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ADDITIONS TO 'NOTES ON SCALE INSECTS OF THE GENUS AULACASPIS OCCURRING ON GRASSES AND HERBS': SOME SPECIES ON WOODY PLANTS (STERNORRHYNCHA: COCCOIDEA: DIASPIDIDAE)

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Abstract

Takagi, S. 2016. Additions to 'Notes on scale insects of the genus *Aulacaspis* occurring on grasses and herbs': Some species on woody plants (Sternorrhyncha: Coccoidea: Diaspididae). *Ins. matsum. n. s*. 72: 33–76, 20 figs.

Ten species of *Aulacaspis*, all occurring on woody plants, are examined on the supposition that the grass- and herb-associated portions of the genus have their origins in the main body of the genus occurring on woody dicotyledons. *A. donacis*, n.sp., occurring on *Donax* in Malaya, is very similar to the grass-feeding *A. herbae* (Green) and *A. discorum* Hall and Williams but is primitive as compared with the latter two in the state of the median trullae. *A. spinosa* (Maskell) and *A. pseudospinosa* Chen et al. are revised and *A. smilacis*, n.sp., is described from Malaya; these three species, together with *A. neospinosa* Tang and *A. takahashii* Takagi, belong to the *spinosa* species group, which is associated mainly with shrubs of *Smilax* and herbaceous plants of orchids. Six species occurring on woody dicotyledons are described as new: *A. nephelii*, A. *cuneiformis*, *A. ixonanthis*, and *A. tenuis* from Malaya, A. *pyriformis* from Malaya and Palawan Is., and *A. milletiae* from Palawan Is.; some of these species appear to be closely related to *A. labucola* Takagi, one of the three known species occurring on herbaceous vines of Cucurbitaceae in Malaya.

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Introduction

This paper is supplementary to 'Notes on scale insects of the genus *Aulacaspis* occurring on grasses and herbs' (Takagi, 2015), in which four species occurring on poaceous grasses and six species on herbaceous plants are described. The supposition may be adopted that, in this genus, the association with grasses and herbaceous plants is secondary, because the majority of species are associated with woody plants of various dicotyledonous families, forming the main body of the genus. At least ten species of the genus are known to occur on poaceous grasses (including bamboos), and eight species have been described from various herbaceous plants. Furthermore, several species that feed on woody plants have been recorded also from herbaceous plants.

In this paper ten species of *Aulacaspis*, all from woody plants, are examined in the expectation that some of them are closely related to grass- or herb-feeding species. One of them, occurring on shrubs of *Donax*, is similar to certain grass-feeding species; three species are associated with shrubby plants of *Smilax* and belong to the *spinosa* group, of which the host plants include orchids; the remaining six species, occurring on various woody dicotyledons, include some ones which are similar to one of the three species described from herbaceous vines of the family Cucurbitaceae.

Terms. The term 'trullae' is adopted in place of 'pygidial lobes' in authors. (In my view, the trullae are used as a cutting or sawing tool when the adult female cleans her working spot on the host plant in constructing the test.) The term 'dorsal macroducts' means the submedian and submarginal dorsal macroducts combined together (therefore, not including the marginal macroducts). The abbreviations 'abd I', 'abd II', and so on are used for the corresponding abdominal segments.

Sample. A sample is composed of conspecific individuals mounted in principle from the same lot of material, which was taken from the same plant individual at the same time. A sample may be divided into subsamples according to feeding sites (foliicolous subsample, ramicolous subsample, etc.) or generations (full-grown and teneral or very immature adult females probably representing two successive generations).

Numbers of wax-secreting organs. Under this heading in each species, the numbers of the main wax-secreting organs are given for each side of the body except for the total number of the perivulvar disc pores and that of the dorsal macroducts; for each sample or subsample, the lowest, mean, and highest values are given in the mentioned order, followed by the sample (or subsample) size (denoted by 'n'); sometimes, for small samples (subsamples), the lowest and highest values in each sample (subsample) or values of individuals are given.

Depositories of the holotypes. The holotypes of the following new species are deposited in the collection of the Entomology Division, Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia: *Aulacaspis donacis*, *A. smilacis*, *A. nephelii*, *A. cuneiformis*, *A. ixonanthis*, and *A. tenuis*. The holotypes of *A. milletiae* and *A. pyriformis* are deposited in the collection of the Museum of Natural History, University of the Philippines at Los Baños, Laguna, Philippines.

A Species of Aulacaspis Occurring on Donax

Some polyphagous species of armoured scale insects were recorded from plants of the monocotyledonous family Maranthaceae, but no species of *Aulacaspis* has been

known in association with this plant family. One species of the genus collected from shrubby plants of *Donax* is described below.

Aulacaspis donacis, n.sp.
(Figs 2, 3)

Material examined

Collected on *Donax grandis* (Maranthaceae) in the grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, 30.VII.1990 (Sample 1). Females and males occurring under leaf-sheaths. The adult females mounted from this sample are generally not good in condition, probably having been collected after their death on the host plant; 32 specimens have been examined in preparing the description below; one the holotype.

Also collected at Ulu Gombak, alt. ca. 500m, Selangor, Malaya, on *Donax* sp., 16.XI.1986 (Sample 2). Female and males on petioles; 3 adult females mounted.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 8–ca. 33 (Sample 1).

Posterior spiracular disc pores: 7–14.2–18 (n=44) (Sample 1); ca. 20–ca. 29 (Sample 2).

Perivulvar disc pores, total: 47–77.6–115 (n=32) (Sample 1); 77, 87, 107 (Sample 2).

Dorsal macroducts, total: 13–26.5–42 (n=32) (Sample 1); 27, 38, 38 (Sample 2).

Lateral macroducts on abd II: 0 (n=50), 1 (n=11), 2 (n=2) (Sample 1); 0 (n=2), 2 (n=3), 3 (n=1) (Sample 2).

Lateral macroducts on abd III: 0 (n=14), 1 (n=30), 2 (n=17), 3 (n=2) (Sample 1); 1–3 (Sample 2).

Lateral gland spines on abd II: 3–6.3–10 (n=61) (Sample 1); 7–11 (Sample 2).

Lateral gland spines on abd III: 4–6.9–10 (n=63) (Sample 1); 7–12 (Sample 2).

Marginal gland spines on abd IV: 2–3.9–7 (n=63) (Sample 1); 4–6 (Sample 2).

Recognition characters

Adult female. Body somewhat variable in shape at full growth, usually obovate, with mesothorax broadest and prepygidial postsomatic segments gradually narrowing posteriorly, all these segments moderately lobed laterally, pygidium deltoid, little roundish on free margin; sometimes body narrower in various degrees. Anterior spiracles each with a crescent-shaped group of disc pores; posterior spiracles each with disc pores usually less numerous. Perivulvar disc pores: 5–18 in median, 11–25 in each anterolateral, and 9–26 in each posterolateral group. Submedian dorsal macroducts on abd III–VI; 1–3, at times absent, on III; 1–4, rarely absent, on IV; 1 or 2 on V, and 1 on VI. Submarginal dorsal macroducts on abd III–V; 1–6 on each segment, rarely absent on III. One or 2 dorsal microducts occurring submedially on each of abd I and II, and also on metathorax at least usually, slightly larger than ventral microducts occurring on these segments. Submarginal dorsal bosses one on each of abd I, III, and V, occurring just laterally to submarginal row of macroducts on III and also on V. Lateral macroducts rather slender; often absent; when present, 1–3 on each of abd II and III. Lateral gland spines occurring on abd II practically as many as those on III. Marginal gland spines 2–7 on abd IV; single on V–VIII. Median trullae small, not sunken into apex of pygidium, set parallel to each other, non-zygotic, with their mesal bases extending toward each other

but separated by a slit; each trulla nearly symmetrical, rounded apically, notched a few times on each side. Second trulla with inner lobule nearly as large as median trulla, and with outer lobule smaller, pointed apically, slanting on lateral margin. Third trulla with both lobules reduced to low serrate processes. Pore prominences and marginal processes low and minutely serrate on abd IV and V.

Remarks

In the body shape of fully grown adult females, this species is similar to *Aulacaspis herbae* and *A. discorum*, grass-feeding species described from Sri Lanka by Green and from Pakistan by Hall and Williams, respectively. *A. herbae* was re-described from South India, and *A. discorum* from Nepal (Takagi, 2015). *A. donacis* and *A. herbae* are somewhat variable in body shape, and their broadest forms are especially closely similar (Fig. 2; Takagi, 2015, fig. 13). The known form of *A. discorum* has a similar but still broader body (Takagi, 2015, fig. 15).

A. donacis differs from *A. herbae* and *A. discorum* especially in the median trullae, which are, above all, non-zygotic. It is distinguishable also in having the marginal gland spines all single on the fifth to eighth abdominal segments (often paired on the seventh and eighth segments in the latter two species), in the submarginal dorsal bosses lacking on the fourth abdominal segment and occurring just laterally to the submarginal rows of macroducts on the third and fifth segments (present on the first and the third to fifth segments and occurring just mesally to the macroduct rows on the third to fifth in the latter two species), and in the wax-secreting organs generally fewer.

The possibility may not be excluded that *A. donacis*, which is associated with shrubby monocotyledonous plants, has some relation to the grass-feeding *A. herbae* and *A. discorum.* In comparison with the latter two species it is apparently primitive in having non-zygotic median trullae. If they are really closely related, *A. donacis* may represent or approach a form ancestral to the latter two.

The spinosa Species Group of Aulacaspis

The *spinosa* group of *Aulacaspis* as recognized in Takagi (2015) is composed of *A. spinosa*, *A. pseudospinosa*, *A. neospinosa*, and *A. takahashii*, which are, as a whole, associated mainly with *Smilax* (shrubby species of the genus, at least usually) and orchids. These forms are very similar to each other, requiring careful comparisons for elucidating their taxonomic relations. In the present paper, *A. spinosa* is revised, *A. pseudospinosa*, which was once synonymized with *A. spinosa*, is recognized as a good species, *A. neospinosa* is supposed, on the basis of the description, to be very close to *A. pseudospinosa*, and *A. smilacis*, n.sp., another member of the group, is described and compared with *A. pseudospinosa* and *A. takahashii*.

The description of *Diaspis rosae* var. *spinosa* Maskell states that this scale insect, occurring in Japan on *Smilax*, has numerous spines; it gives no further clues for recognizing the insect. Samples of *Aulacaspis* collected on *Smilax* have been available from 23 localities in Japan, and some hundreds of adult females mounted from them have been examined. I have no doubt that all these specimens belong to one and the same species and that this species is identical with Maskell's *D. rosae* var. *spinosa*, which has been treated as *Aulacaspis spinosa* since Kuwana (1926).

A. spinosa was recorded also from Taiwan, continental China, and Korea.

Specimens collected in Taiwan and Nepal and closely similar to those from Japan have been available for the present study. Those from Taiwan were once (Takagi, 1970) identified with *A. spinosa.*

In my close examinations, I have noticed some differences between the specimens from Taiwan and Nepal and those from Japan. These differences may appear to be trifling but, for a certain reason, I take the view that the specimens from Taiwan and Nepal represent a species different from *A. spinosa*, and adopt the name *A. pseudospinosa* Chen et al., 1980, for it.

A. pseudospinosa was originally described from continental China and from *Smilax* and three other plants, whereas these host plants are not related to each other particularly closely. The identification of the specimens from Taiwan and Nepal with *A. pseudospinosa* is not without problems: the published descriptions (Chen et al., 1980; Chen, 1983) are not sufficiently detailed (especially concerning the state of the yoke connecting the bases of the median trullae), the comparisons made by Chen (1983) among the forms associated with the different plants are incomplete and not fully convincing, and there is no mention of the designation of holotype in spite of the diverse host plants (though *Smilax* is named first among them). Furthermore, no specimens from continental China have been available for my study.

A. pseudospinosa as understood on the basis of the specimens from Taiwan and Nepal and as compared with *A. spinosa* is characterized in having the body less robust at full growth, the prosomatic tubercles rather prominent, the lateral macroducts moderate in size and shape, and the bases of the median trullae are connected by a slender sclerotized arch. In the samples of *A. spinosa* from Japan, the body is stout at full growth, with both the prosoma and the postsoma becoming considerably broadened and with the prosomatic tubercles usually not, at most only slightly, indicated, the lateral macroducts are more or less attenuated, and the basal connection of the median trullae is developed into a robust arch. The body gradually changes in shape during growth, *A. pseudospinosa* at full growth (Figs 7–9) being similar to *A. spinosa* at a growing stage (Fig. 5) in body outline, and the attenuation of the lateral macroducts in *A. spinosa* is a tendency rather than a distinct state, whereas the state of the basal connection of the median trullae is considerably stable throughout the examined samples in either species.

The examined samples of *A. pseudospinosa* and *A. spinosa* broadly overlap in the numbers of the main wax-secreting organs, and there are no simple and obvious differences in these features between the two. They, however, show a noticeable pattern of their relative tendencies in the frequencies of the numbers of the wax organs occurring on the lateral lobes of the second and third abdominal segments (Fig. 1): in the samples of *A. pseudospinosa*, the lateral macroducts tend to be more numerous, whereas the lateral gland spines less numerous, than in those of *A. spinosa*. The marginal gland spines occurring on the fourth segment, too, tend to be less numerous in the samples of *A. pseudospinosa*. (The samples of *A. pseudospinosa* available for the present study are few and small, but the examined specimens of *A. spinosa* are sufficiently numerous for providing, though unilaterally, a good basis for the comparison.) The term 'character cross-over' may be applied to such a pattern, which suggests that the forms concerned do not entirely coincide in body organization: *A. pseudospinosa* and *A. spinosa* should have somewhat different numerical schemes for the lateral organs occurring on the second and third abdominal segments, the marginal gland spines on the succeeding segment, the fourth abdominal segment, being also involved in the schemes.

A. pseudospinosa has been treated as a synonym of *A. spinosa*. The former as understood in the present study is, as stated above, not entirely the same as the latter in some features. The observed differences in the prosomatic tubercles and the lateral macroducts are not always distinct, and the difference in the development of the basal connection of the median trullae is not very conspicuous; all these differences, therefore, may have been overlooked or disregarded by authors. The character cross-over observed in the numbers of the lateral organs of the second and third abdominal segments suggests that *A. pseudospinosa* and *A. spinosa* represent distinct taxonomic units rather than any infraspecific variation (for example, geographical races). The state of the basal connection of the median trullae is stable in either species, and affords useful diagnostic characters in distinguishing between the two.

Aulacaspis spinosa
=*Diaspis rosae*, Sandberg, var. *spinosa* Maskell, 1897
(Figs 1, 4–6)

Material examined

The samples available for the present study were collected in Japan on shrubby plants of the genus *Smilax* (Smilacaceae), all or most of the host plants probably belonging to *S. china*. Most examined adult females were mounted from the stems and often from under the stipules, and the others from the leaves; male tests were observed on the stems and leaves.

The samples were collected at localities broadly scattered in Honsyû, Sikoku, and Kyûsyû, and in various environments (seaside forests, inner lowlands, hills, and low mountains). Nine selected samples are numbered according to the relative positions of their localities in latitude from the north to the south. The locality of Sample 1 is the northernmost and that of Sample 9 the southernmost among the localities of all the available samples, the localities of the other numbered samples being scattered between them. In the present study, only the selected nine samples have been examined for the numbers of the main wax-secreting organs. They represent a small part of the available material, but may give rough outlines of these features in *A. spinosa.* Sample 1–6 and 9 are relatively large; scores of adult females were mounted from each of them, and 35 specimens, all ramicolous, in each sample were examined; Sample 4 and 5 were collected in the same locality, but with an interval of 15 years. Sample 7 and 8, collected in the same locality and within two successive days, are much smaller but adopted for a comparison between the ramicolous and foliicolous specimens, 17 ramicolous adult females having been mounted from Sample 7 and two ramicolous and 19 foliicolous ones from Sample 8. Foliicolous specimens were mounted also from other samples, but few in each of those samples. The unnumbered samples are various in size, but generally are not sufficiently large.

In the following list, the names of the islands and localities are spelled in the Nippon system of romanization, with spellings in the Hepburn system given in brackets.

Samples numbered:

Honsyû [Honshū]. Morioka, Iwate Pref., 11.X.1965 (Sample 1); Omote-Hikimi-Kyô, Simane [Shimane] Pref., 6.X.1982 (Sample 2); Simoda [Shimoda], Sizuoka [Shizuoka] Pref., 4.X.1965 (Sample 3); Gobô, Wakayama Pref., 2.XI.1971 (Sample 4), 31.VII.1986 (Sample 5).

Sikoku [Shikoku]. Matuyama [Matsuyama], Ehime Pref., 3.VII.1974, T. Tachikawa (Sample 6); Morigauti [Morigauchi], Kôti [Kōchi] Pref., 5.XI.1964 (Sample 7), 6.XI.1964 (Sample 8).

Kyûsyû [Kyūshū]. Cape Sata, Kagosima [Kagoshima] Pref., 26.IV.1963 (Sample 9).

Other samples:

Honsyû. Kamidaki, Toyama Pref.; Kanazawa, Isikawa [Ishikawa] Pref.; Maibara, Siga [Shiga] Pref.; Kurayosi [Kurayoshi], Tottori Pref.; Hôrai, Aiti [Aichi] Pref.; Yunoyama, Mie Pref.; Mt. Katuragi [Katsuragi], Nara Pref.; Koza, Kozagawa, and Taidi [Taiji], Wakayama Pref.

Sikoku. Yanaze and Cape Muroto, Kôti Pref.

Kyûsyû. Waniura and Iduhara [Izuhara], Tusima [Tsushima] (islands north of the mainland of Kyûsyû), Nagasaki Pref.; Miyazaki City and Mt. Kirisima [Kirishima], Miyazaki Pref.

Numbers of wax-secreting organs

In the list below, the numbers of the main wax-secreting organs are given for ramicolous congenerational adult females of Sample 1–7 and 9 and for foliicolous ones of Sample 8 (the foliicolous subsample of Sample 8 being denoted by '8f').

The trilocular disc pores associated with the anterior spiracles are crowded together and usually difficult to count exactly. One or a few quinquelocular disc pores occasionally occur medially or submedially on the segment anterior to the groups of the perivulvar disc pores; these extra 'perivulvar' disc pores should be atavistic and abnormal in occurrence, and are excluded from the list. Submedian dorsal macroducts occur on the second to sixth abdominal segments and submarginal ones on the second to fifth; one or a few additional submedian macroducts occur on the first abdominal segment in five samples with frequencies variable but low or very low, and they are added to the total number of the dorsal macroducts on the supposition that their occurrence is in normal variation. Eight marginal macroducts are arranged on the third to seventh abdominal segments as usual in the genus (1+2+2+2+1=8); the lateral one of the paired marginal macroducts occurring on the fourth segment is sometimes lacking, probably abnormally. Usually a few to several attenuated macroducts occur on the lateral lobes of the second and third abdominal segments but, rarely, there are no lateral macroducts on the second or third; the frequencies of their absence are recorded, apart from data for their occurrence, on the interpretation that their absence represents the incipiency of an evolutionary trend toward the usual or normal disappearance of lateral macroducts. One or a few lateral gland spines, much diminished in size, have occasionally been observed on the first abdominal segment; they are apparently atavistic and abnormal in occurrence, and are excluded from the list.

Anterior spiracular disc pores: varying from ca. 22 to ca. 65 in the examined samples; their exact numbers are probably somewhat different among samples.

Posterior spiracular disc pores: 8–12.2–17 (n=64) (Sample 1); 7–14.9–23 (n=70) (Sample 2); 6–11.8–20 (n=59) (Sample 3); 7–11.0–18 (n=69) (Sample 4); 4–8.5–12 (n=70) (Sample 5); 3–11.8–18 (n=70) (Sample 6); 3–8.2–15 (n=33) (Sample 7); 4–7.6–12 (n=38) (Sample 8f); 6–9.8–18 (n=68) (Sample 9).

Perivulvar disc pores, total: 130–157.5–183 (n=35) (Sample 1); 129–178.1–205 (n=35) (Sample 2); 93–144.1–194 (n=35) (Sample 3); 116–154.9–193 (n=35) (Sample 4); 114–141.3–189 (n=35) (Sample 5); 109–141.9–168 (n=35) (Sample 6); 83–132.0–152 (n=16) (Sample 7); 98–129.6–148 (n=19) (Sample 8f); 110–145.7–181 (n=35) (Sample 9).

Dorsal macroducts, total: 92–132.9–164 (n=35) (Sample 1); 98–129.8–178 (n=35) (Sample 2); 67–100.5–131 (n=35) (Sample 3); 73–113.2–147 (n=35) (Sample 4); 65–113.3–143 (n=35) (Sample 5); 100–127.5–143 (n=35) (Sample 6); 40–83.3–113 (n=16) (Sample 7); 44–83.3–116 (n=19) (Sample 8f); 69–120.2–150 (n=35) (Sample 9).

Lateral macroducts on abd II: 1–5.0–8 (n=70) (Sample 1); 1–4.4–9 (n=70) (Sample 2); 1–3.4–6 (n=68) (Sample 3); 0 (n=1), 1–3.4–7 (n=69) (Sample 4); 2–5.0–8 (n=70) (Sample 5); 2–6.8–11 (n=70) (Sample 6); 0 (n=2), 1–2.4–8 (n=30) (Sample 7); 0 (n=3), 1–3.5–7 (n=32) (Sample 8f); 3–6.1–10 (n=70) (Sample 9).

Lateral macroducts on abd III: 0 (n=8), 1–2.4–5 (n=62) (Sample 1); 0 (n=1), 1–3.1–7 (n=69) (Sample 2); 1–2.5–5 (n=70) (Sample 3); 0 (n=1), 1–2.7–5 (n=69) (Sample 4); 2–4.1–6 (n=70) (Sample 5); 2–4.3–7 (n=70) (Sample 6); 0 (n=1), 1–2.5–5 (n=31) (Sample 7); 0 (n=3), 1–2.4–4 (n=34) (Sample 8f); 1–3.2–5 (n=70) (Sample 9).

Lateral gland spines on abd II: 10–17.1–26 (n=69) (Sample 1); 6–13.4–21 (n=70) (Sample 2); 6–10.2–20 (n=68) (Sample 3); 3–12.1–17 (n=70) (Sample 4); 6–13.1–18 (n=70) (Sample 5); 8–14.4–20 (n=70) (Sample 6); 2–6.6–11 (n=32) (Sample 7); 4–8.3–12 (n=35) (Sample 8f); 8–12.2–16 (n=70) (Sample 9).

Lateral gland spines on abd III: 12–17.6–24 (n=69) (Sample 1); 6–16.0–22 (n=70) (Sample 2); 8–13.0–17 (n=70) (Sample 3); 9–15.1–22 (n=70) (Sample 4); 9–16.1–23 (n=70) (Sample 5); 12–17.2–24 (n=70) (Sample 6); 4–10.3–16 (n=32) (Sample 7); 6–11.3–17 (n=36) (Sample 8f); 9–14.8–19 (n=70) (Sample 9).

Marginal gland spines on abd IV: 6–8.5–11 (n=70) (Sample 1); 6–8.9–12 (n=70) (Sample 2); 5–7.3–10 (n=70) (Sample 3); 5–8.2–11 (n=70) (Sample 4); 5–7.8–11 (n=70) (Sample 5); 5–8.3–11 (n=70) (Sample 6); 5–6.5–10 (n=32) (Sample 7); 3–6.6–9 (n=38) (Sample 8f); 6–8.5–12 (n=70) (Sample 9).

Recognition characters

Adult female. Body stout at full growth, broadened in both prosoma and postsoma; prosoma distinctly though not much wider than postsoma, roundish, broadly rounded along free margin, tending to be sclerotized; prosomatic tubercles usually indiscernible, at most represented by slight swellings; metathorax and abd I–III moderately lobed laterally, nearly equal in width or gradually narrower, pygidium broadly deltoid. Anterior spiracles each with a crescent group of disc pores; posterior spiracles with disc pores less numerous and often divided into a few or several small clusters. Submedian dorsal macroducts on abd II–VI, clearly divided into segmental and infrasegmental series on II and III; 1–8, usually 3–7, on VI; at times 1–3 occurring on I. Submarginal dorsal macroducts on abd II–V, in single rows. Submarginal dorsal bosses one on abd I, and also on abd III just mesally to row of submarginal macroducts. Lateral macroducts on abd II and III, a few to several on each lateral lobe, rarely none; tending to be attenuated, though variable in the degree of attenuation even on the same lateral lobes. Lateral gland spines on abd II and III, well elongated, tending to be numerous. Marginal gland spines 3–12 on IV, single on succeeding segments. Median trullae largely sunken into apex of pygidium, divergent, rounded apically, smooth or obscurely serrate on diverging mesal margins; stout in ramicolous specimens, sometimes narrower in foliicolous specimens; their bases connected by a robust sclerotized arch. Second and third trullae with both lobules well developed. Pore prominences and marginal processes on abd IV and V low, serrate.

Remarks

This species occurs broadly in Japan, but has been unknown from Hokkaidô and the Ryûkyû Islands. *A. spinosa* was recorded from Taiwan by Takahashi repeatedly, from southern continental China by Scott and also by Tang, and from southern Korea

by Kwon. I (Takagi, 1970) recorded *A. spinosa* from Taiwan, but in the present study I acknowledge this record as my error and identify the specimens with *A. pseudospinosa*. I therefore recognize the necessity for critical re-examinations on the other records of *A. spinosa* from outside Japan. In the view adopted in the present study, Tang's records of *A. spinosa* were made on the basis of specimens of *A. pseudospinosa* (see *Remarks* under *Aulacaspis pseudospinosa*).

Scott (1952) recorded *A. spinosa* from 'Yeung Kong, Kwangtung Province, China' on the basis of material from the Ferris collection. He gave a figure drawn not from the Yeung Kong material but from specimens which were 'from *Smilax*, without further certain data but in all probability part of the type material' (that is, specimens from Japan). His figure shows only slightly pronounced prosomatic tubercles and no lateral macroducts, and suggests the presence of a well-developed connection between the bases of the median trullae. In my observations on the specimens from Japan, the lateral macroducts are usually present on the second and third abdominal segments, but they are often so attenuated that sometimes they may easily be confused with the microducts of neighbouring gland spines and, thus, overlooked; moreover, their absence on the second or third segment has rarely been observed, and the possibility that they are absent on both these segments may not be excluded. On this understanding, Scott's figure is not in discord with the concept of *A. spinosa* adopted in the present study, and his view that it was drawn on the basis of part of the type material is acceptable.

In the present study nine selected samples, Sample 1–9, have been examined for the numbers of the main wax-secreting organs. Among them, two pairs are noteworthy from the viewpoint of local variation. Sample 4 and 5 were collected in the same locality with an interval of 15 years; they agree with each other especially in the mean values of the total dorsal macroducts. Sample 7 and 8 were collected in the same locality in two successive days; the ramicolous specimens from Sample 7 and the foliicolous specimens from Sample 8 do not remarkably different from each other in most features and agree especially in the numbers of the total dorsal macroducts. Similar examples are known in *Aulacaspis yabunikkei*. One of them is especially noteworthy: two samples collected in the same locality with an interval of 17 years agree closely or even almost exactly with each other in both the mean values and the ranges of the numbers not only of the total dorsal macroducts but also of all the other main wax-secreting organs (Takagi, 2014, p. 95). These observations suggest that the populations concerned were responding adaptively to some environmental conditions of the localities in the numbers of wax-secreting organs and especially in the number of the dorsal macroducts (provided that the local environmental conditions concerned were stable for years). It may easily be understood that the number of the dorsal macroducts, in particular, varies in adaptation to environmental conditions, because it should be essentially concerned with constructing the dorsal test, which protects the long-living adult female, deposited eggs, and newly hatched crawlers, creating under its cover microenvironmental conditions suitable for them.

The nine samples are variable in the numbers of the main wax-secreting organs, probably reflecting environmental conditions in their localities, but they broadly overlap in the ranges of these numbers. On a scatter diagram drawn on trial for the correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores these samples are scattered in a positive trend (r=+0.74) loosely along the regression line applied to them. If the nine samples are really so selected as to show a

general trend in the correlation between these features in *A. spinosa*, further samples (when sufficiently large in size) will be plotted closely around them.

Aulacaspis pseudospinosa Chen, Wu, and Su, 1980
(Figs 1, 7–9)

Material examined

Collected on shrubby plants of *Smilax* (Smilacaceae) in Taiwan and Nepal.

Taiwan: collected in April, 1965; in Southeastern Taipei Hsien, on roadside (Sample 1); at Kuantzuling (Sample 2); at Fenchihu (Sample 3). Sample 1 from northern Taiwan; the other two samples from the mountainous region in central Taiwan. All these samples are not sufficiently large for statistical comparison, nine, 14, and three adult females having been examined from Sample 1, 2, and 3, respectively, and not all of these specimens are in good condition. The feeding sites of the specimens on the host plants are not written down on the labels. These specimens were identified with *A. spinosa* in Takagi (1970).

Nepal: at Godavari, alt. ca. 1600m, Kathmandu Valley, 19.VIII.1975 (Sample 4). Ten ramicolous adult females were mounted from under stipules; three foliicolous specimens are also available, one of them being mummified.

Numbers of wax-secreting organs

Submedian dorsal macroducts occur on the second to sixth abdominal segments and submarginal ones on the second to the fifth. Submedian macroducts occur also on the first abdominal segment occasionally, and are added to the total number of dorsal macroducts. Submarginal macroducts occur also on the first abdominal segment in two of the three foliicolous adult females of Sample 4, and are added to the total number. 'Sample 4r' and 'Sample 4f' stand for the ramicolous and foliicolous subsamples of Sample 4.

Anterior spiracular disc pores: crowded together, usually not countable exactly; approximate numbers varying from ca. 32 to ca. 55 in Sample 1 and 2, and from ca. 42 to ca. 70 in Sample 4.

Posterior spiracular disc pores: 9–14.9–19 (n=18) (Sample 1); 8–13.0–17 (n=27) (Sample 2); 8–17 (Sample 3); 15–19.6–36 (n=19) (Sample 4r); 9(?)–18 (Sample 4f).

Perivulvar disc pores, total: 104–115.2–130 (n=9) (Sample 1); 91–123.1–149 (n=14) (Sample 2); 118, 136, 140 (Sample 3); 122–154.7–184 (n=10) (Sample 4r); 113, 144, 158 (Sample 4f).

Dorsal macroducts, total: 116–120.8–129 (n=9) (Sample 1); 78–105.5–139 (n=14) (Sample 2); 131, 143, 155 (Sample 3); 65–98.0–130 (n=8) (Sample 4r); 69, 128, 169 (Sample 4f).

Lateral macroducts on abd II: 7–10.2–13 (n=18) (Sample 1); 3–6.4–13 (n=27) (Sample 2); 10–14 (Sample 3); 3–6.0–11 (n=19) (Sample 4r); 6–11 (Sample 4f).

Lateral macroducts on abd III: 4–6.8–9 (n=18) (Sample 1); 3–4.7–7 (n=28) (Sample 2); 7–9 (Sample 3); 3–4.6–7 (n=18) (Sample 4r); 4–8 (Sample 4f).

Lateral gland spines on abd II: 8–9.8–12 (n=18) (Sample 1); 2–5.5–8 (n=27) (Sample 2); 5–11 (Sample 3); 6–9.9–17 (n= 19) (Sample 4r); 6–14 (Sample 4f).

Lateral gland spines on abd III: 9–10.7–12 (n=18) (Sample 1); 5–7.8–12 (n=28) (Sample 2); 7–12 (Sample 3); 7–10.2–15 (=18) (Sample 4r); 8–17 (Sample 4f).

Marginal gland spines on abd IV: 5–6.5–8 (n=18) (Sample 1); 2–4.6–6 (n=28) (Sample 2); 5–8 (Sample 3); 4–6.1–8 (n=19) (Sample 4r); 6–9 (Sample 4f).

Recognition characters

Adult female. Body at full growth with prosoma moderately swollen, distinctly wider than postsoma; metathorax and basal two abdominal segments roughly equal in width, the second abdominal segment a little more strongly lobed laterally; prosomatic tubercles in a small or low triangle, prosomatic margin broadly rounded between the tubercles, broadly lobed laterally; pygidium deltoid, little roundish. Anterior spiracles each with a crescent-shaped group of many disc pores; posterior spiracles each with a smaller group of disc pores, which are often divided into small clusters. Submedian dorsal macroducts on abd II–VI; 1–9, often 3 or 4, on VI; at times 1–7 on I; distinctly separated into segmental and infrasegmental series on II and III. Submarginal dorsal macroducts on abd II–V in single rows; none in ramicolous specimens and none or a few in foliicolous specimens on I. Submarginal dorsal bosses one on abd I, and also on III just mesally to submarginal row of macroducts. Lateral macroducts not attenuated. Lateral gland spines well elongated. Marginal gland spines 2–9 on abd IV. Median trullae largely sunken into apex of pygidium, divergent, oblong, rounded apically, not or faintly serrate on diverging mesal margins; bases connected by a slender sclerotized arch. Second and third trullae well developed. Pore prominences and marginal processes on abd IV and V low.

Remarks

Aulacaspis pseudospinosa was described from material collected in Sichuan, southern China, on leaves of *Smilax* sp. and later on *Smilax* sp., *Cymbidium* sp., *Trachycarpus excelsus*, and *Phoebe nanmu*. These plants belong to three monocotyledonous families and the Lauraceae. The diversity of the host plants naturally requires careful comparisons among the forms associated with the different plants, but no detailed comparisons have been made.

I have no doubt that the specimens collected on *Smilax* in Taiwan and Nepal and examined in the present study belong to one and the same species. Because these areas are widely separated from each other, this species should occur also in the region between them, that is, southern continental China. This is one of the reasons for adopting the view that this species is identical with *A. pseudospinosa* or, at least, with the *Smilax*-associated form of the latter.

Tang (1986) synonymized *A. pseudospinosa* with *A. spinosa*. His figure of *A. spinosa* (fig. 76) shows small but distinct prosomatic tubercles, lateral macroducts of usual type, and a slender basal connection on the median trullae. In having these characters, it agrees with *A. pseudospinosa* identified as such in the present study. The view may be adopted that Tang was right enough in regarding *A. pseudospinosa* (which he understood through the literature) as identical with his *A. spinosa* (which was *A. pseudospinosa* in reality) and that all the records of *A. spinosa* made by him in continental China (Anhui; Zhejiang; Sichuan) are assignable to *A. pseudospinosa*.

The specimens from Taiwan and Nepal have one to seven additional submedian macroducts on the first abdominal segment with frequencies variable among samples but low in Sample 1 and 2 and in the ramicolous subsample of Sample 4. The three available specimens of Sample 3 have one to five submedian macroducts on that segment. The three available foliicolous specimens of Sample 4 are provided with one to seven macroducts submedially, and two of these specimens also with one to three macroducts

submarginally, on that segment, the additional submedian macroducts occurring in segmental and infrasegmental series in three cases in two specimens (Fig. 9, D). It should be added that, in the specimens of *A. spinosa* from Japan, a few submedian macroducts have been observed occasionally on the first abdominal segment but no submarginal macroducts have been found on that segment in spite of the abundance of the examined specimens.

Tang (1986) described *Aulacaspis neospinosa* from material collected on *Cymbidium virescens* cultivated under glass in Beijing City and on *Cymbidium* sp. (probably also cultivated) in Guangzhou City. It belongs to the *spinosa* group, thus requiring careful comparisons with other forms of the group for its taxonomic relations with them. According to the description, it has dorsal macroducts submedially and submarginally on the first abdominal segment, but not constantly ('0–4' submedian and '0–2' submarginal macroducts occurring on the segment), and the possibility of their total absence from that segment may not be excluded. In the arrangement of the dorsal macroducts on the abdominal segments, therefore, *A. neospinosa* may not differ from *A. pseudospinosa* and especially from the foliicolous form of the latter (see the preceding paragraph). Tang's figure of *A. neospinosa* (fig. 77) shows slight prominences for the prosomatic tubercles, lateral macroducts of usual type, and a slender basal connection between the median trullae, and it seems that *A. neospinosa* does not differ from *A. pseudospinosa* in these characters, either. After all, the view may be adopted that *A. neospinosa* represents the foliicolous form of *A. pseudospinosa* occurring on *Smilax* and *Cymbidium*. In fact, *A. pseudospinosa* was recorded from both *Smilax* and *Cymbidium* in Sichuan. I refrain, however, from synonymizing *A. neospinosa* with *A. pseudospinosa*, because no specimens collected in China and on these plants, especially on *Cymbidium*, are available for the present study.

It should be added that the records of *A. pseudospinosa* from *Trachycarpus* (Arecaceae) and *Phoebe* (Lauraceae) in Sichuan remain to be re-examined critically.

Aulacaspis takahashii, another species of the *spinosa* group, was described from an undetermined orchid intercepted at quarantine inspection and reported as from Nepal (Takagi, 2015). At that time, it was supposed to be very close to *A. pseudospinosa* and to be distinguishable from the latter only in having less numerous perivulvar disc pores and dorsal macroducts. Now that *A. pseudospinosa* recognized as such in the present study has the median trullae connected by a slender sclerotized arch basally, the relation between the two species should not be very close as once supposed. In *A. takahashii*, the median trullae have a pair of strong sclerites basally, which are appressed together and may appear to form a mass or a robust arch. In this respect, *A. takahashii* should be distinct also from *A. neospinosa* or the supposed *Cymbidium*-associated form of *A. pseudospinosa*.

Aulacaspis smilacis, n.sp.
(Fig. 10)

Material examined

Collected on an undetermined shrubby species of *Smilax* (Smilacaceae) on Bukit Fraser [Fraser's Hill], alt. ca. 1300m, Pahang, Malaya, 25.X.1986. Females and males occurring on leaves, and exclusively on the lower surface; 32 mounted adult females examined, one the holotype.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 20–30.6–41 (n=60).
Posterior spiracular disc pores: 6–8.9–17 (n=64).
Perivulvar disc pores, total: 85–119.2–143 (n=32).
Dorsal macroducts, total: 67–86.0–112 (n=32).
Lateral macroducts on abd II: 5–7.4–10 (n=61).
Lateral macroducts on abd III: 5–6.9–9 (n=61).
Lateral gland spines on abd II: 5–8.2–11 (n=61).
Lateral gland spines on abd III: 7–8.8–11 (n=60).
Marginal gland spines on abd IV: 3 (n=24), 4 (n=37), 5 (n=2), 6 (n=1).

Recognition characters

Adult female. Body at full growth with prosoma moderately swollen, distinctly wider than metathorax, broadly rounded on anterior margin, and broadly lobed laterally, tending to be sclerotized, at times rather strongly; prosomatic tubercles produced rather prominently; prepygidial postsoma roughly parallel on lateral sides, with second abdominal segment a little more strongly lobed laterally than the others; pygidium deltoid, little rounded along free margin. Anterior spiracles each with a crescent-shaped group of many disc pores; posterior spiracles each with less numerous disc pores, which are often divided into small clusters. Submedian dorsal macroducts on abd III–VI, rows on III and IV divided into segmental and infrasegmental series; 2–4 on VI. Submarginal dorsal macroducts on III–V; row on III often double partly and irregularly. Submarginal dorsal bosses one on abd I, and also on abd III just mesally to or in submarginal row of macroducts. Lateral macroducts of usual type on abd II and III. Lateral gland spines well represented on abd II and III, shorter than marginal gland spines on abd IV. Marginal gland spines 3–6, usually 3 or 4, on abd IV. Median trullae largely sunken into pygidium, divergent, oblong, roundish apically, minutely serrate on diverging mesal margins; basally connected by a slender sclerotized arch. Second and third trullae well developed. Pore prominences and marginal processes on abd IV and V low, serrate.

Remarks

Among the known forms of the *spinosa* group, this species is characterized in having the dorsal macroducts restricted to the third to sixth abdominal segments. This character is stable throughout the examined specimens, no macroducts occurring on the first and second abdominal segments in all of them. The median trullae are connected basally by a slender sclerotized arch in common with *A. pseudospinosa*, from which it is easily distinguishable in the absence of dorsal macroducts anteriorly to the third abdominal segment.

Aulacaspis takahashii has dorsal macroducts on the third to sixth abdominal segments and often also on the second. It has no macroducts, both submedially and submarginally, on the second segment not infrequently (at a rate of ca. 20% in the type series). *A. smilacis*, therefore, is not always distinguishable from *A. takahashii* in the occurrence of dorsal macroducts on abdominal segments, but it differs from the latter in having much more numerous dorsal macroducts (in spite of the fact that these macroducts are always restricted to the third to sixth abdominal segments) and in having the median trullae connected basally by a slender sclerotized arch. (As to *A. takahashii*,

also see the last paragraph of *Remarks* under *A. pseudospinosa*.)

Six Species of Aulacaspis with a Tapering Body

Until recently, herbaceous vines of the family Cucurbitaceae were seldom mentioned as host plants of armoured scale insects, having been recorded as hosts of a few polyphagous species only occasionally. In spite of this, three species of *Aulacaspis* are now known from wild plants of this family, having been collected in natural forests at three localities in the Malay Peninsula (Takagi, 2015). Two of them, *Aulacaspis trichosanthis* and *A. hodgsoniae*, are peculiarly characterized in having the median trullae roughly dentate and the dorsal macroducts very numerous, some of them forming clusters, and, therefore, are probably highly specialized for living on cucurbitaceous leaves. The other one, *A. labucola*, differs much from them, and is not especially peculiar, in these features. It is, thus, relatively generalized morphologically, and the possibility may not be excluded that it represents or approximates a form ancestral to the former two. The origins of these cucurbit-feeding species should ultimately be traced back into the main body of the genus associated with woody plants of various dicotyledonous families.

In this section, six species of *Aulacaspis* are described as new, all having been collected from woody dicotyledons. These species are similar to the three cucurbit-associated species especially in having the body remarkably tapering, with the lateral sides of the postsoma converging toward the pygidial apex. Two of them are very similar to *A. labucola* in other features, too, and are distinguishable from the latter in the number of the dorsal macroducts or in the state around the bases of the median trullae. Other two species are also similar to *A. labucola*, but distinct from the latter mainly in having dorsal macroducts on one or two more abdominal segments. The remaining two differ from the former four, and also from *A. labucola*, in having less elongated median trullae or unusually elongated macroducts.

Some known species occurring on woody plants or grasses are similar to the cucurbit-associated species and the six species described in this paper in having the body remarkably tapering. Among them, *Aulacaspis thorntoni* should be mentioned here. This species was collected in Rakata Is., the Krakatau Islands, and in another island near Java, on *Calophyllum* and *Barringtoni*a, and at Kuala Lumpur, Malaya, on 'Tembrusu' (probably Tembusu, *Fagraea fragrans*) (Williams and Miller, 2010). So far as based on the description and especially on the figure (fig. 2), it may be related to *A. labucola* and certain ones of the new species. However, it disagrees with all of the three cucurbit-associated species and the six new species, above all, in having the median trullae set close together basally and then 'diverging slightly'; the figure suggests that the bases of these trullae are not connected by a zygotic sclerite nor yoked by a sclerotized band but are confluent with a pair of sclerotized lines extending anteriorly on the pygidial derm of the ventral surface.

Aulacaspis nephelii, n.sp.
(Fig. 11)

Material examined

Collected in the Mencali Forest Reserve, near Kuala Rompin, Pahang, Malaya, on *Nephelium*

maingayi (Sapindaceae), 17.VIII.1990 (Sample 1). Occurring on leaves and exclusively on the lower surface; 23 mounted specimens of the adult female are available, not all of them in good condition, one the holotype.

Also collected on Mt. Beremban, alt. 1860m, Cameron Highlands, Malaya, on *Helixanthera* sp. (Loranthaceae), 22.X.1986 (Sample 2). One full-grown adult female mounted from the lower surface of a leaf, not in good condition.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 7–13.9–19 (n=41) (Sample 1); 21, ca. 21 (Sample 2).
Posterior spiracular disc pores: 3–5.4–8 (n=42) (Sample 1); 8, ca. 8 (Sample 2).
Perivulvar disc pores, total: 59–78.7–94 (n=22) (Sample 1); 112 (Sample 2).
Dorsal macroducts, total: 15–33.4–49 (n=22) (Sample 1); 31 (Sample 2).
Lateral macroducts on abd II: 3–4.7–7 (n=41) (Sample 1); 5, 5 (Sample 2).
Lateral macroducts on abd III: 4–6.0–7 (n=41) (Sample 1); 5, 7 (Sample 2).
Lateral gland spines on abd II: 2–4.7–8 (n=39) (Sample 1); 5, 7 (Sample 2).
Lateral gland spines on abd III: 5–9.2–12 (n=41) (Sample 1); 7, 9 (Sample 2).
Marginal gland spines on abd IV: 1 (n=2), 2 (n=16), 3 (n=25) (Sample 1); 2, 2 (Sample 2).

Recognition characters

Adult female. Body at full growth cuneiform in rough outline, prosoma well swollen, distinctly wider than postsoma, broadly rounded along anterior margin, weakly lobed on lateral sides; prosomatic tubercles usually produced, at times rather strongly; postsoma with lateral sides converging toward pygidial apex, abd II lobed laterally more strongly than other segments. Anterior spiracles each with a moderate number of disc pores in a group; posterior spiracles with a few or several disc pores just laterally and with other ones further laterally and arranged in a short arc. Submedian dorsal macroducts on abd III–V; usually 2–5 on III, occurring segmentally and infrasegmentally, at times only 1 segmentally; usually 2 or 3 on IV, occurring segmentally and infrasegmentally, at times only 1 or 2 segmentally; usually 1 or 2, at times 3, on V. Submarginal dorsal macroducts on abd III–V, 1–5 on each segment. Submarginal dorsal bosses one on abd I, and also on III just anteriorly to marginal macroduct. Lateral macroducts well represented on abd II and III. Lateral gland spines short, well represented on abd II and III. Marginal gland spines usually 2 or 3, at times 1, on abd IV. Median trullae largely sunken into apex of pygidium, united basally by a well-developed zygotic sclerite, elongated, divergent, minutely serrate on diverging mesal margins, blunt apically. Second and third trullae well developed. Pore prominences on abd IV and V pointed apically, followed by a serrate, low marginal prominence on IV and by two such prominences on V.

Remarks

Among the six new species, this species is most closely similar to *Aulacaspis labucola*. Above all, their agreement in the state of the basal connection of the median trullae, which are apparently zygotic, should be emphasized. Both the available samples differ from *A. labucola* in having the dorsal macroducts apparently less numerous.

Sample 2 was obtained from a mountain-inhabiting population. The available single specimen of this sample differs from the specimens of Sample 1 in having more numerous perivulvar disc pores, whereas it is not distinguishable from *A. labucola* in

this feature. In the numbers of the other wax-secreting organs, however, it does not differ from Sample 1.

A. labucola and Sample 1 of *A. nephelii* were collected in lowland forests situated at localities about 110km apart from each other and probably under environmental conditions not very different, and yet differ remarkably in their numbers not only of the dorsal macroducts but also of the perivulvar disc pores. The available samples of *A. nephelii* are too limited to show local or any other kind of variation within the species; the sample of *A. labucola* compared with them is also very meagre. So far as represented by these samples, however, *A. nephelii* and *A. labucola* are clearly distinguishable from each other at least in the numbers of the dorsal macroducts, and may be treated as distinct taxonomic units tentatively.

Aulacaspis milletiae, n.sp.
(Fig. 12)

Material examined

Collected at Puerto Princesa, Palawan Is., Philippines, on *Milletia brachycarpa* (Fabaceae), 11.VIII.1993. Females and males occurring on the upper surface of leaves, females also on the lower surface; female test nearly rounded, flat; 32 mounted specimens of the adult female examined, one the holotype.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 13–21.2–33 (n=56).
Posterior spiracular disc pores: 4–7.1–11 (n=63).
Perivulvar disc pores, total: 87–105.6–126 (n=32).
Dorsal macroducts, total: 39–57.4–73 (n=32).
Submedian macroducts on abd VI: 0 (n=7), 1 (n=47), 2 (n=10).
Lateral macroducts on abd II: 6–8.1–11 (n=61).
Lateral macroducts on abd III: 6–7.9–9 (n=62).
Lateral gland spines on abd II: 5–8.3–11 (n=59).
Lateral gland spines on abd III: 8–11.1–15 (n=63).
Marginal gland spines on abd IV: 2–3.6–6 (n=63).

Recognition characters

Adult female. Body at full growth cuneiform in rough outline; prosoma well swollen, distinctly wider than postsoma, broadly rounded along anterior margin, little or weakly lobed on lateral sides; prosomatic tubercles well represented in rounded prominences; postsoma tapering, with lateral sides converging toward pygidial apex, abd II lobed laterally more strongly than other segments; derm tending to be sclerotized. Anterior spiracles each with disc pores in a group of moderate size; posterior spiracles each with a few or several disc pores just laterally and with others further laterally and arranged in a short arc. Submedian dorsal macroducts on abd III–V and often also on VI; 1–6 in segmental and 1–4 in infrasegmental series on III; 1–5 in segmental and 1–4 in infrasegmental series on IV; 2–5 on V; usually 1, at times 2 or absent, on VI. Submarginal dorsal macroducts on abd III–V; 3–8 on III, 2–5 on IV and also on V. Submarginal dorsal bosses one on abd I, and also on III just anteriorly to marginal macroduct. Lateral macroducts well represented on abd II and III. Lateral gland spines

short, well represented on abd II and III. Marginal gland spines 2–6 on abd IV. Median trullae largely sunken into apex of pygidium, basally with a pair of small sclerites separated from each other by a narrow space; divergent, elongate, minutely serrate on diverging mesal margins. Second and third trullae well represented. Pore prominences on abd IV and V pointed apically, followed by two marginal processes low and serrate on V.

Remarks

Aulacaspis milletiae is very similar to *A. labucola* in most features and almost agrees with the latter in the numbers of the main wax-secreting organs. It differs from the latter in the median trullae apparently non-zygotic basally. This character, in which it is distinct also from *A. nephelii,* should be more significant taxonomically than any numerical differences. The close agreement between *A. milletiae* and *A. labucola* in the numbers of the wax organs, accordingly, may not necessarily suggest that they are particularly closely related to each other.

Aulacaspis cuneiformis, n.sp.
(Figs 13–15)

Material examined

Collected at Tanah Rata, alt. ca. 1400m, Cameron Highlands, Malaya, on *Henslowia* sp. (Santalaceae), 14.X.1986 (Sample 1). Females and males occurring on both surfaces of leaves; 19 mounted specimens of the adult female examined, one the holotype.

Also collected at Desaru, Johor, Malaya, on *Connarus paniculatus* (Connaraceae), 21.VIII.1990 (Sample 2). Females and males occurring on the lower surface of leaves, females also on the upper surface of leaves and on twigs; female tests on the leaf blade thin and flattish; 32 adult females mounted from leaves (Sample 2f) and 8 adult females mounted from twigs (Sample 2r) have been examined.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 17–22.5–28 (n=38) (Sample 1); 10–15.6–23 (n=60) (Sample 2f); 14–17.3–20 (n=16) (Sample 2r).

Posterior spiracular disc pores: 6–7.8–10 (n=38) (Sample 1); 3–5.5–8 (n=60) (Sample 2f); 4–6.4–8 (n=14) (Sample 2r).

Perivulvar disc pores, total: 134–170.0–199 (n=18) (Sample 1); 73–93.4–106 (n=32) (Sample 2f); 91–103.4–124 (n=8) (Sample 2r).

Dorsal macroducts, total: 39–81.0–113 (n=17) (Sample 1); 36–61.9–86 (n=32) (Sample 2f); 58–77.5–103 (n=8) (Sample 2r).

Submedian dorsal macroducts on abd VI: 0 (n=3), 1 (n=30), 2 (n=3) (Sample 1); 0 (n=1), 1 (n=63) (Sample 2f); 1 (n=16) (Sample 2r).

Lateral macroducts on abd II: 8–12.8–16 (n=29) (Sample 1); 6–7.8–10 (n=58) (Sample 2f); 7–8.6–10 (n=11) (Sample 2r).

Lateral macroducts on abd III: 8–12.6–15 (n=33) (Sample 1); 7–8.6–12 (n=62) (Sample 2f); 8–9.8–11 (n=11) (Sample 2r).

Lateral gland spines on abd II: 6–9.1–16 (n=24) (Sample 1); 4–6.4–10 (n=56) (Sample 2f); 6–8.4–11 (n=11) (Sample 2r).

Lateral gland spines on abd III: 11–15.5–19 (n=31) (Sample 1); 7–9.5–12 (n=61) (Sample 2f); 7–10.5–12 (n=11) (Sample 2r).

Marginal gland spines on abd IV: 1 (n=1), 2 (n=3), 3 (n=27), 4 (n=7) (Sample 1); 2 (n=8), 3 (n=55) (Sample 2f); 3 (n=16) (Sample 2r).

Recognition characters

Adult female. Body at full growth cuneiform in rough outline; prosoma well swollen, distinctly wider than metathorax, broadly rounded along anterior margin, weakly lobed laterally; prosomatic tubercles well produced; postsoma tapering, with lateral sides converging toward pygidial apex, metathorax well developed, abd II lobed laterally more strongly than other segments. Anterior spiracles each with a loose group of disc pores; posterior spiracles each with a few or several disc pores strewn just laterally and others further laterally in a short row. Submedian dorsal macroducts on abd II–V and usually also on VI; usually distinctly divided into segmental and infrasegmental series on II and III; usually 1, at times 2 or absent, on VI. Submarginal dorsal macroducts on abd III–V in single rows. Submarginal dorsal bosses one on abd I, and also on III just anteriorly to marginal macroduct. Lateral macroducts well represented. Lateral gland spines short, well represented especially on abd III. Marginal gland spines 1–4, usually 3, on abd IV. Median trullae largely sunken into apex of pygidium, basally with a pair of small sclerites separated from each other by a space, each with a linear extension onto pygidial derm on ventral surface; elongate and divergent, minutely serrate on diverging mesal margins, blunt or roundish apically. Second and third trullae well developed. Pore prominences and marginal processes on abd IV and V low, the processes minutely serrate.

Remarks

Aulacaspis cuneiformis is distinct from *A. labucola* and the other species of the group in having submedian macroducts occurring on and restricted to the second to sixth abdominal segments. The median trullae are non-zygotic, their basal sclerites being separated from each other by a good space, but there is often a sclerotic band across the space to make the bases of the trullae appear to be yoked together.

Sample 1 represents a mountain population and Sample 2 a lowland one of the species. The former apparently tends to have more numerous wax-secreting organs.

Aulacaspis pyriformis, n.sp.
(Figs 16, 17)

Material examined

Collected in Palawan Is., Philippines: at Batarasa, on *Viscum articulatum* (Loranthaceae), 18.VIII.1993 (Sample 1); in the Maasin Forest, *Orophea entercarpoidea* (Annonaceae), 20.VIII.1993 (Sample 2). Females and males occurring on leaves; 19 specimens, one the holotype, from Sample 1; 14 from Sample 2.

Also collected in Malaya: on Mt. Beremban, alt. 1860m, Cameron Highlands, on *Helixanthera* sp. (Loranthaceae), 22.X.1986 (Sample 3); on Mt. Jerai, alt. 930m, on *Henslowia* sp. (Santalaceae), 3.XI.1991 (Sample 4). One foliicolous adult female from Sample 3; 5 foliicolous adult females (Sample 4f) and 12 ramicolous ones (Sample 4r).

Numbers of wax-secreting organs

Submedian dorsal macroducts occur on the first to sixth abdominal segments

and submarginal ones on the second to fifth in all the samples examined. On the first segment, one to eight submarginal ones are often observed in Sample 1 and a single one rarely in Sample 2, whereas none in Sample 3 and 4. These submarginal macroducts are added to the total number of dorsal macroducts.

Anterior spiracular disc pores: 9–14.0–21 (n=34) (Sample 1); 18–24.1–30 (n=28) (Sample 2); 17 (Sample 3); 14–22.9–29 (n=10) (Sample 4f); 15–20.0–26 (n=24) (Sample 4r).

Posterior spiracular disc pores: 4–7.1–10 (n=36) (Sample 1); 7–10.0–15 (n=28) (Sample 2); 4, 7 (Sample 3); 6–7.6–9 (n=10) (Sample 4f); 5–6.7–8 (n=22) (Sample 4r).

Perivulvar disc pores, total: 105–125.5–162 (n=18) (Sample 1); 117–142.6–163 (n=14) (Sample 2); 137 (Sample 3); 122–139.7–175 (n=4) (Sample 4f); 121–134.1–152 (n=12) (Sample 4r).

Dorsal macroducts, total: 142–197.2–238 (n=13) (Sample 1); 121–140.6–176 (n=14) (Sample 2); 201 (Sample 3); 81–130.0–160 (n=5) (Sample 4f); 91–136.3–170 (n=11) (Sample 4r).

Submedian dorsal macroducts on abd VI: 1 (n=3), 2 (n=19), 3 (n=16) (Sample 1); 1(n=2), 2 (n=23), 3 (n=2), 4 (n=1) (Sample 2); 2, 3 (Sample 3); 1(n=8), 2 (n=2) (Sample 4f); 1 (n=17), 2 (n=6), 3 (n=1) (Sample 4r).

Submarginal dorsal macroducts on abd I: 0 (n=13), 1 (n=11), 2 (n=3), 3 (n=5), 4 (n=2), 5 (n=1), 6 (n=1), 7 (n=1), 8 (n=1) (Sample 1); 0 (n=26), 1 (n=2) (Sample 2).

Lateral macroducts on abd II: 9–12.4–14 (n=20) (Sample 1); 8–11.0–13 (n=25) (Sample 2); 12, 15 (Sample 3); 11–13.7–16 (n=10) (Sample 4f); 10–12.4–15 (n=23) (Sample 4r).

Lateral macroducts on abd III: 8–10.1–12 (n=22) (Sample 1); 9–10.6–15 (n=24) (Sample 2); 10, 11 (Sample 3); 12–13.0–15 (n=10) (Sample 4f); 10–12.0–14 (n=23) (Sample 4r).

Lateral gland spines on abd II: 8–10.7–13 (n=18) (Sample 1); 9–12.0–16 (n=24) (Sample 2); 10 (Sample 3); 9–10.9–13 (n=10) (Sample 4f); 6–9.2–12 (n=23) (Sample 4r).

Lateral gland spines on abd III: 10–12.2–16 (n=22) (Sample 1); 11–14.3–18 (n=24) (Sample 2); 12, 12 (Sample 3); 14–15.5–17 (n=10) (Sample 4f); 10–13.1–17 (n=23) (Sample 4r).

Marginal gland spines on abd IV: 3 (n=35), 4 (n=1) (Sample 1); 3 (n=20), 4 (n=5), 5 (n=1) (Sample 2); 3, 3 (Sample 3); 3 (n=7), 4 (n=3) (Sample 4f); 3 (n=17), 4 (n=6), 5 (n=1) (Sample 4r).

Recognition characters

Adult female. Body at full growth obpyriform in rough outline; prosoma well swollen and broadened, much wider than metathorax, nearly rounded on free margin; prosomatic tubercles weakly produced; postsoma with lateral sides converging toward pygidial apex; metathorax well developed. Anterior spiracles each with a loose group of disc pores; posterior spiracles each with a few or several disc pores strewn just laterally and others further laterally and arranged in a short row. Dorsal macroducts abundant. Submedian macroducts on abd I–VI, divided into segmental and infrasegmental series on I–IV or V, 1 or a few on VI. Submarginal macroducts on abd II–V, present or absent on I. Submarginal dorsal bosses one on abd I, a smaller one on III just anteriorly to marginal macroduct. Lateral macroducts well represented on abd II and III. Lateral gland spines

short, well represented on abd II and III. Marginal gland spines 3–5, often 3, on abd IV. Median trullae largely sunken into pygidial apex, basally with a pair of small sclerites separated from each other by a space and each with a linear extension onto pygidial derm on ventral surface; more or less divergent, elongated, minutely serrate on diverging mesal margins, narrowly rounded apically. Second and third trullae well developed. Pore prominences and serrated marginal processes low.

Remarks

This species is undoubtedly closely related to *A. cuneiformis*, from which it is easily distinguishable in having dorsal macroducts on one more segment, the first abdominal segment. The adult female at full growth is stout, being obpyriform rather than cuneiform in rough outline. The state around the bases of the median trullae is similar to that in *A. cuneiformis*: the basal sclerites of the median trullae are separated from each other by a space, but there is often a sclerotic band across the space, connecting the bases of the trullae.

The median trullae show some difference between the samples from Palawan Is. (Sample 1 and 2) and those from the Malay Peninsula (Sample 3 and 4) in the degree of their divergence, in which, however, both groups are somewhat variable. The occurrence of submarginal macroducts on the first abdominal segment has also been observed only in the samples from Palawan Is. There may be recognized, therefore, some geographical differentiation, but no difference has been found sufficient to separate the samples into distinct species.

Aulacaspis ixonanthis, n.sp.
(Fig. 18)

Material examined

Collected in the Mencali Forest Reserve, near Kuala Rompin, Pahang, Malaya, on *Ixonanthes icosandra* (Linaceae), 17.VIII.1990. Females occurring on twigs; 32 mounted specimens examined, one the holotype.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 11–19.2–29 (n=57).
Posterior spiracular disc pores: 6–9.5–15 (n=64).
Perivulvar disc pores, total: 58–87.9–109 (n=32).
Dorsal macroducts, total: 23–29.6–39 (n=28).
Submedian dorsal macroducts on abd VI: 0 (n=48), 1 (n=16).
Lateral macroducts on abd II: 0 (n=3), 1–2.7–5 (n=59).
Lateral macroducts on abd III: 2–4.5–7 (n=63).
Lateral gland spines on abd II: 0 (n=2), 1–1.7–4 (n=59).
Lateral gland spines on abd III: 3–6.1–10 (n=63).
Marginal gland spines on abd IV: 1 (n=2), 2 (n=59), 3 (n=2).

Recognition characters

Adult female. Body at full growth stout, obpyriform in rough outline; prosoma well swollen and broadened, much wider than metathorax, broadly rounded along free margin;

prosomatic tubercles usually indicated by low prominences; postsoma with lateral sides converging toward pygidial apex, metathorax and abd I and II strongly lobed laterally. Anterior spiracles each with disc pores forming a curved group; posterior spiracles with a smaller, loose group of disc pores. Submedian dorsal macroducts 1–3 on each of abd III–V and sometimes 1 on VI. Submarginal dorsal macroducts on abd III–V, 1–5 on III, 1–3 on IV, and 1–6 on V. Submarginal dorsal bosses one on abd I, a smaller one on III just anteriorly to marginal macroduct. Lateral macroducts, a few or several ones on abd II and also on III, rarely none on II. Lateral gland spines short, a few or several ones or rarely none on abd II, usually well represented on III. Marginal gland spines 1–3, usually 2, on abd IV. Marginal macroducts tending to be elongated; those occurring on abd VII extending anteriorly much beyond bases of median trullae. Median trullae somewhat sunken into apex of pygidium, basally united through a well-developed zygotic sclerite, divergent, robust, rounded apically. Second and third trullae well represented. Pore prominences and serrate marginal processes on abd IV and V low.

Remarks

This species differs from the other ones of the group in the shape of the median trullae, which are not elongated. The marginal macroducts have a tendency to be elongated, and those occurring just laterally to the median trullae surpass the trullae in height, extending much anteriorly. In this character it is similar to *A. tenuis* described below.

Aulacaspis tenuis, n.sp.
(Figs 19, 20)

Material examined

Collected on Mt. Jasar, alt. ca. 1300m, Cameron Highlands, Malaya, 17.X.1986, on *Helixanthera* sp. (Loranthaceae) (Sample 1) and *Elaeocarpus* sp. (Tiliaceae) (Sample 2). Females occurring on leaves, on the upper surface or, in Sample 1, on both surfaces; 32 adult females, one the holotype, from Sample 1 and 15 from Sample 2 have been examined.

Numbers of wax-secreting organs

Anterior spiracular disc pores: 5–8.8–12 (n=62) (Sample 1); 7–9.3–13 (n=30) (Sample 2).

Posterior spiracular disc pores: 4–5.4–8 (n=62) (Sample 1); 4–5.9–8 (n=28) (Sample 2).

Perivulvar disc pores, total: 66–80.0–94 (n=32) (Sample 1); 72–87.5–108 (n=15) (Sample 2).

Dorsal macroducts, total: 20–28.0–36 (n=32) (Sample 1); 27–30.4–36 (n=15) (Sample 2).

Submedian dorsal macroducts on abd VI: 0 (n=3), 1 (n=60), 2 (n=1) (Sample 1); 0 (n=1), 1 (n=27), 2 (n=2) (Sample 2).

Lateral macroducts on abd II: 3–4.6–6 (n=58) (Sample 1); 4–4.9–6 (n=30) (Sample 2).

Lateral macroducts on abd III: 3–5.9–8 (n=58) (Sample 1); 5–6.7–9 (n=30) (Sample 2).

Lateral gland spines on abd II: 2–2.9–5 (n=56) (Sample 1); 2–3.1–5 (n=29) (Sample

2).

Lateral gland spines on abd III: 3–5.3–8 (n=57) (Sample 1); 5–6.3–8 (n=30) (Sample 2).

Marginal gland spines on abd IV: 1 (n=1), 2 (n=61) (Sample 1); 2 (n=28), 3 (n=1) (Sample 2).

Recognition characters

Adult female. Body at full growth cuneiform in rough outline; prosoma well swollen, broadly rounded along anterior margin, little lobed laterally, distinctly wider than metathorax; prosomatic tubercles represented by low roundish prominences; a roundish disc present mesally to each prosomatic tubercle on dorsal surface, sclerotized marginally; postsoma with lateral sides converging toward pygidial apex. Anterior spiracles each with a small loose group of disc pores; posterior spiracles each with some disc pores arranged in a row running horizontally and then curved anteriorly. Dorsal macroducts elongated and somewhat attenuated. Submedian dorsal macroducts on abd III–V, and usually also on VI; 1–4 on III, 1–3 on IV and also on V; usually 1, rarely 2 or absent, on VI. Submarginal dorsal macroducts on abd III–V, 1–4 on III, 1–3 on IV, 2–5 on V. Lateral macroducts and short lateral gland spines on abd II and III. Marginal gland spines 1–3, usually 2, on abd IV. Marginal macroducts much elongated and somewhat attenuated, those occurring on abd VII extending anteriorly much beyond bases of median trullae. Median trullae largely sunken into pygidial apex, basally with a pair of small sclerites set close together, each with a linear extension onto pygidial derm on ventral surface; divergent, elongated, minutely serrate on diverging mesal margins, narrowly rounded apically. Second and third trullae well represented. Pore prominence on abd V produced apically in a triangle. Marginal processes on abd IV and V low and serrate.

Remarks

Among the six species of the group, *A. tenuis* is characteristic in having all the dorsal and marginal macroducts elongated and attenuated unusually for a member of the genus (so that it is named *tenuis*). *A. ixonanthis* also has long marginal macroducts, those on the seventh abdominal segment much exceeding the median trullae in height, but it differs from *A. tenuis*, above all, in having distinctly zygotic median trullae. In *A. tenuis* as well as in *A. cuneiformis* and *A. pyriformis* the median trullae are non-zygotic and still sometimes appear to be connected basally by a slender, more or less sclerotic band of the derm.

Concluding Remarks

The premise assumed in this paper is that the grass- and herb-associated portions of *Aulacaspis* have their origins in the main body of the genus composed of abundant species occurring on woody dicotyledons. There are diverse grass-feeding species, and they may not necessarily have a single origin in the main body of the genus. The search made in this paper for the origins of the grass-feeding species, however, is limited to *Aulacaspis donacis*, which occurs on shrubby plants of the monocotyledonous genus *Donax* and may approach an ancestral form of the grass-feeding *A. herbae* and *A. discorum*.

The *spinosa* group contains five named forms, of which two are known from shrubby *Smilax*, other two from orchids, and the remaining one from *Smilax* and an orchid (the last form having been recorded also from two other plants). This group may readily present an example of the supposed expansions of *Aulacaspis* from woody plants to herbaceous ones, but both *Smilax* and orchids belong to the Monocotyledoneae. The five forms are comprised in the group on account of their close resemblance rather than of any commonly possessed peculiar character or characters. Being rather ordinary forms of *Aulacaspis*, they easily find similar or possibly related species in the main body of the genus.

Some species occurring on woody dicotyledons are similar to *Aulacaspis labucola*, a relatively generalized form among the three known cucurbit-associated species. One of them, *Aulacaspis nephelii*, is especially close to *A. labucola*, differing from the latter only in having the dorsal macroducts apparently fewer. It is very probable, therefore, that there are further forms of *Aulacaspis* which are promising for tracing the expansion of the genus from woody dicotyledons to herbaceous vines of Cucurbitaceae.

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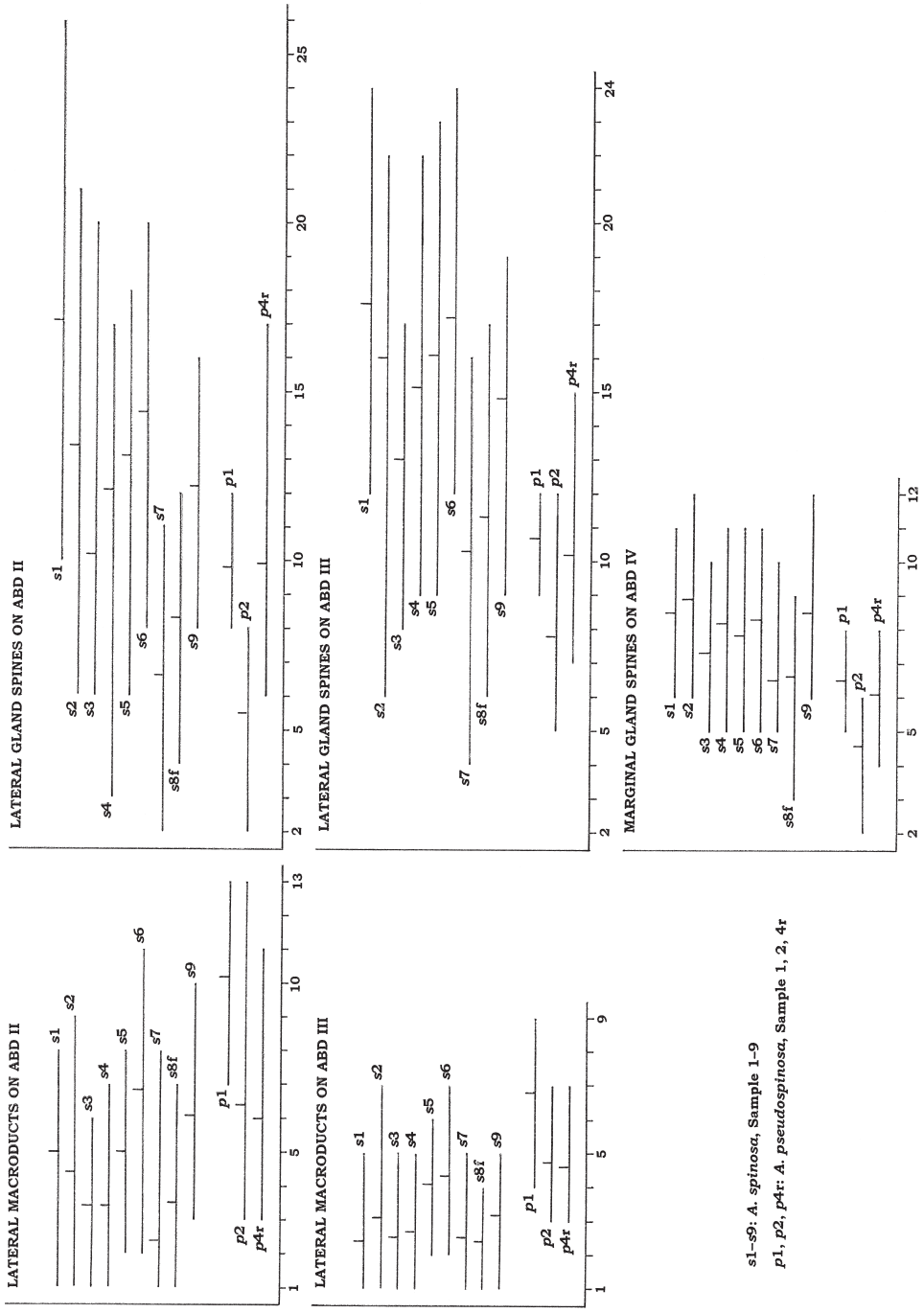

Fig. 1. Character cross-over between *Aulacaspis spinosa* and *A. pseudospinosa* in the numbers (ranges and means) of the lateral macroducts and lateral gland spines on the second and third abdominal segments and of the marginal gland spines on the fourth.

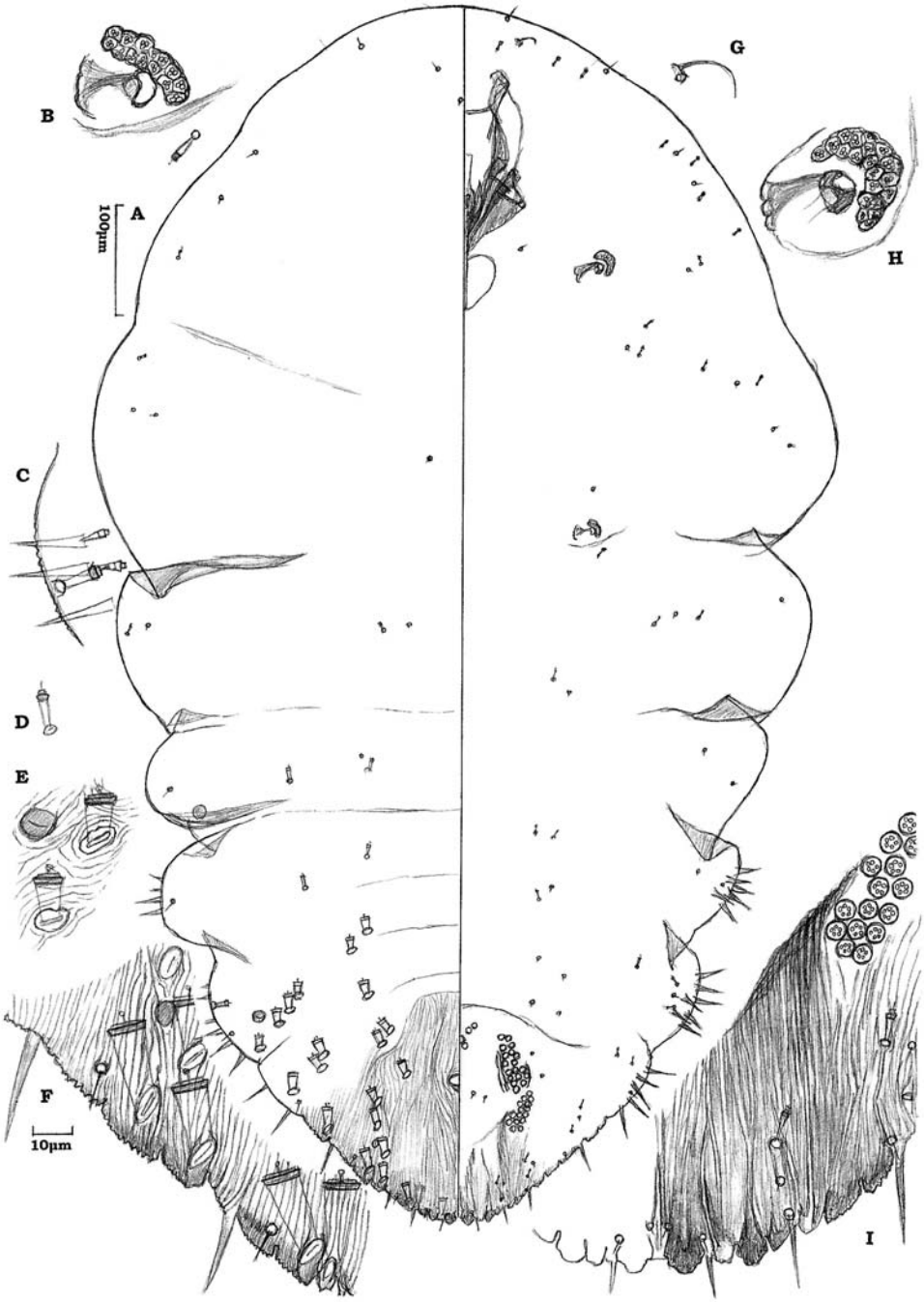

Fig. 2. *Aulacaspis donacis*, fully grown adult female. Sample 1, Malaya, *Donax*. B, posterior spiracle; C, lateral lobe, abd III, dorsal surface; D, submedian dorsal microduct (abd I and II); E, submarginal macroducts and boss, abd III; F, pygidial margin, abd V and VI, dorsal surface; G, antenna; H, anterior spiracle; I, trullae. Scale bar, 100µm: A; 10µm: B–I.

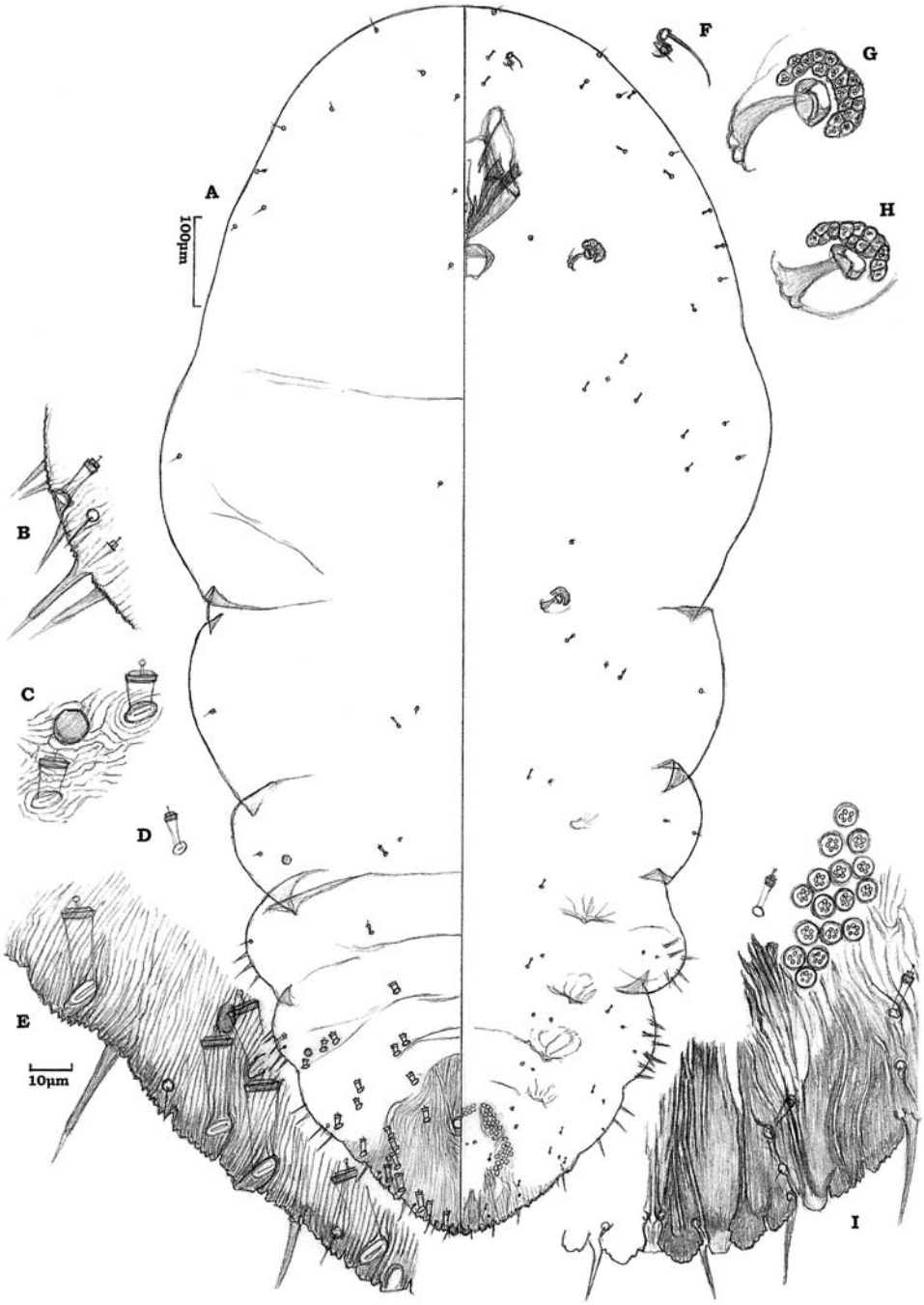

Fig. 3. *Aulacaspis donacis*, fully grown adult female. Sample 1, Malaya, *Donax*. B, lateral lobe, abd III, dorsal surface; C, submarginal macroducts and boss, abd III; D, submedian dorsal microduct (abd I and II); E, pygidial margin, abd IV–VI, dorsal surface; F, antenna; G, anterior spiracle; H, posterior spiracle; I, trullae. Scale bar, 100µm: A; 10µm: B–I.

Fig. 4. *Aulacaspis spinosa*, fully grown adult female. Sample 9, Kyûsyû, *Smilax*. B, posterior spiracle; C, antenna; D, E, lateral lobe, abd II (D) and III (E), dorsal surface, part; F, pygidial margin, abd IV and V, dorsal surface; G, median trullae (another specimen); H, anterior spiracle; I, third trulla; J, median and second trullae. Scale bar, 100µm: A; 10µm: B–J.

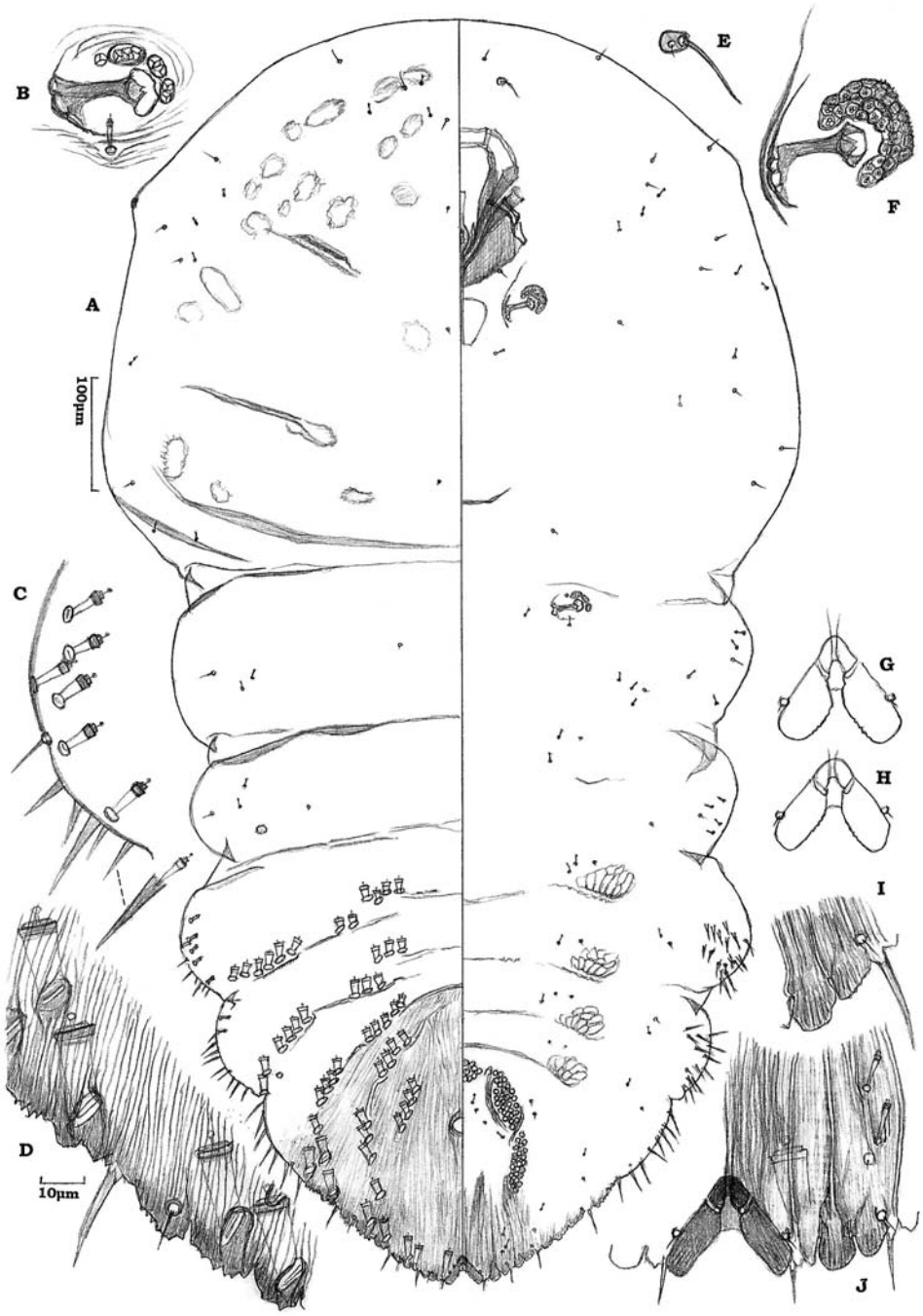

Fig. 5. *Aulacaspis spinosa*, growing foliicolous adult female. Mt. Kirisima, Kyûsyû, *Smilax*. B, posterior spiracle; C, lateral lobe, abd II, dorsal surface; D, pygidial margin, abd IV and V, dorsal surface; E, antenna; F, anterior spiracle; G, H, median trullae (other specimens); I, third trulla; J, median and second trullae. Scale bar, 100µm: A; 10µm: B–J.

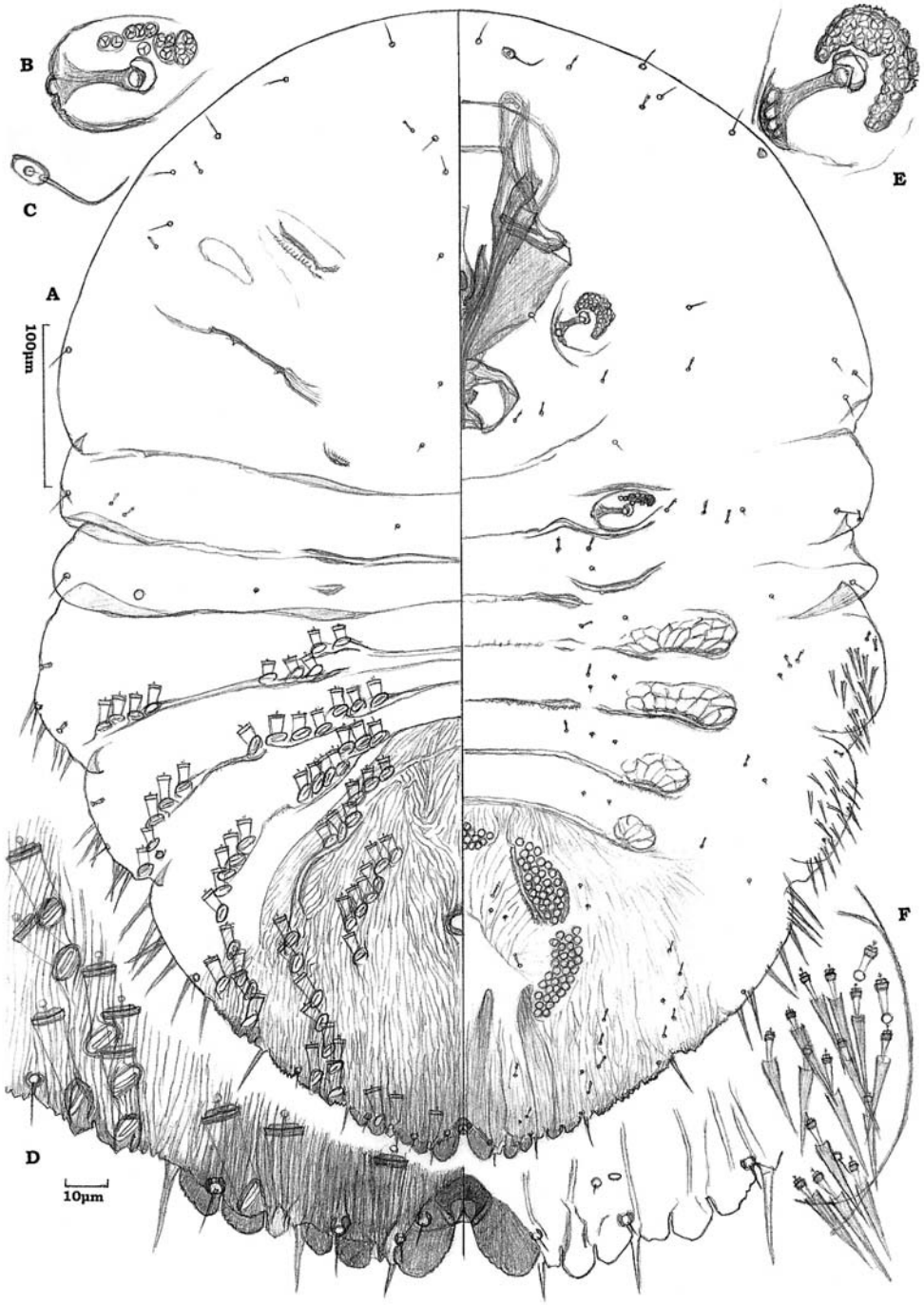

Fig. 6. *Aulacaspis spinosa*, teneral adult female. Sample 1, Honsyû, *Smilax*. B, posterior spiracle; C, antenna; D, pygidial margin; E, anterior spiracle; F, lateral lobe, abd II, ventral surface. Scale bar, 100µm: A; 10µm: B–F.

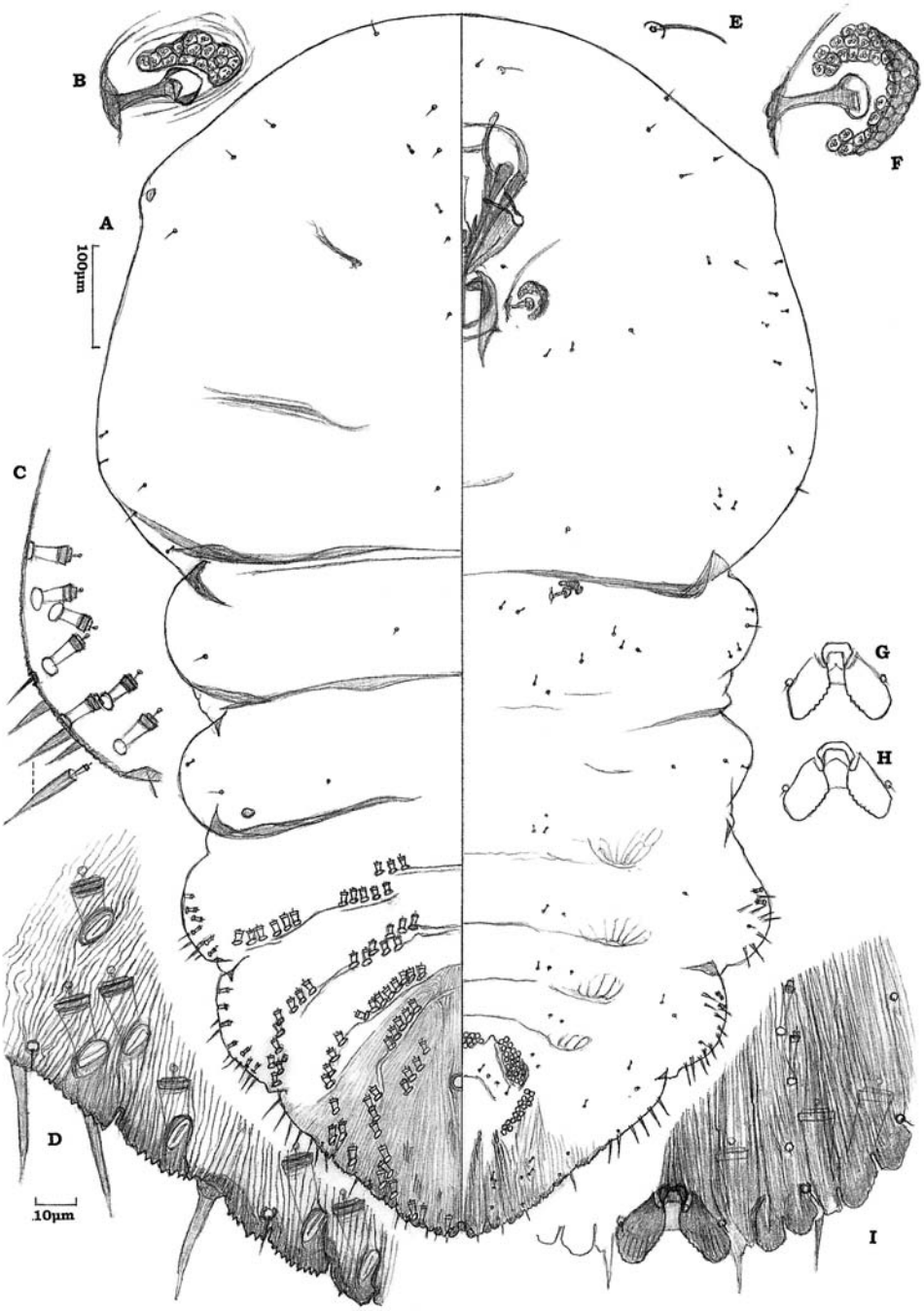

Fig. 7. *Aulacaspis pseudospinosa*, fully grown adult female. Sample 1, Taiwan, *Smilax*. B, posterior spiracle; C, lateral lobe, abd II, dorsal surface; D, pygidial margin, abd IV and V, dorsal surface; E, antenna; F, anterior spiracle; G, H, median trullae (other specimens); I, trullae. Scale bar, 100µm: A; 10µm: B–I.

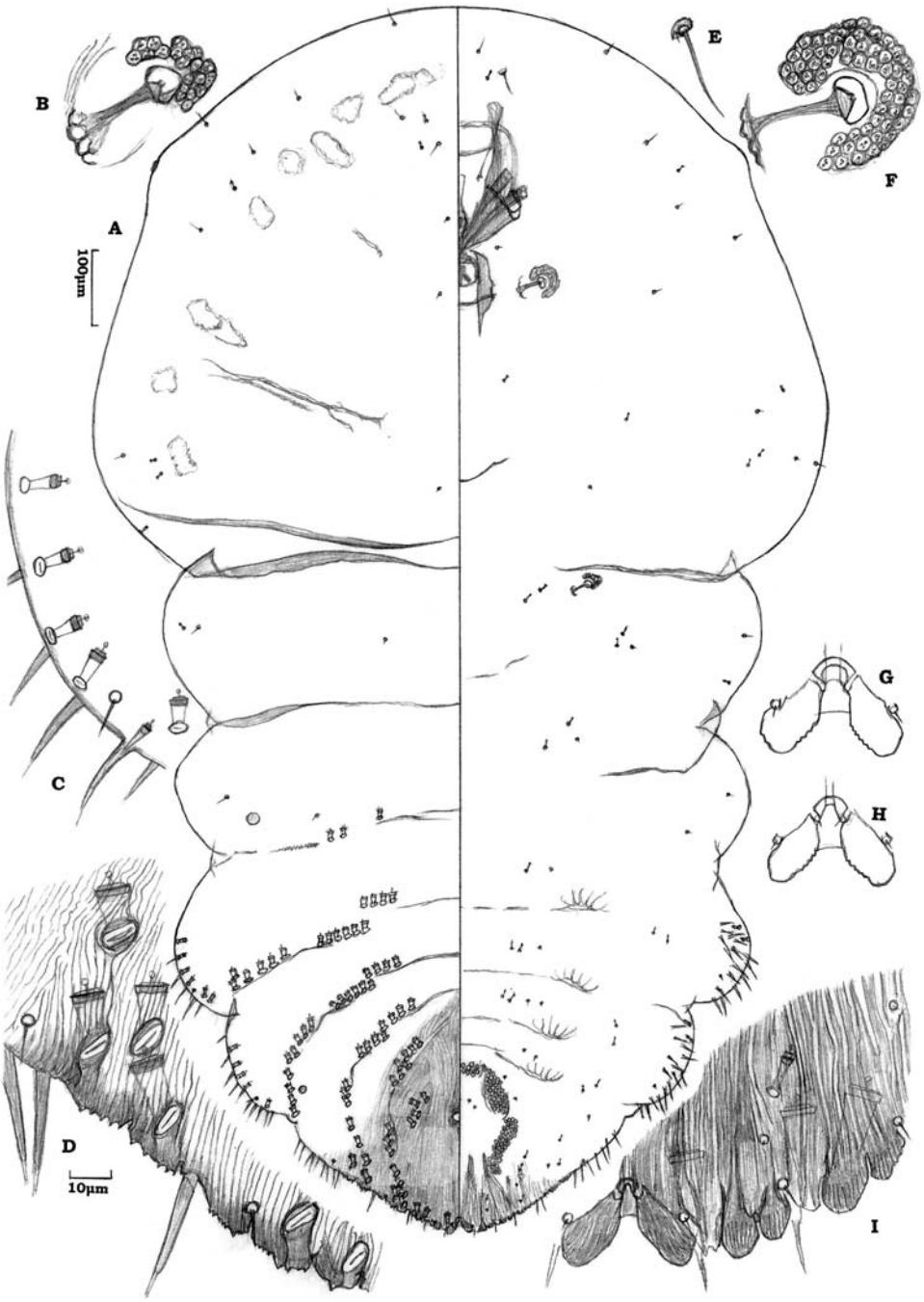

Fig. 8. *Aulacaspis pseudospinosa*, fully grown adult female. Sample 4r, Nepal, *Smilax*. B, anterior spiracle; C, lateral lobe, abd II, dorsal surface; D, pygidial magin, abd IV and V, dorsal surface; E, antenna; F, anterior spiracle; G, H, median trullae (other specimens); I, trullae. Scale bar, 100µm: A; 10µm: B–I.

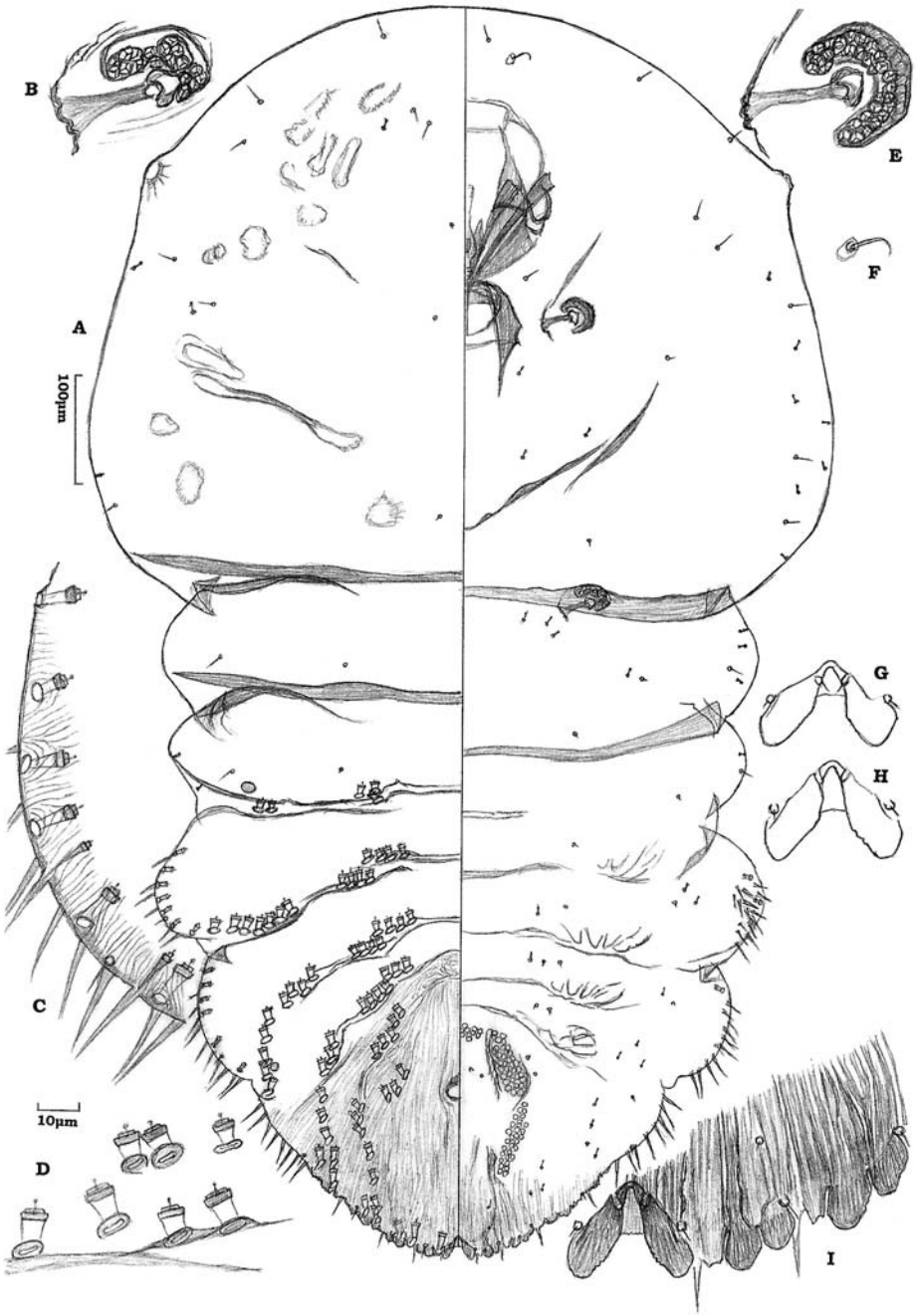

Fig. 9. *Aulacaspis pseudospinosa*, mummified adult female, apparently fully grown. Sample 4f, Nepal, *Smilax*. B, posterior spiracle; C, lateral lobe, abd III, dorsal surface; D, submedian macroducts in segmental and infrasegmental series, abd I (another specimen, not mummified); E, anterior spiracle; F, antenna; G, H, median trullae (other specimens, not mummified); I, trullae. Scale bar, 100µm: A; 10µm: B–I.

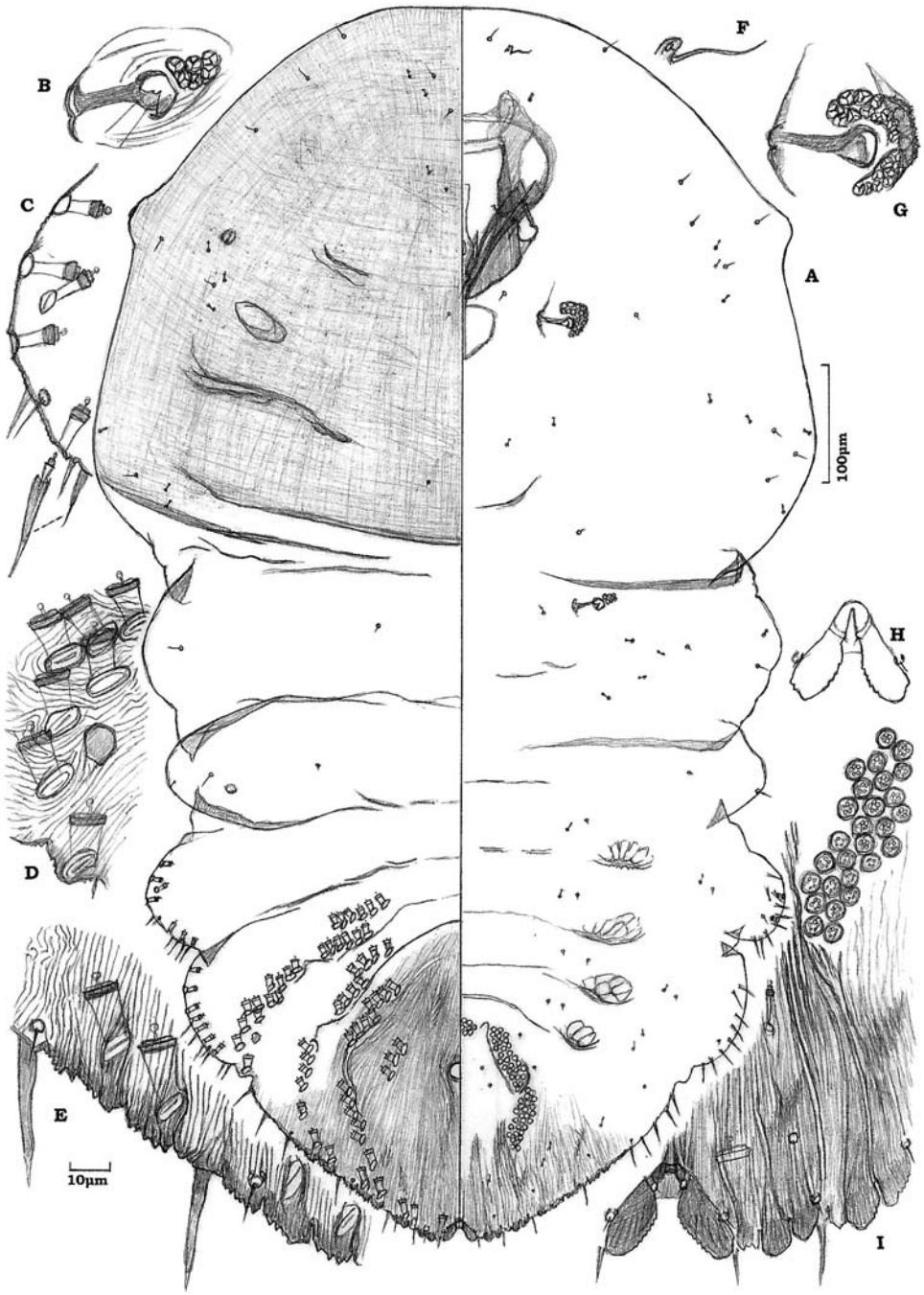

Fig. 10. *Aulacaspis smilacis*, fully grown adult female. Malaya, *Smilax*. B, anterior spiracle; C, lateral lobe, abd II, dorsal surface; D, marginal and submarginal macroducts, abd III; E, pygidial margin, abd IV and V, dorsal surface; F, antenna; G, anterior spiracle; H, median trullae (another specimen); I, trullae. Scale bar, 100µm: A; 10µm: B–I.

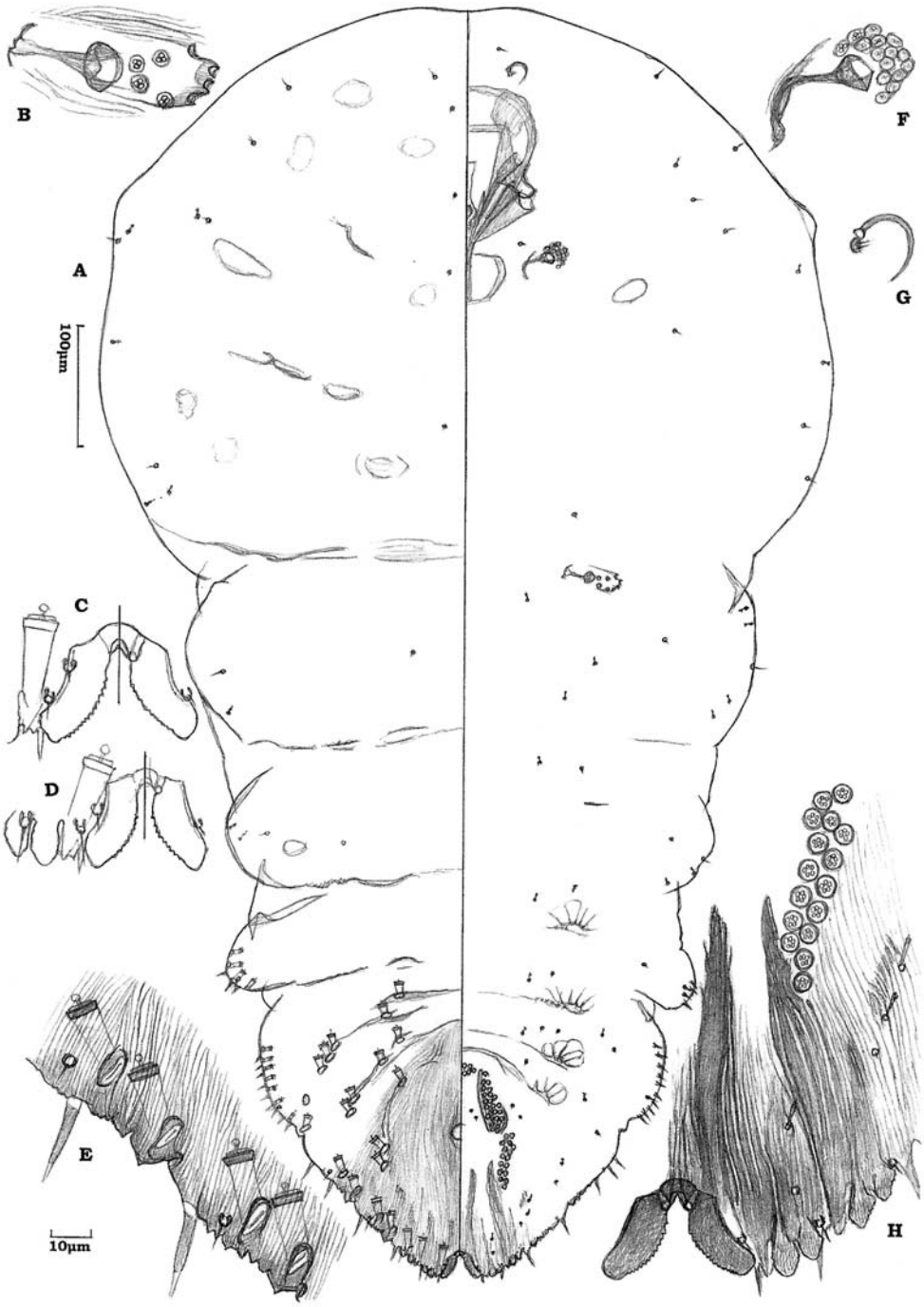

Fig. 11. *Aulacaspis nephelii*, fully grown adult female. Malaya, *Nephelium*. B, posterior spiracle; C, D, median trullae (other specimens); E, pygidial margin, abd IV and V, dorsal surface; F, anterior spiracle; G, antenna; H, trullae. Scale bar, 100µm: A; 10µm: B–H.

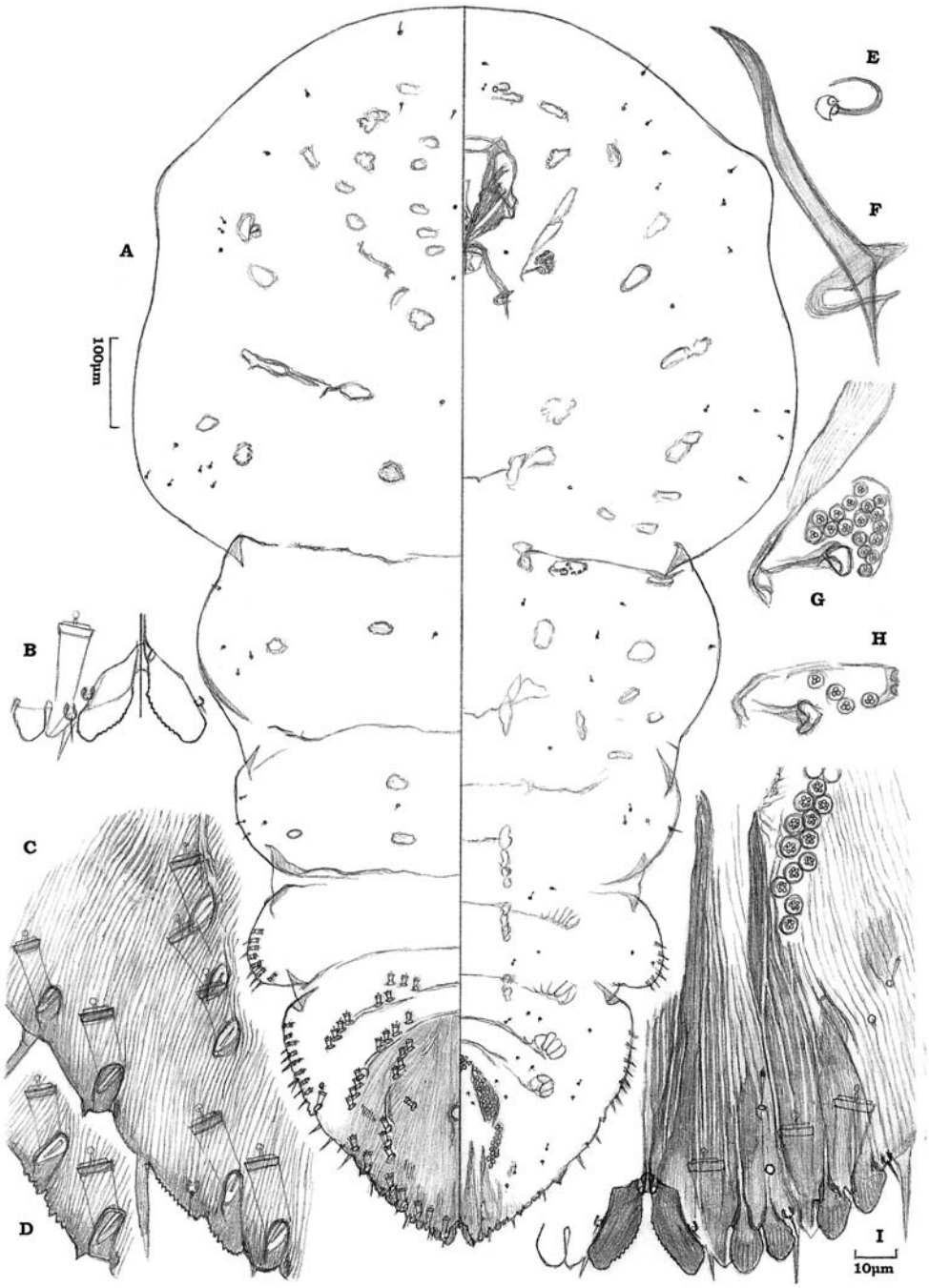

Fig. 12. *Aulacaspis milletiae*, fully grown adult female. Palawan Is., *Milletia*. B, median trullae (another specimen); C, pygidial margin, abd IV and V, dorsal surface; D, margin of abd IV, dorsal surface (another specimen); E, antenna; F, peribuccal sclerosis; G, anterior spiracle; H, posterior spiracle; I, trullae. Scale bar, 100µm: A; 10µm: B–I.

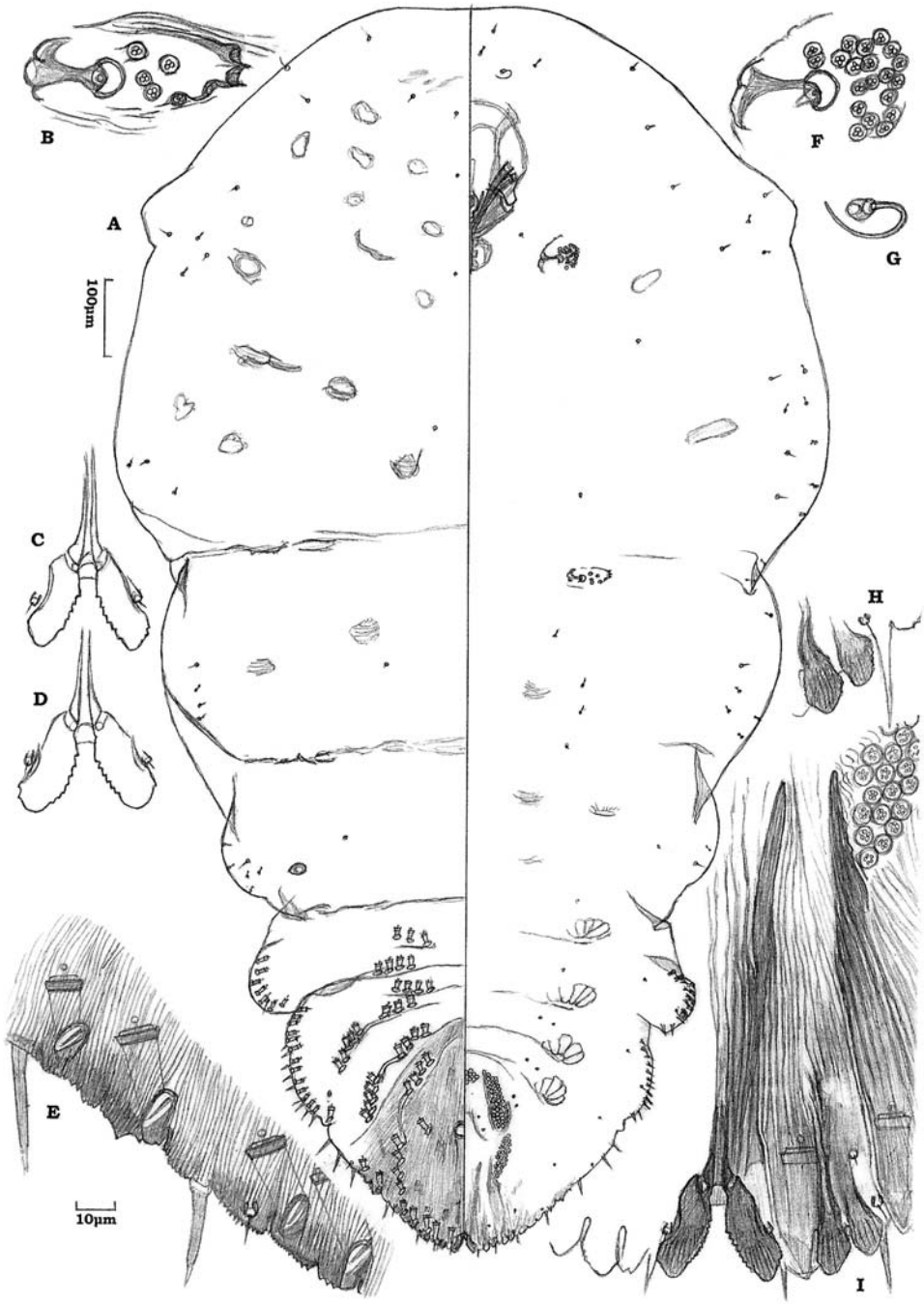

Fig. 13. *Aulacaspis cuneiformis*, fully grown adult female. Sample 1, Malaya, *Henslowia*. B, posterior spiracle; C, D, median trullae (other specimens); E, pygidial margin, abd IV and V, dorsal surface; F, anterior spiracle; G, antenna; H, third trulla; I, median and second trullae. Scale bar, 100µm: A; 10µm: B–I.

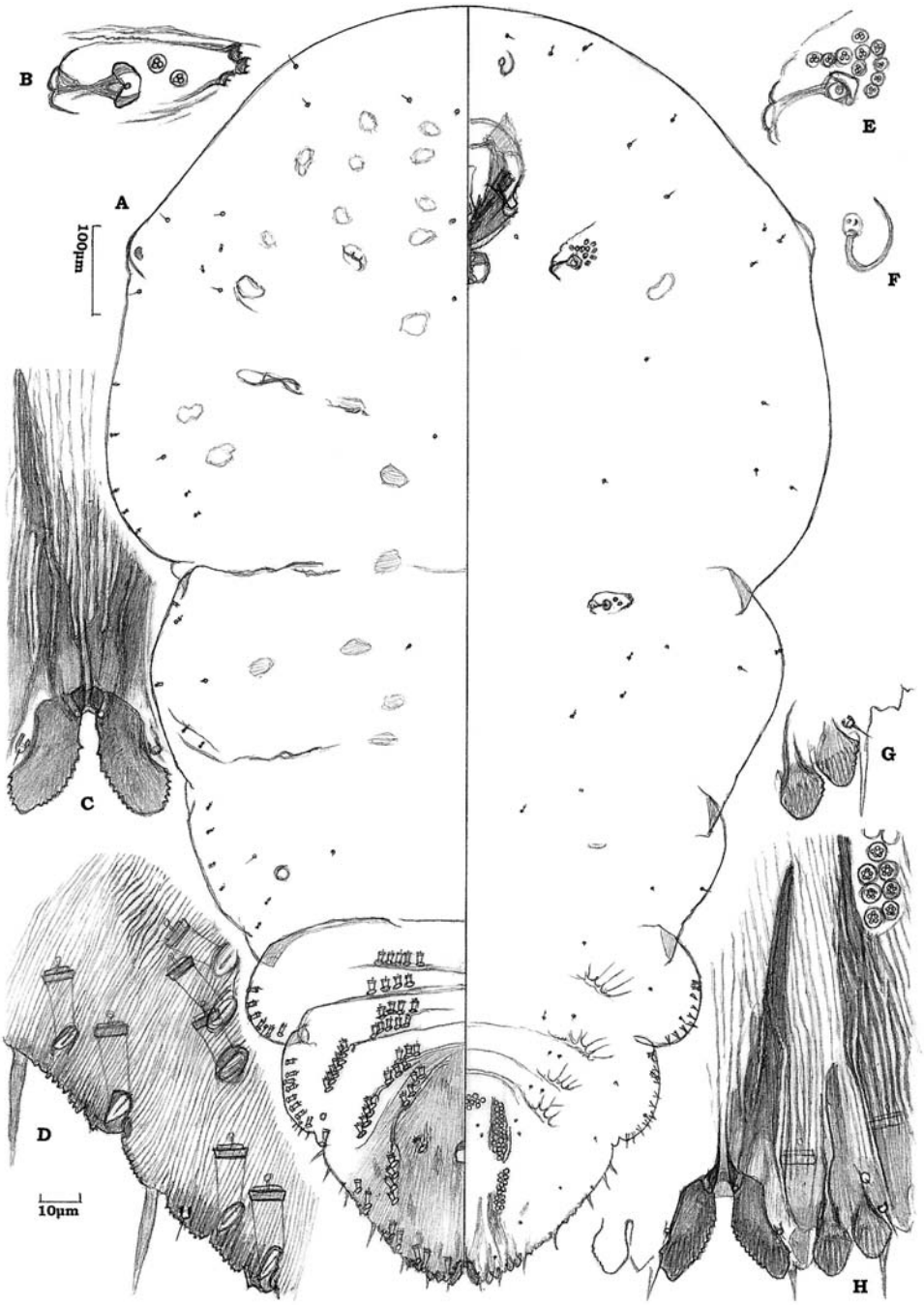

Fig. 14. *Aulacaspis cuneiformis*, fully grown adult female. Sample 2, Malaya, *Connarus*. B, posterior spiracle; C, median trullae (another specimen); D, pygidial margin, abd IV and V, dorsal surface; E, anterior spiracle; F, antenna; G, third trulla; H, median and second trullae. Scale bar, 100µm: A; 10µm: B–H.

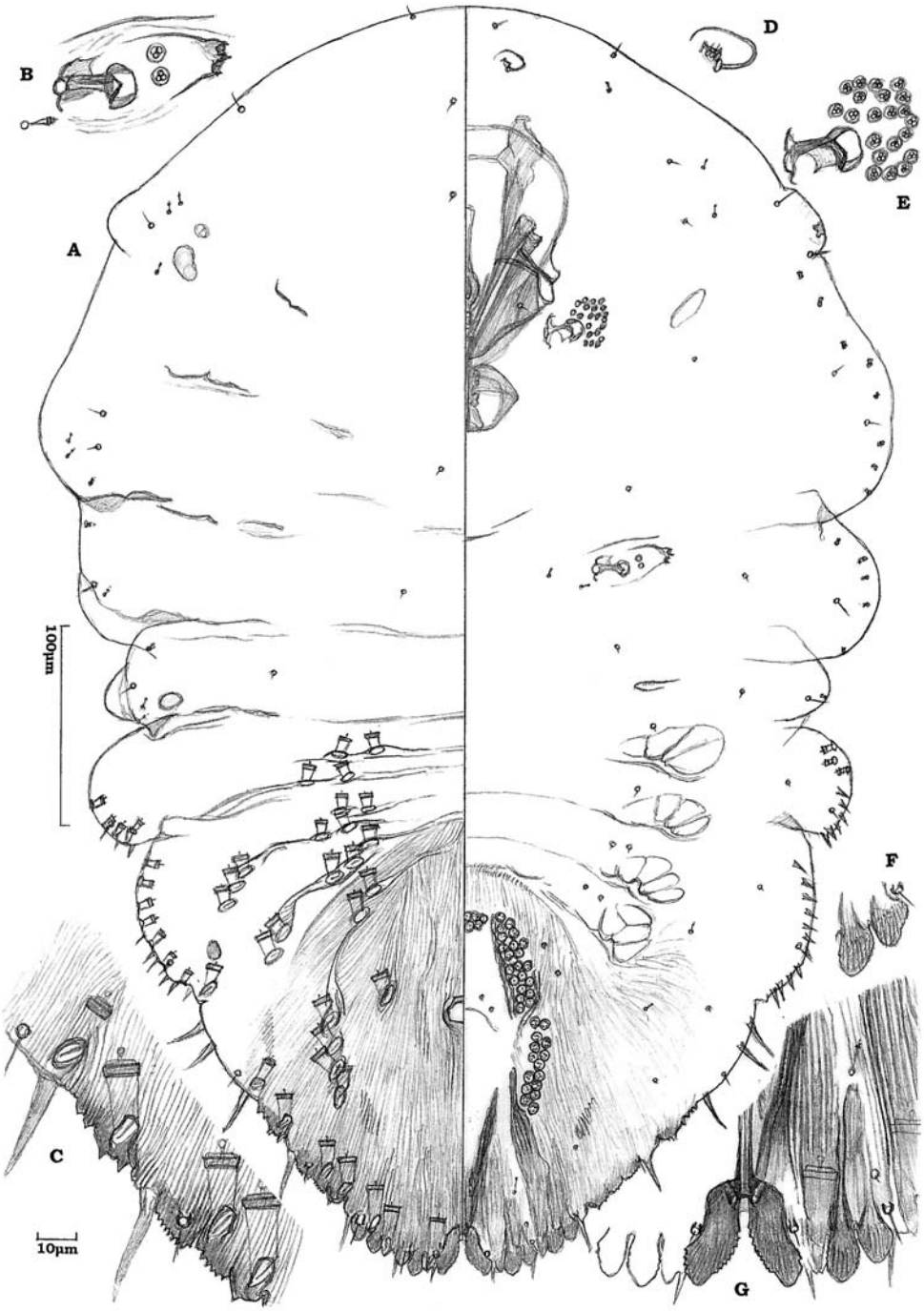

Fig. 15. *Aulacaspis cuneiformis*, teneral adult female. Sample 2, Malaya, *Connarus*. B, posterior spiracle; C, pygidial margin, abd IV and V, dorsal surface; D, antenna; E, anterior spiracle; F, third trulla; G, median and second trullae. Scale bar, 100µm: A; 10µm: B–G.

Fig. 16. *Aulacaspis pyriformis*, fully grown adult female. Sample 1, Palawan Is., *Viscum*. B, posterior spiracle; C, median trullae (another specimen); D, pygidial margin, abd IV and V, dorsal surface; E, antenna; F, anterior spiracle; G, third trulla; H, median and second trullae. Scale bar, 100µm: A; 10µm: B–H.

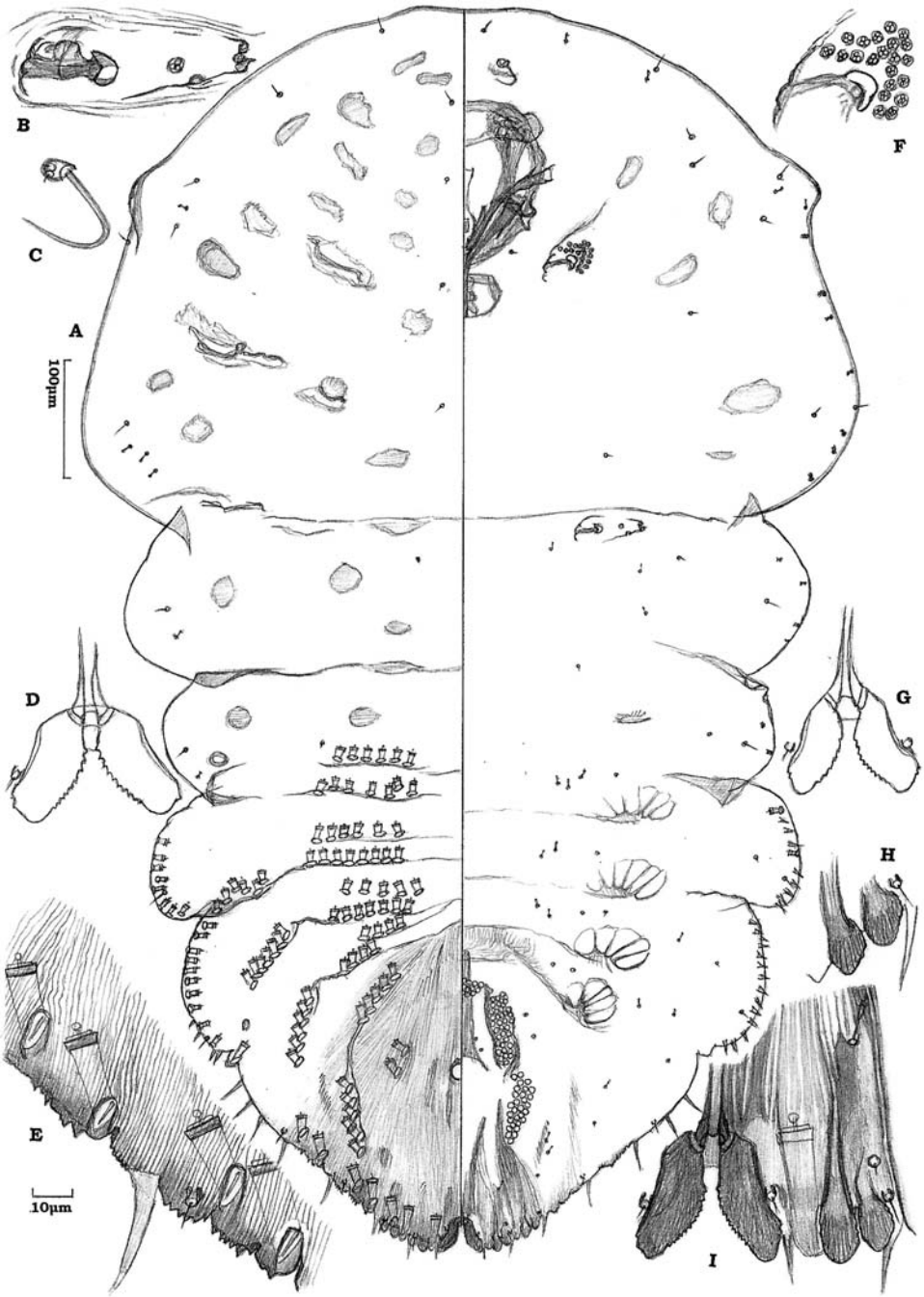

Fig. 17. *Aulacaspis pyriformis*, growing adult female. Sample 4r, Malaya, *Henslowia*. B, posterior spiracle; C, antenna; D, G, median trullae (other specimens); E, pygidial margin, abd IV and V, dorsal surface; F, anterior spiracle; H, third trulla; I, median and second trullae. Scale bar, 100µm: A; 10µm: B–I.

Fig. 18. *Aulacaspis ixonanthis*, fully grown adult female. Malaya, *Ixonanthes*. B, posterior spiracle; C, peribuccal sclerosis; D, pygidial margin, abd V–VIII, dorsal surface; E, pygidial margin, abd IV, dorsal surface; F, anterior spiracle; G, antenna; H, trullae. Scale bar, 100µm: A; 10µm: B–H.

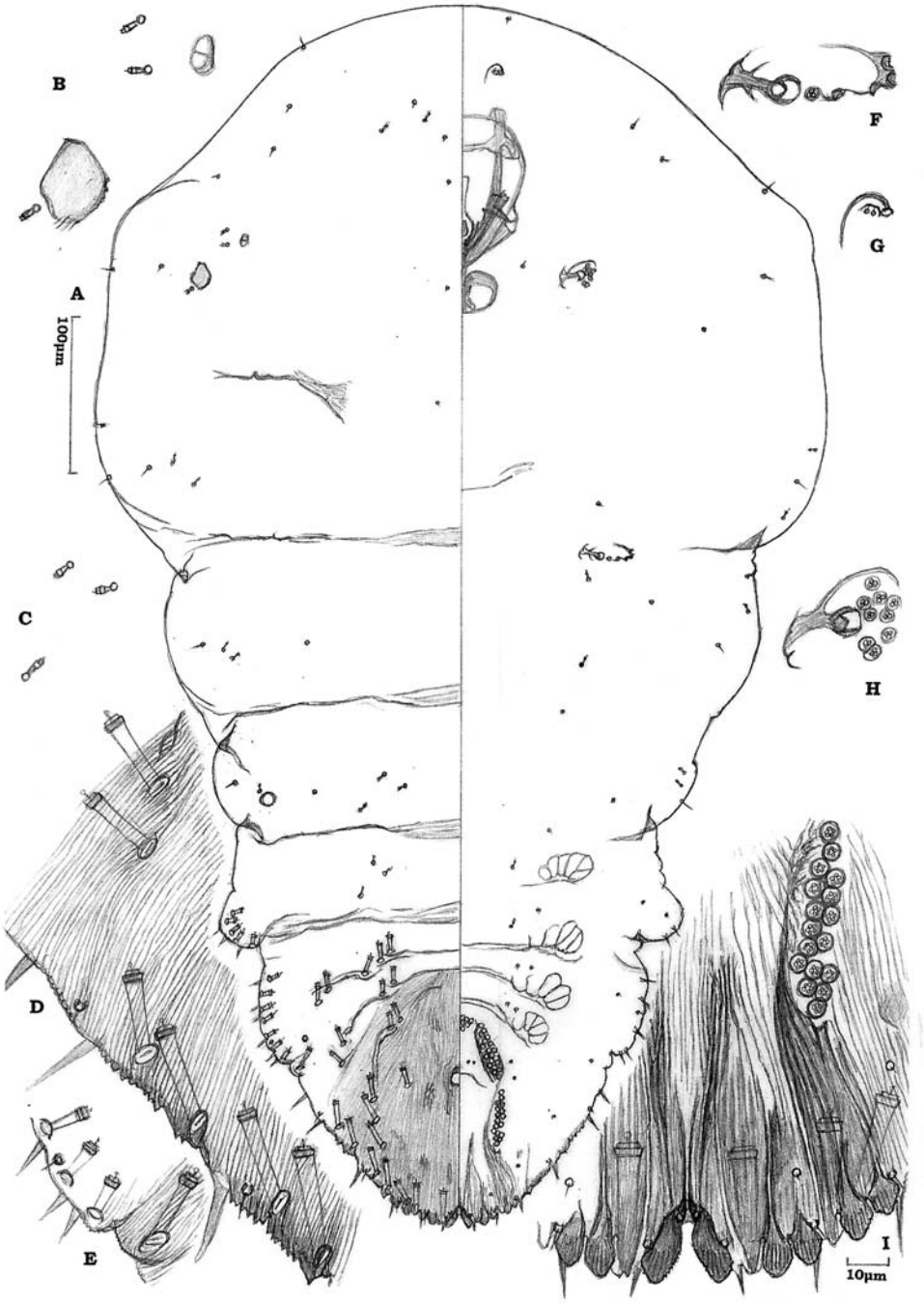

Fig. 19. *Aulacaspis tenuis*, fully grown adult female. Sample 1, Malaya, *Helixanthera*. B, submarginal dorsal disc on prothoracic area; C, submedian dorsal microducts (abd I and II); D, pygidial margin, abd IV and V, dorsal surface; E, marginal macroduct, abd III; F, posterior spiracle; G, antenna; H, anterior spiracle; I, trullae. Scale bar, 100µm: A; 10µm: B–I.

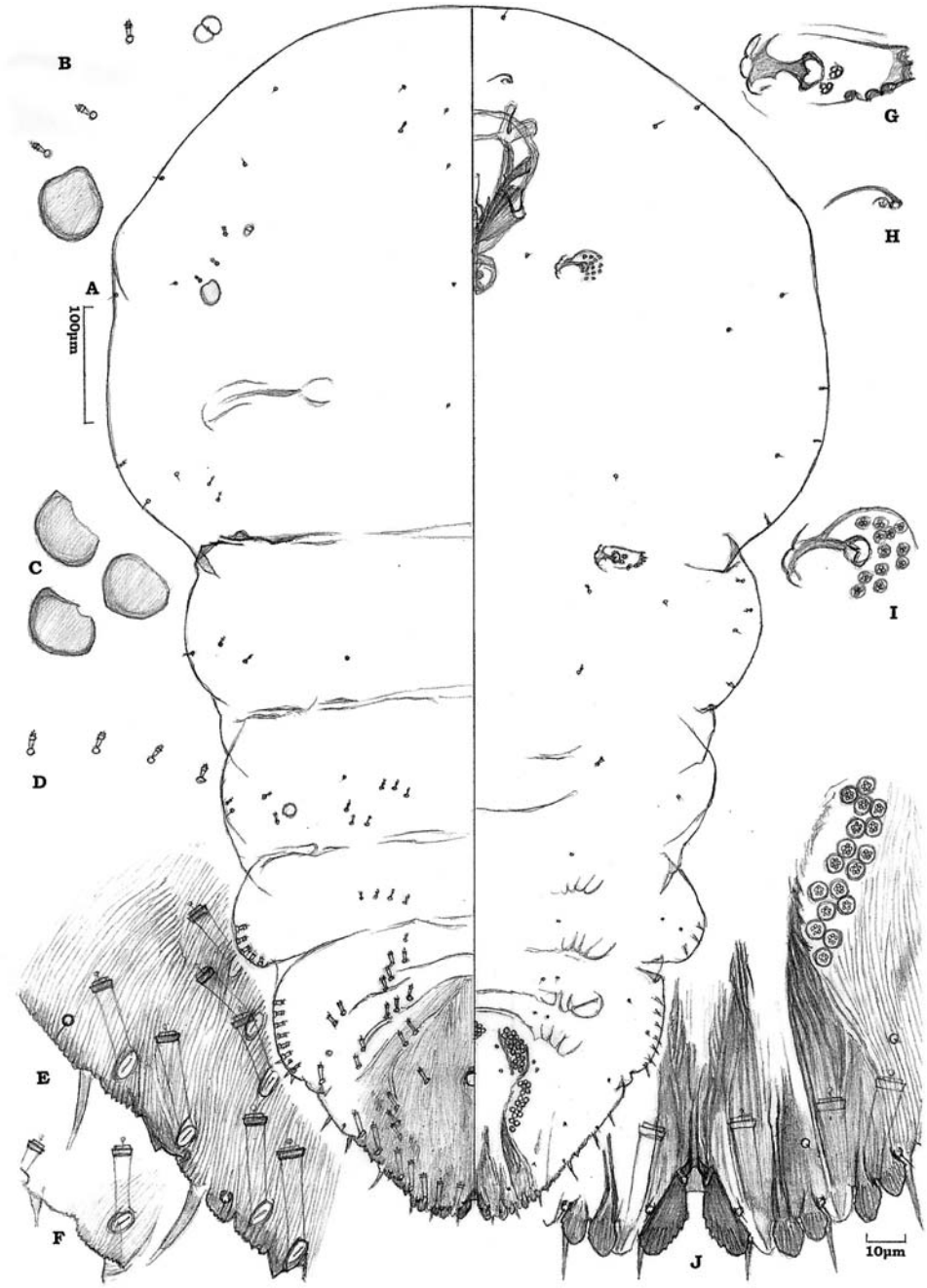

Fig. 20. *Aulacaspis tenuis*, fully grown adult female. Sample 2, Malaya, *Elaeocarpus*. B, C, submarginal dorsal disc on prothoracic area (C, other specimens); D, submedian dorsal microducts (abd I and II); E, pygidial margin, abd IV and V, dorsal surface; F, marginal macroduct, abd III; G, posterior spiracle; H, antenna; I, anterior spiracle; J, trullae. Scale bar, 100µm: A; 10µm: B–J.