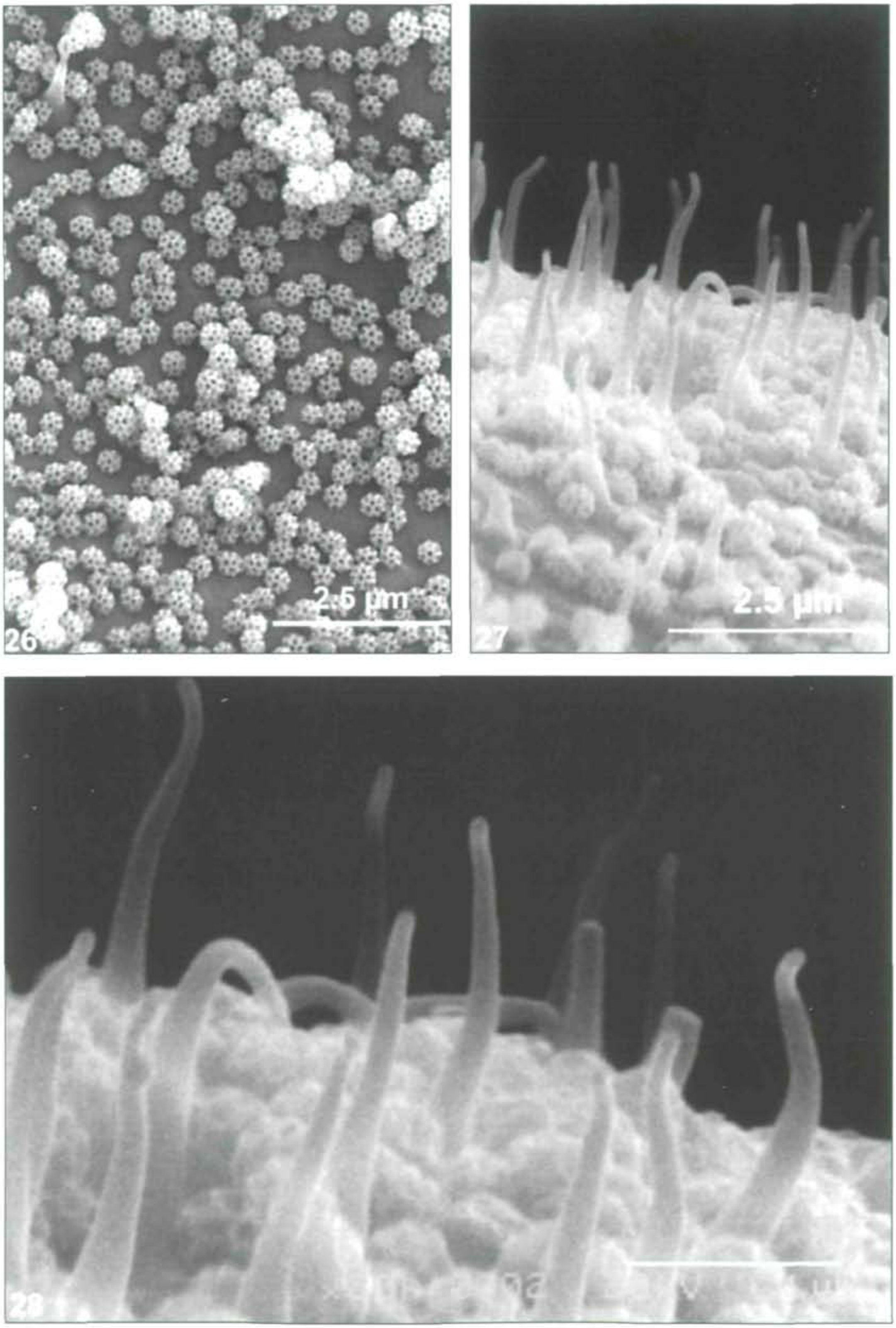


Figs 20-23:
wax-field, cleared of brochosomes, visible transverse ridges (20); sensory seta on smooth surface of wax-field, high magnification (21); costal cell caudad of wax-field cleared of brochosomes, dorsal side (22); underside of the wax-field on fore wing hosting accumulation of brochosomes (23).

Figs 24-25:
hind wing, dorsal side, costal margin to the left (24); posterior parts of hind wing (above) and fore wing (below), ventral side, frames indicate areas increased in subsequent Figs 26-28 (25)

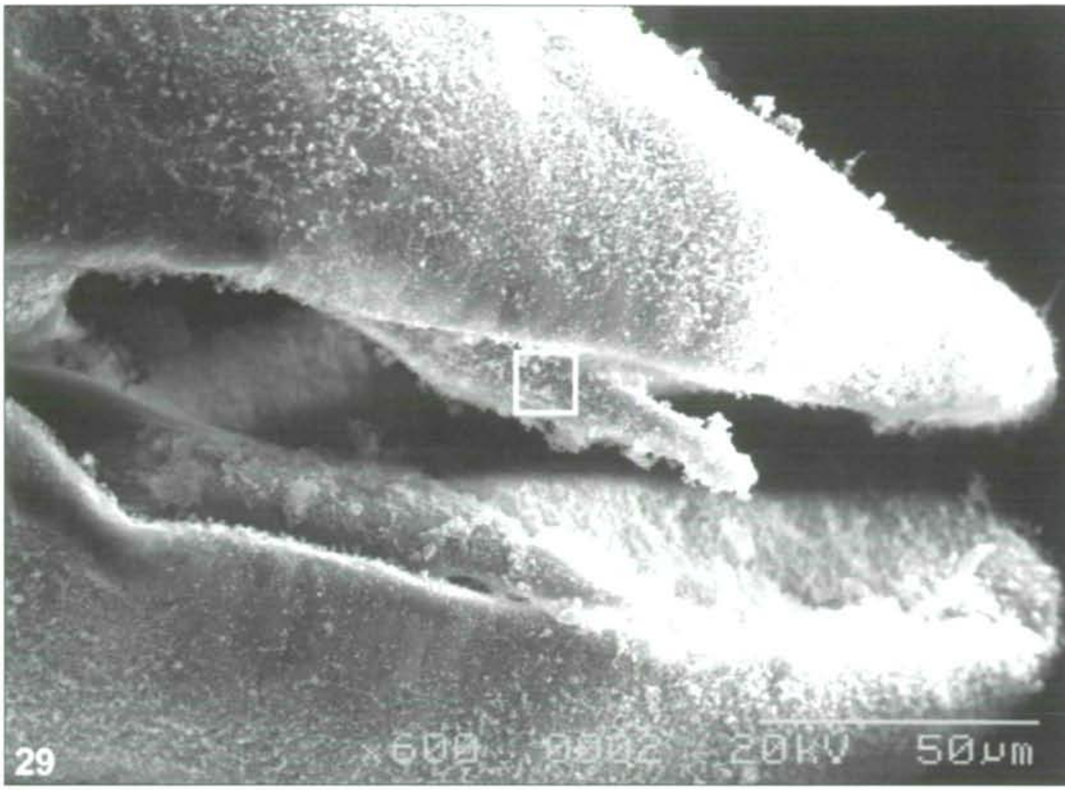


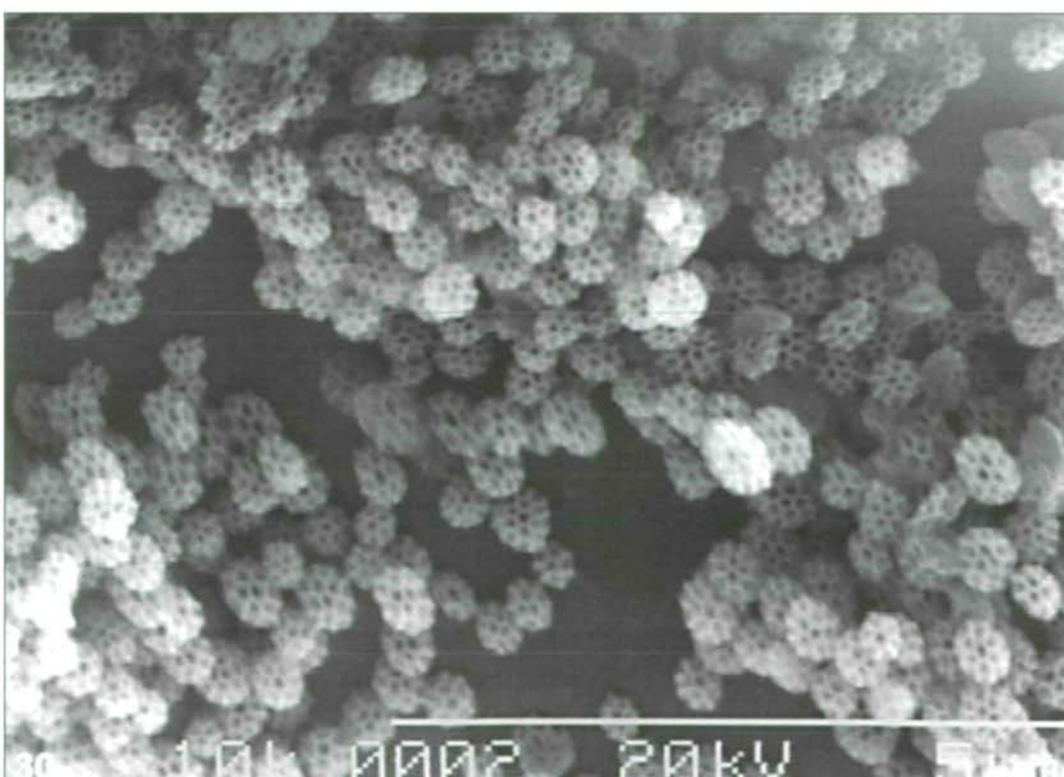


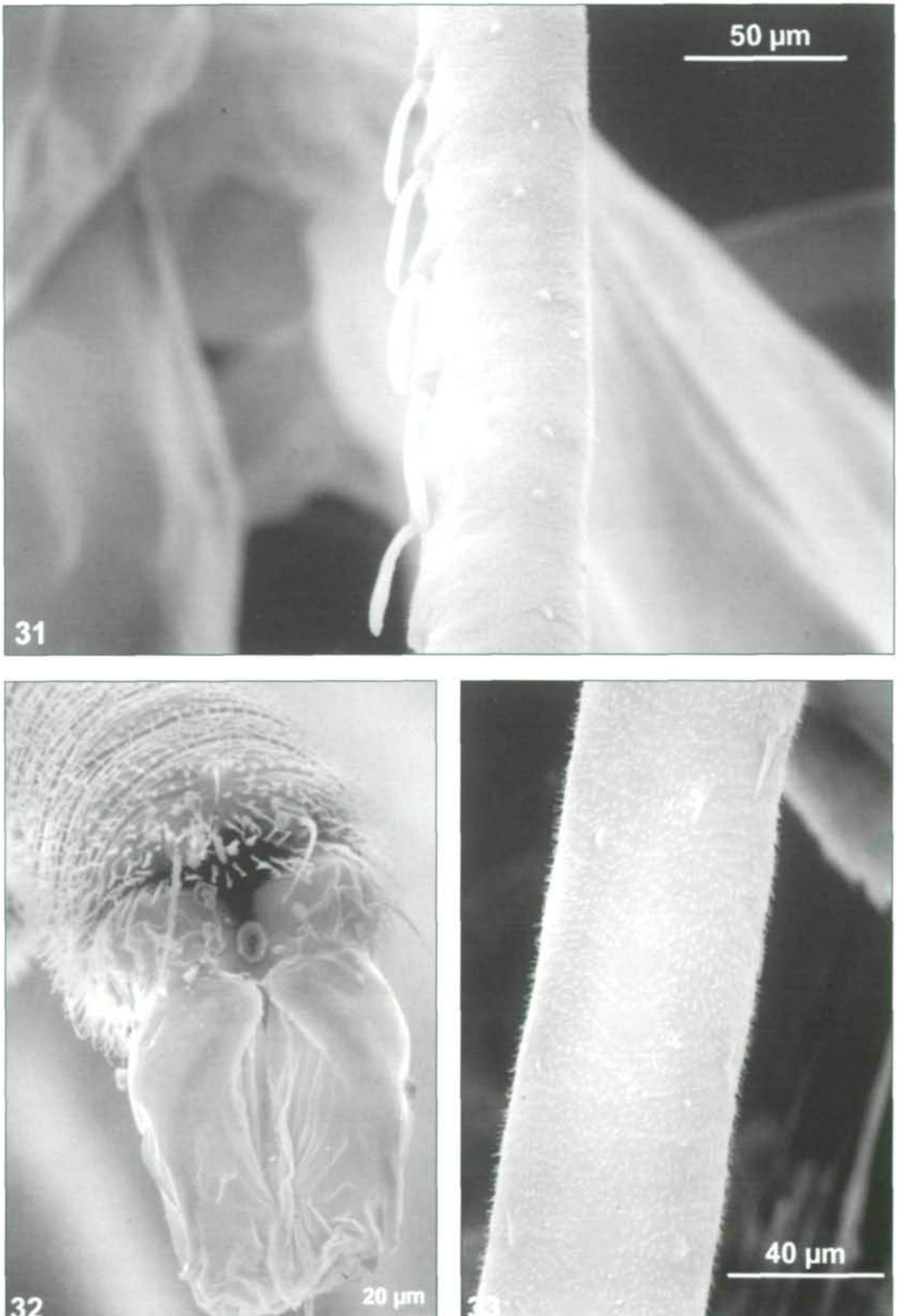


Figs 26-28:
hind wing, brochosomes accumulated on cua apical cell (as indicated by a frame in Fig, 25), ventral side (24); fore wing, brochosomes accumulated at postero-apical angle, ventral side (27); same, higher magnification (28).

Figs 29-30:
male terminalia, ventral view, area on paramere indiocated by a frame (29); same, area indicated in Fig, 29 on tibial part of paramere, higher magnification (30).

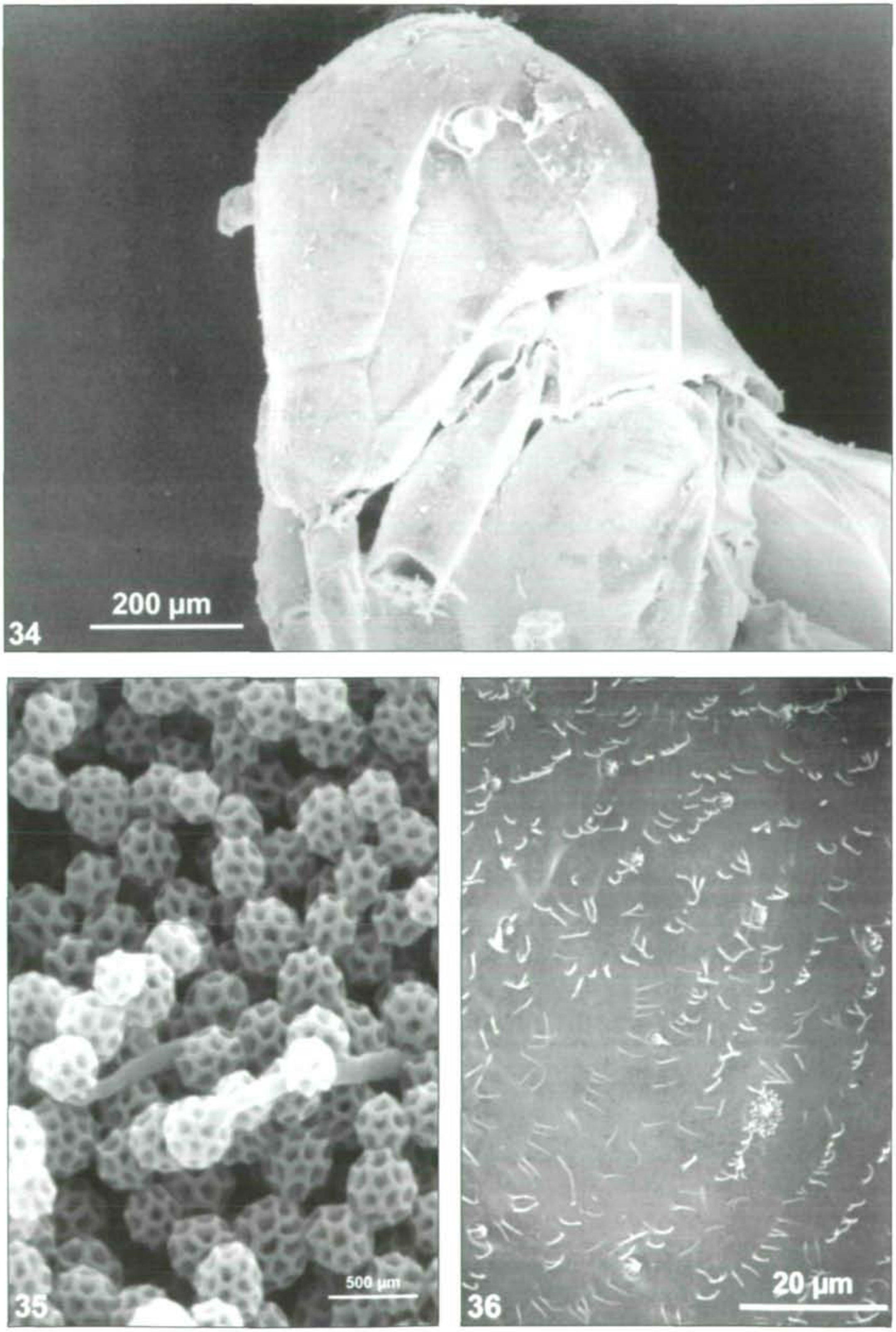


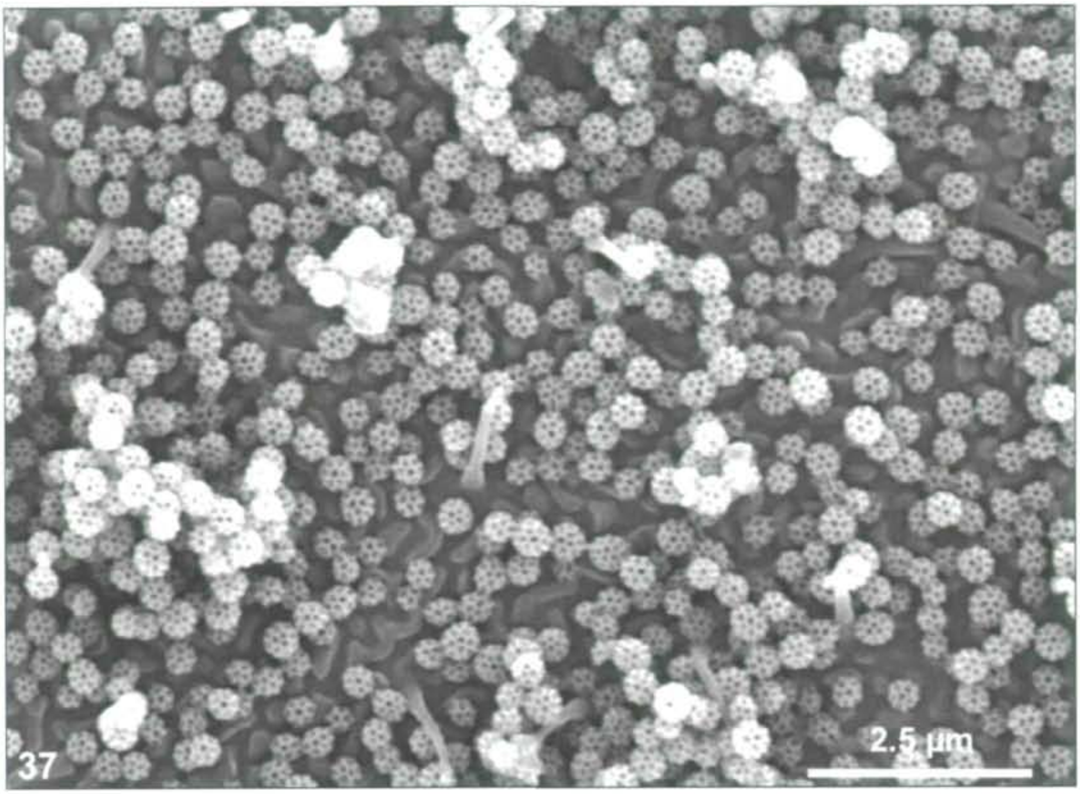


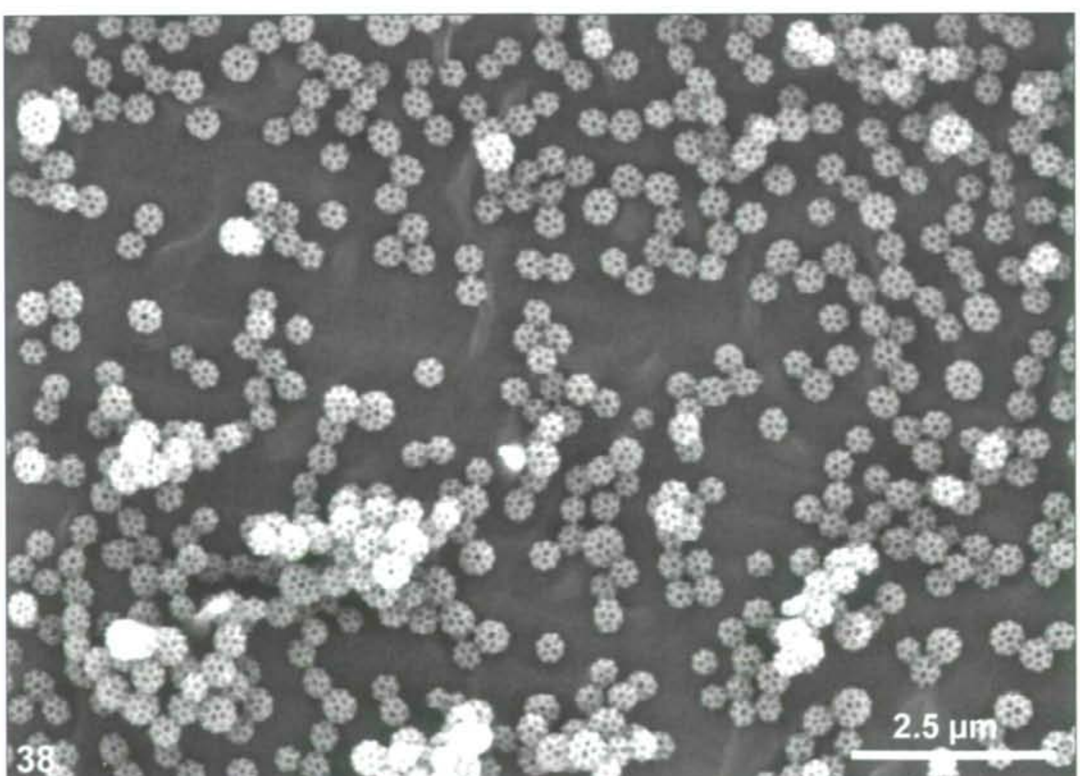


Figs 31-33:
fore tibia with comb of specialized setae (31); meso and metatarsus of fore leg (32); mesotibia without comb of specialized setae (33).

Figs 34-36:
anterior part of body of female, lateral view, the frame (34) indicates accumulation of brochosomes (35); arrangement of cuticular outgrowths holding brochosomes as in Fig. 35, surface cleared of brochosomes (36).

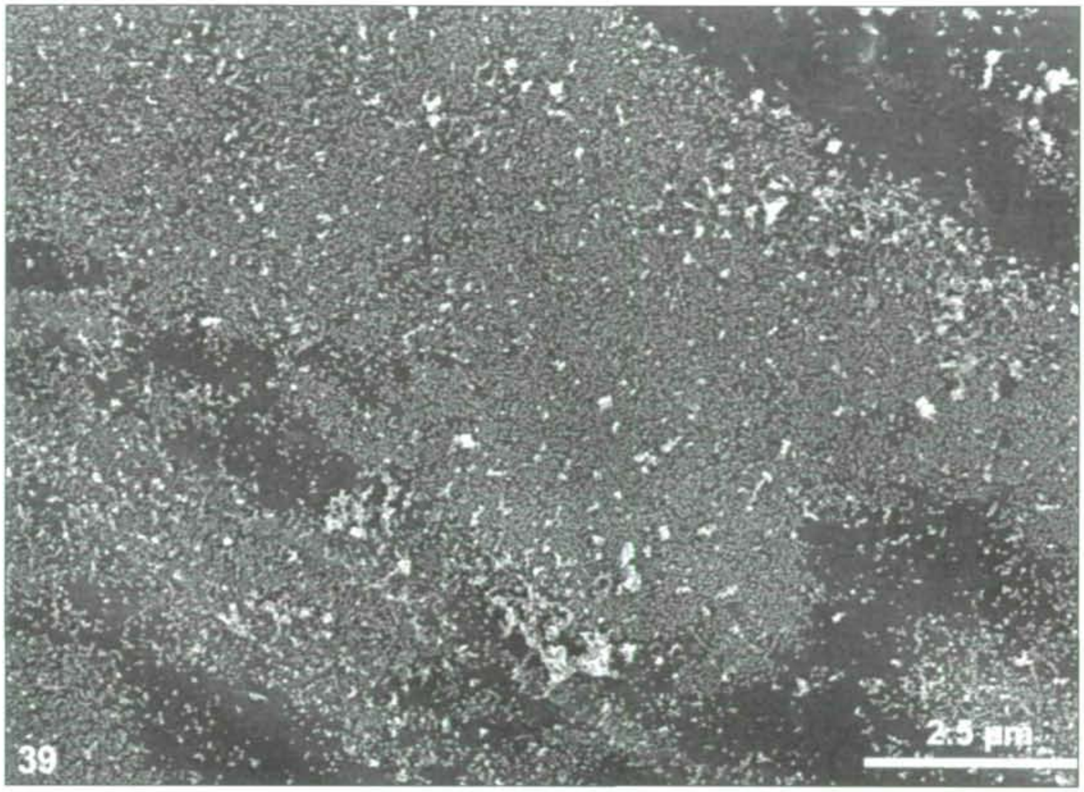


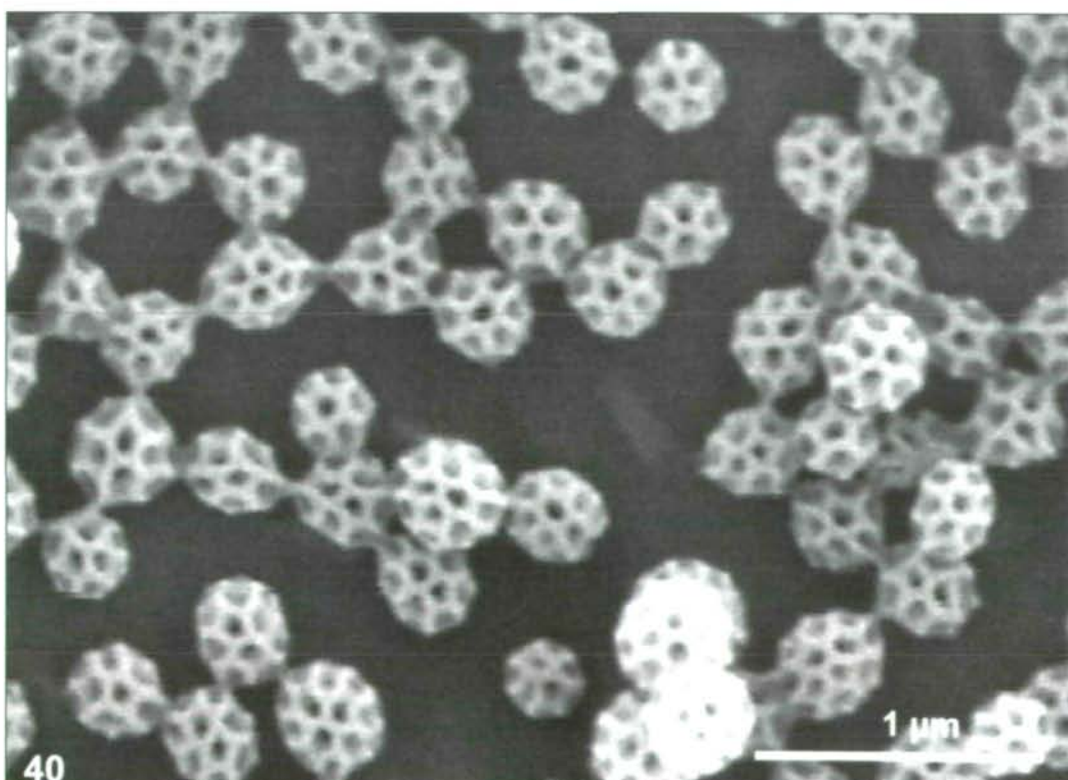


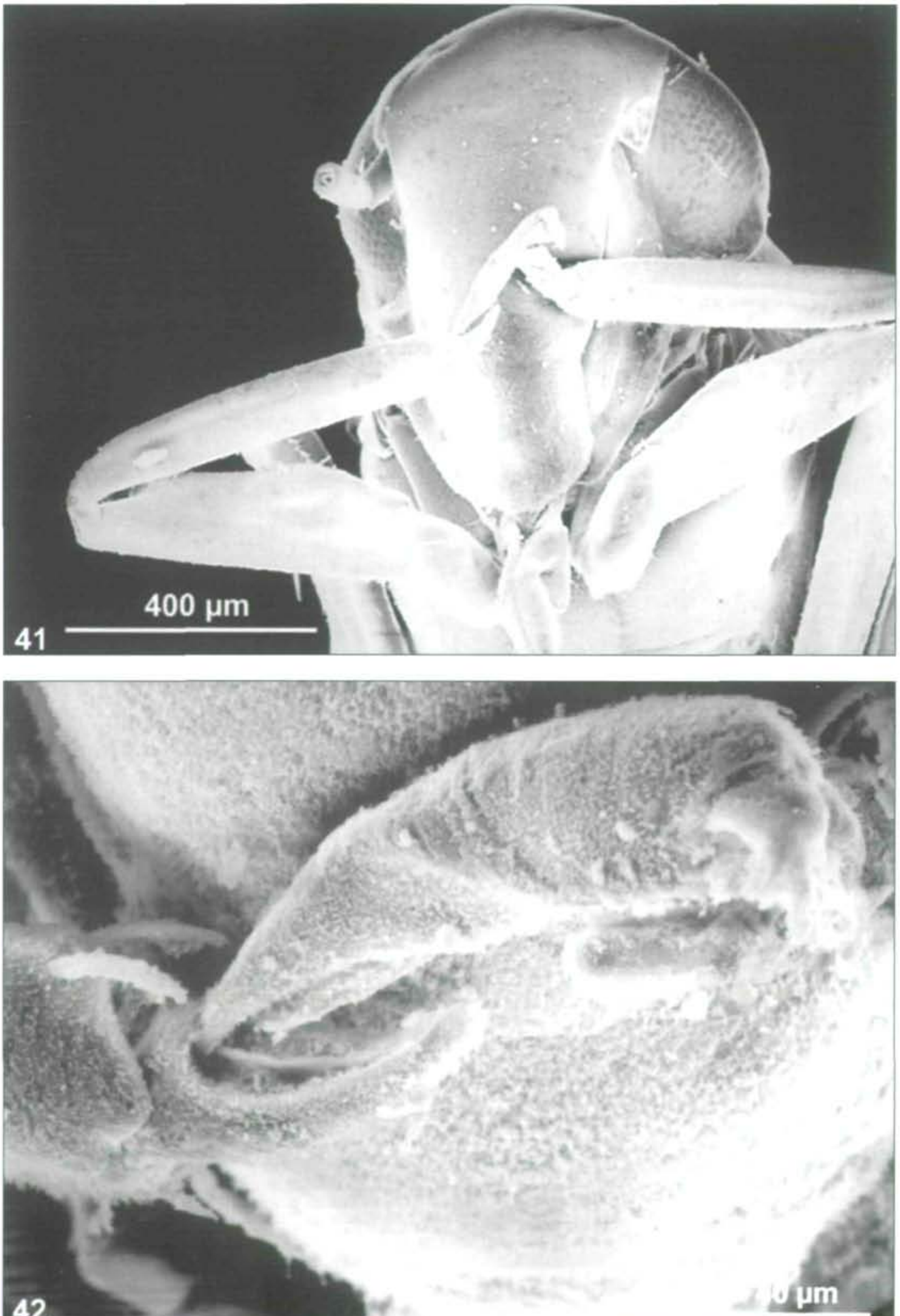


Figs 37-38:
coat of brochosomes on dorsal side of fore wing, m cell on the level of mid-length of wax-field (37); same site in m cell on ventral side of fore wing (38).

Figs 39-40:
dorsal surface of hind wing, midlength of cua cell coated with brochosomes (39); same site, brochosomes in higher magnification (40).

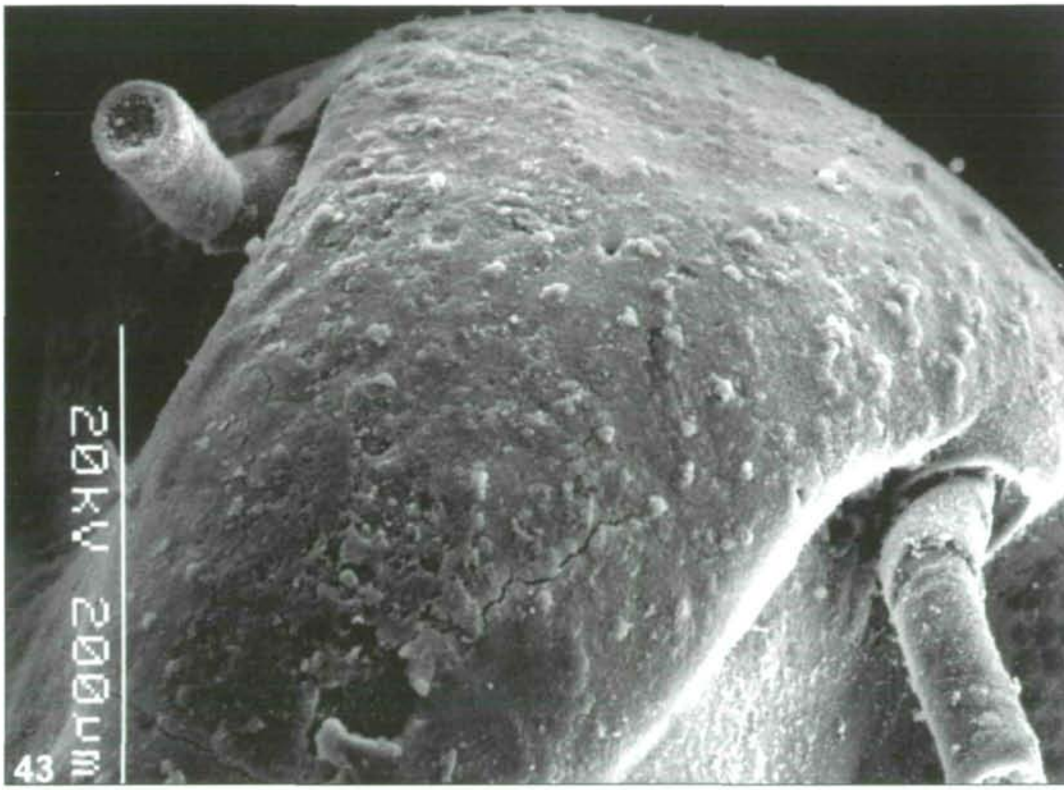


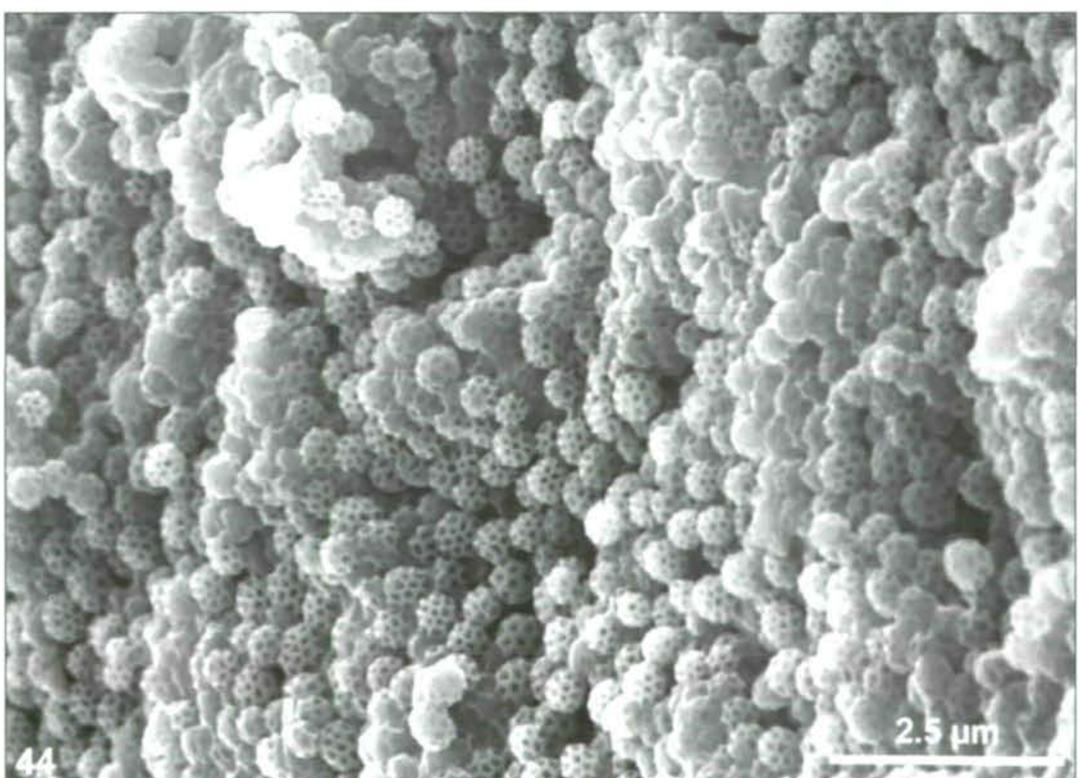


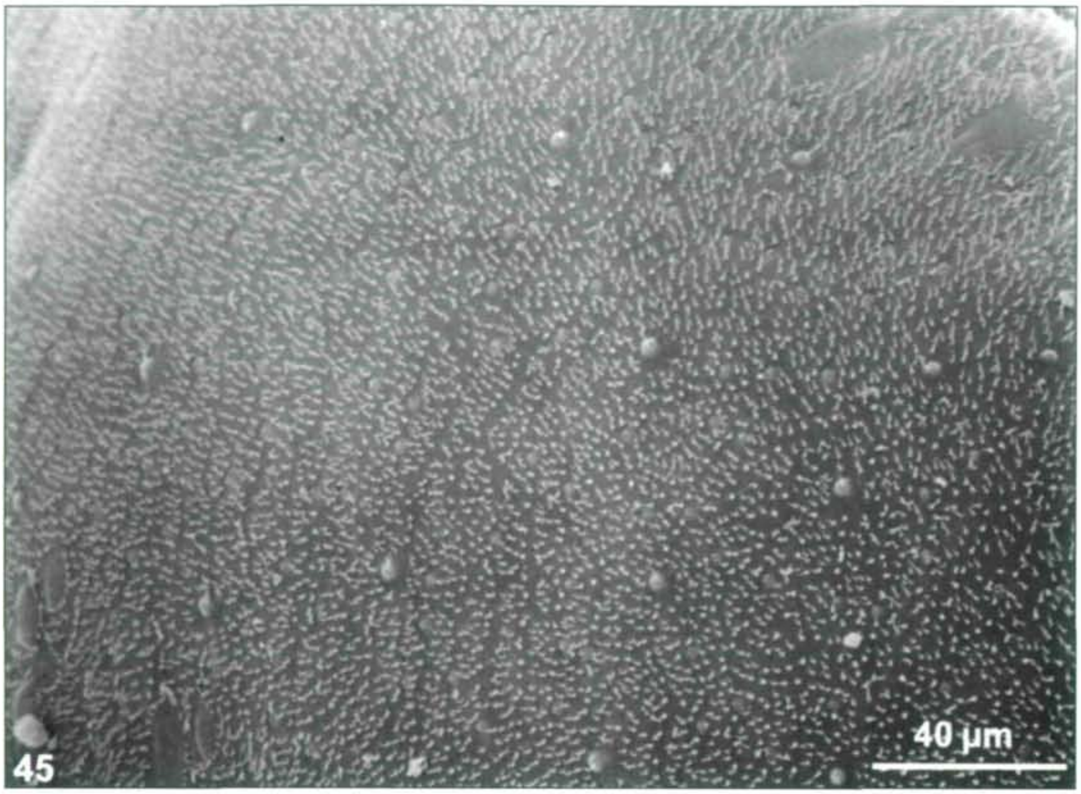


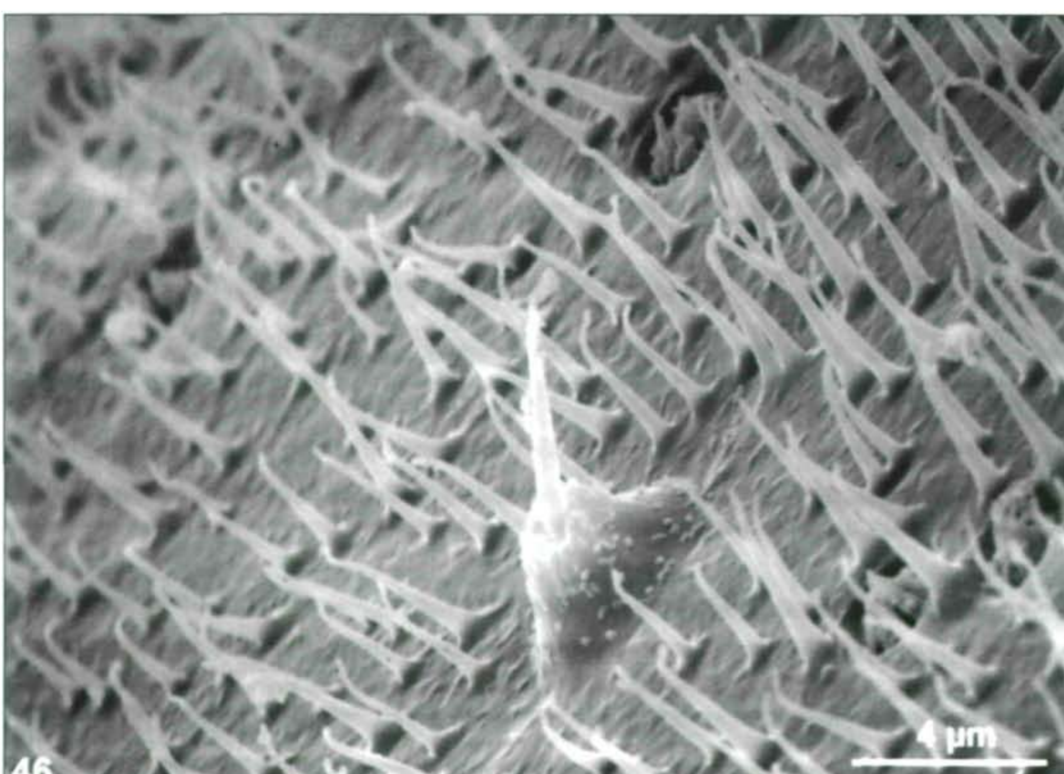
Figs 41-42:
face of male with fore feet on frontoclypeus (41); high magnification of right fore foot of the specimen seen in Fig. 41 (42).

Figs 43-44:
face of male, fronto-clypeus coated with very thick layer of brochosomes (43); brochosomes on frontoclypeus of the same male (44).









Figs 45-46: frontoclypeus of male cleared of brochosomes (45); same in higher magnification (46).

Figs 47-48: frontoclypeus of female cleared of brochosomes (47); same in higher magnification (48).