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Title	The scale insect genus Myrtaspis (Sternorrhyncha: Coccoidea: Diaspididae)
Author(s)	Takagi, Sadao
Citation	Insecta matsumurana. New series : Journal of the Research Faculty of Agriculture Hokkaido University, series entomology., 76, 23-89
Issue Date	2020-10
Doc URL	https://hdl.handle.net/2115/81658
Type	departmental bulletin paper
File Information	03.Takagi.pdf



**THE SCALE INSECT GENUS MYRTASPIIS
(STERNORRHYNCHA: COCCOIDEA: DIASPIDIDAE)**

By SADAO TAKAGI

Abstract

TAKAGI, S., 2020. The scale insect genus *Myrtaspis* (Sternorrhyncha: Coccoidea: Diaspididae). *Ins. matsum. n. s.* 76: 23–89, 36 figs.

The genus *Myrtaspis* Takagi, 1999, is distinguished from *Chionaspis* in having the antennae in the first instar nymphs five-segmented and the antennal setae in the adult females tending to be outstandingly elongated. Fifteen species are treated and 11 of them, all from Malaysia (Malaya, Sarawak, and Sabah) and one of them also from Singapore, are formally named as new species. The known distribution range of the genus composed of them and three other species includes the Nilgiri Hills and Dehra Dun in India, the Terai lowland in Nepal, and two localities in southern China. Twelve species are known to be associated with plants of the family Myrtaceae mainly or exclusively. Two species described as members of *Chionaspis* from New Guinea may also belong to *Myrtaspis*. Four species have the trullae in the adult females varying in their own manners. These peculiar cases are interpreted to represent some stages in the emergence of polyphenism in association with feeding sites on the host plants.

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Scientific paper for the united projects: Hokkaidô University Expeditions to the Himalaya: Research Trips for Agricultural and Forest Insects in the Subcontinent of India; Systematic and Ecological Surveys on Some Plant-parasitic Microarthropods in Southeast Asia.

INTRODUCTION

In 1999, in connection with my study on the *calcarata* species group of *Aulacaspis*, I erected the genus *Myrtaspis* on the basis of a new species, *M. marginalis*. At that time, one species from *Chionaspis* and two from *Semichionaspis* were transferred to the new genus. So far as based on adult female characters, *Chionaspis*, *Aulacaspis*, and *Myrtaspis* are closely related with one another and should belong to the subtribe Chionaspidina. *Myrtaspis* was supposed to be related with *Aulacaspis* more closely than with *Chionaspis*. This supposition was made especially with emphasis laid on the numbers of antennal segments in their first instar nymphs.

In the tribe Diaspidini, the first instar nymphs are divisible into two types in the number of the antennal segments, one of them with six-segmented, and the other with five-segmented, antennae. Most if not all of the species referred to *Chionaspis* by recent authors belong to the former type, while *Aulacaspis*, at least as represented by the greater part, is of the latter type. The type species of *Myrtaspis* and the three species transferred to the genus have five-segmented antennae in their first instar nymphs.

Taxonomic studies of scale insects have been based on adult female characters largely or exclusively. This may be justified by the view that the stage of the long-living adult females performs a major rôle in the adaptive evolution of these insects generally. However, genera or higher taxa thus composed may sometimes contain nymphs of remarkably different types, and contradictions thus brought forth are to be explained biologically or resolved taxonomically.

In a paper published in 2019 I described 13 species of scale insects from tropical Asia, all as members of *Chionaspis*, a Holarctic genus in our recent understanding. They inhabit oak forests on separated and even distant mountains, and at least one of them is closely connectable taxonomically with three species occurring on the Himalayas. Their isolation on tropical mountains is, therefore, explainable by supposing expansions from the northern Asian fauna under the Glacial Age conditions of climate and geography. The exuvial casts of the first instar were available in 12 out of the 13 species, and all of them have six-segmented antennae. This observation not only supports the generic assignment adopted for these species but also confirms the view that *Chionaspis* species should have six-segmented antennae in the first instar at least in general or even without exception. This view affords a starting point for the present study on *Myrtaspis*.

Abbreviations. The abbreviations ‘prth’, ‘msth’, and ‘mtth’ stand for pro-, meso-, and metathorax; ‘abd I’, ‘abd II’, and so on, for abdominal segments.

Wax-secreting organs in adult females. The numbers of main wax-secreting organs (disc pores, macroducts, gland spines) are given for each side of the body except for their total numbers (and, needless to say, also median perivulvar disc pores). The total number of dorsal macroducts means that of submedian and submarginal macroducts combined, not including marginal macroducts (even on the third abdominal segment). The following values of total numbers are given for each sample or subsample: lowest–mean–highest values; lowest–highest values; or values in individuals; ‘[n]’ for sample or subsample size.

Depository of the holotypes. In this paper, 11 new species, all from Malaysia, are formally named. The holotypes of these species are deposited in the collection of the Entomology Division, Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia.

1. NOTES ON THE TRULLAE

The trullae or pygidial lobes are formed by extensions of the ventral derm on the pygidial margin. They are used primarily for cleaning the spot on the plant body where the female builds her test or waxy cover. In cleaning, they function as little knives or saws in co-operation with some movement of the pygidium, postsoma, or the whole body. The trullae are diverse in size and shape, probably reflecting their adaptive adjustment to a variety of minute surface structures on the plant body and also to a variety of movements of the female body. The females of some diaspidids burrow under the upper epidermal layer of the host plants, and it seems that the emergence of this behaviour requires the development of the cleaning behaviour as an indispensable preceding condition. In the burrowing mode of life, the trullae are subject to further adjustment (in this connection, see Takagi, 2003).

There is an evolutionary tendency for the median trullae to develop as the main or even sole implement for cleaning and burrowing, the lateral trullae often becoming much reduced or even obsolete. The median trullae are situated at the apex of the pygidium and are distinctly separated from each other originally. Each of them belongs to the eighth abdominal segment on each side of the body. The pygidial area between the bases of the median trullae represents the ninth and succeeding segments, which, corresponding to the terminal segments of the abdomen in the original insect body, are compressed together to make a slender longitudinal area extending for some length along the midline of the pygidium posteriorly to the vulvar opening. A pair of setae grow between the mesal bases of the median trullae. Each of these setae should belong to the ninth abdominal segment on each side of the body and represent the ventral marginal seta of the segment. Usually, however, these setae are mentioned and illustrated simply as a pair of marginal setae without further discrimination.

In a common case, the union between the median trullae begins with the sclerotization of derm in the form of a band between their bases, followed by the formation of a pair of small but distinct sclerites just mesally to the basal sockets of the marginal setae occurring on the ninth abdominal segment. At this stage the median trullae appear to be yoked together through the basal sclerites and the sclerotized band of derm. The further reduction of the original terminal segments makes the basal sclerites set close together and then united at their anteromesal corners to produce a single basal sclerosis, which is deeply notched or slit medially except for the anterior end. Ultimately, the union of the basal sclerites becomes complete for the entire length. The median trullae become set close together basally, appressed together on their mesal sides, or fused together throughout.

2. STARTING POINT

The view is adopted that *Chionaspis* species should have six-segmented antennae in the first instar (see Introduction). *Chionaspis trochodendri* (= *Phenacaspis trochodendri* Takahashi) (Fig. 1) occurring in Taiwan and *Chionaspis americana* Johnson (Fig. 3) distributed in North America meet this condition. Provided *C. trochodendri* is related with the other species of *Chionaspis* closely enough to be congeneric with them, it represents a very primitive form of the genus so far as the state of the bases of the median trullae is concerned. *Chionaspis syzygii* Takagi (Fig. 2) was described from low altitude

localities in the Himalayan region and compared with *C. trochodendri* (see Takagi, 1985). These two species are similar to each other, especially in the state of the trullae. Among the members of the genus, *C. americana* is one of the species which are very derivative in the state of the trullae. *Chionaspis lumbiniana* Takagi (Fig. 4), which occurs in lowland Nepal, is surprisingly similar to *C. americana*, especially in the characters of the trullae.

When importance is attributed to the adult females primarily, *C. trochodendri* and *C. syzygii* should be closely related species and *C. americana* and *C. lumbiniana* should be sister species distributed in bicontinental allopatry. These four species may be interpreted to represent a primitive pair and a derivative one within the genus *Chionaspis*. These assumptions may appear to be quite reasonable from the traditional standpoint.

On the other hand, *C. syzygii* and *C. lumbiniana* are distinctly different from *C. trochodendri* and *C. americana* in having five-segmented antennae in the first instar. I (Takagi, 1999) excluded the former two from *Chionaspis*, with emphasis laid on the first instar, and transferred *C. syzygii* to the newly erected genus *Myrtaspis*. The generic position of *C. lumbiniana* was left pending at that time. In the present paper, this species, too, is transferred to *Myrtaspis*.

In the present study, I have treated many new samples collected in Malaysia, in addition to those from the Indian Subcontinent, as belonging to *Myrtaspis* on the basis of, primarily, their first instar nymphs (mostly represented by their exuvial casts). However, it has practically been impossible to distinguish the genus, thus composed, from *Chionaspis* in the adult females. I have tried in vain to find a character or a combination of characters which is stable in the adult females of all the examined samples and useful for recognizing the genus and especially for separating it from *Chionaspis*. In this investigation, I have noticed that in these adult females the antennal setae have a tendency to be outstandingly elongated especially when compared with those in *Chionaspis*. Actually, however, these setae are variable in the degree of elongation among species, among samples referred to the same species, among individuals in the same samples, and even between the opposite body sides of the same individuals. In a rough generalization, the length of the antennal setae in the samples falls in a range of about 20–60µm, while in the *Chionaspis* species I examined it is restricted to about 10–30µm, there being an overlapping zone in 20–30µm. The length of the antennal setae affords no dichotomous key characters for distinguishing between *Myrtaspis* and *Chionaspis*. It makes, however, a statistical difference between them, and this fact may be worthy of taxonomic consideration. I therefore adopt the tendency of the antennal setae to be outstandingly elongated in the adult females as an auxiliary diagnostic character in addition to the five-segmented antennae in the first instar nymphs for distinguishing *Myrtaspis* from *Chionaspis*.

It should be added that the second instar males of nine species of *Myrtaspis* have been examined and they all belong to the *Uluococcus* type, showing nothing particularly different from those of the same type in *Chionaspis*.

3. SPECIES OF MYRTASPIS

3.1. *Myrtaspis marginalis* Takagi, 1999 (Fig. 5)

Recognition characters

Median trullae similar to lobules of second and third trullae in shape and size, basally elongate, sunken into apex of pygidium; basal ends set close together, leaving a slender space between them and appearing to be connected together by a weakly sclerotized patch of derm. Margin of abd IV with a small spur-like process between marginal macroducts. Submedian macroducts on abd III–VI; submarginal macroducts on III–V; lateral macroducts on I–III. Lateral gland spines on abd I–III; marginal gland spines 4 or 5 on IV, 2 on V.

Remarks

This species was described from a sample collected at Rantau Abang, Terengganu, Malaya, on *Eugenia grandis*, Myrtaceae, and the genus *Myrtaspis* was erected on the basis of the species. At that time, the close relation of the genus to *Aulacaspis* was emphasized on account of the occurrence of a pair of derm pockets in addition to a frontal prominence (or a pair of swellings) posteriorly to the antennae (Fig. 5, D) as in *Aulacaspis* species of the *vitis* type and also of a spur-like process on the margin of the fourth abdominal segment (Fig. 5, B) as in the *calcarata* species group of *Aulacaspis*. In the other species referred to the genus in the present study, however, the occurrence of derm pockets is neither universal nor stable and the spur-like process on the pygidial margin is found only in *M. calcarifera*. Another character in the adult female, the tendency of the antennal setae to be elongated outstandingly, which is adopted as an auxiliary diagnostic character of the genus in addition to the five-segmented antennae in the first instar (Section 2), has been confirmed in *M. marginalis* (Fig. 5, D).

3.2. *Myrtaspis breviloba*, n.sp. (Fig. 6)

Material examined

Collected on Cape Rachado, Port Dickson, Negeri Sembilan, Malaya, on *Eugenia glauca*, Myrtaceae, 10.XI.1986. Females occurring on twigs, also on leaves, both surfaces, and petioles; males on leaves, lower surface. Most of the mounted adult females are from twigs, and the present study is based on 30 specimens, one the holotype, mounted from twigs. Also collected in the same locality on *Eugenia* sp., 8.XI.1986. Two foliicolous adult females were mounted from the sample collected on *E. glauca* and 4 from *E. sp.* They are not in good condition generally, and not particularly different from the ramicolous individuals mounted from *E. glauca*.

Wax-secreting organs in adult females

Spiracular disc pores. Associated with each anterior spiracle: 2–3.5–5 [$n=59$]; with each posterior spiracle: 0 [10], 1 [50].

Perivulvar disc pores. In median group: 6–10; in each anterolateral group: 9–14; in each posterolateral group: 7–13. Total: 41–52.3–62 [$n=30$].

Dorsal macroducts. Submedian macroducts: 0 [$n=32$], 1 [23], 2 [5] on abd III; 0 [2], 1 [22], 2 [19], 3 [17] on IV; 1 [40], 2 [20] on V; 0 [60] on VI. Submarginal macroducts: 1–7 on III; 2–5 on

IV; 1–3 on V. Total: 15–24.5–37 [30].

Lateral macroducts. 0 [$n=59$], 1 [1] on msth; 3–9 on mtth; 3–8 on abd I; 2–5 on II; 2–4 on III. Total: 28–37.7–48 [30].

Gland spines. Lateral on mtth to abd III, marginal on abd IV–VIII, single on V–VIII. 0 [$n=6$], 1–3 [52] on mtth; 1–4 on I; 2–5 on II; 2–4 on III; 1 [1], 2 [58], 3 [1] on IV. Total on mtth to IV: 17–25.1–34 [28].

Recognition characters

Adult female. Median trullae small, being as large as or a little larger than mesal lobules of second and third trullae, not deeply sunken basally into apex of pygidium; expanded toward rounded apex; basally set close together, without distinct basal sclerites connected by a sclerotized band of derm. Second and third trullae bilobulate, with both lobules well represented. Anterior spiracles each with a few to several disc pores; posterior spiracles often with a single disc pore. Perivulvar disc pores not numerous. Submedian macroducts occurring often on abd III, usually on IV, and always on V, few on each segment; absent on VI. Submarginal macroducts occurring on abd III–V, not numerous on each segment. Lateral macroducts usually absent on msth; always occurring on mtth and abd I–III. Marginal gland spines usually 2 on abd IV.

Remarks

This species is similar to *Myrtaspis syzygii*, from which it may be distinguished in having the median trullae set closer to each other and not yoked together basally, the submedian macroducts lacking on the sixth abdominal segment, and the lateral macroducts usually lacking on the mesothorax.

3.3. *Myrtaspis syzygii* (Fig. 2, 7–9)

=*Chionaspis syzygii* Takagi, 1985

Material examined

Material newly examined and identified with this species was collected on Tanjong Gelang, Kuantan, Pahang, Malaya, on *Eugenia cumingiana*, Myrtaceae, 9.VII.1990, Sample 1.—Also collected on Mt. Kinabalu, alt. ca. 1500m, Sabah, on *Tristania obovata*, Myrtaceae, 5.X.1988, Sample 2.

Sample 1 with females and males occurring on leaves, lower surface; females also on petioles. Sample 2 with females occurring on leaves, upper surface, in the narrow groove running along the midrib; male scales on leaves, lower surface.

Wax-secreting organs in adult females

In Sample 1, 7 and 3 adult females were mounted from leaf blades and petioles, respectively. These subsamples are, seemingly, not different in the numbers of the organs, so that they are lumped together in the table below.

Spiracular disc pores.

<Sample 1>. Associated with each anterior spiracle: 7–9.8–15 [$n=19$]; with each posterior spiracle: 2 [18], 3 [1].

<2>. ca.14–22 [15]; 4 [11], 5 [4], 6 [2].

Perivulvar disc pores.

<Sample 1>. In median group: 5–10; in each anterolateral group: 13–21; in each posterolateral group: 10–18. Total: 56–72.0–82 [$n=10$].

<2>. 9–12; 17–28; 15–24. Total: 76–90.8–111 [10].

Dorsal macroducts.

<Sample 1>. Submedian macroducts: 2–10 on abd III; 2–6 on IV; 2–4 on V; 1 [$n=20$] on VI. Submarginal macroducts: 0 [1], 2–6 [19] on III; 1–4 on IV; 1–3 on V. Total: 27–47.0–56 [10].

<2>. 2–5 on III; 2–5 on IV; 1–3 on V; 1 [16] on VI. 3–6 on III; 2–6 on IV; 2–4 on V. Total: 31–40.3–51 [7].

Lateral macroducts.

<Sample 1>. 2–5 on msth; 4–7 on mtth; 4–7 on abd I; 4–7 on II; 1–5 on III. Total: 39–45.1–52 [$n=9$].

<2>. 1–3 on msth; 3 [2], 4 [9] on mtth; 4–6 on I; 4–7 on II; 3 [9], 4 [2] on III. Total: 33–36.8–40 [5].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. A few minute gland spines often occurring laterally on msth and mtth. Total: on I–IV.

<Sample 1>. 1–4 on I; 4–7 on II; 4–7 on III; 1 [$n=1$], 2 [19] on IV. Total: 26–30.4–36 [9].

<2>. 1 [5], 2 [7], 3 [1] on I; 2–6 on II; 5–7 on III; 2 [1], 3 [10], 4 [2] on IV. Total: 24–29.5–34 [6].

Recognition characters

Adult female. Median trullae small, as large as or a little larger than mesal lobules of second and third trullae, divergent, basally yoked together through a sclerotized derm band. Submedian macroducts occurring on abd III–VI; lateral macroducts on msth to abd III.

Remarks

Myrtaspis syzygii was originally described as a member of *Chionaspis* on the basis of samples collected at Dehra Dun, northwestern India, and in the Terai lowland, Nepal, on *Syzygium jambos* (= *Eugenia jambos*), *S. cumini* (= *E. cumini*), and *Cleistocalyx operculatus*, these host plants belonging to the family Myrtaceae (Takagi, 1985). The samples from Malaya and Sabah are identified with this species especially because of their agreement with the samples from India and Nepal in the diagnostic characters given above. However, their localities are too distant from those in the Indian Subcontinent and are widely separated also from each other, so that the identification is made not without question. Provided all these samples really belong to the same species, *M. syzygii* should occur in a broad geographical extent and under some different environmental conditions. In this respect, differences in the numbers of wax-secreting organs may not be unexpected among the samples, especially between the samples from the Indian Subcontinent and those from Southeast Asia (compare with Table 1 in Takagi, 1985).

The second instar males from the Terai lowland have four modified macroducts on each side of the abdomen (Takagi, 1985). In the present study, eight individuals of this stage were mounted from Sample 1. They differ from the Terai form in having six modified macroducts on each side of the abdomen. The taxonomic evaluation of this difference, too, requires further material, especially from intermediate areas. It should be added that recently (Takagi, 2019) I have shown a remarkable variation in the number of modified macroducts in individuals of the second instar male mounted from a single sample of *Chionaspis pogonanthrae* Takagi.

3.4. *Myrtaspis calcarifera*, n.sp. (Fig. 10–15)

Material examined

Collected in Malaya (Sample 1–4), Singapore (Sample 5), Sarawak (Sample 6, 7), and Sabah (Sample 8, 9) on plants of the families Myrtaceae (Sample 1–7) and Rubiaceae (Sample 8, 9).

Rantau Abang, Terengganu, on *Melaleuca cajuputi*, Sample 1, and *Rhodomyrtus tomentosus*, Sample 2, 9.VII.1990.—Tanjong Gadung, Terengganu, on *Rhodamnia cinerea*, 16.VII.1990, Sample 3.—Telok Cempedak, Kuantan, on *Eugenia* sp., 8.VII.1990, Sample 4.—Bukit Timah, on *Eugenia longiflora*, 7.VII.1992, Sample 5.—Taman Bako, on *Eugenia tecta*, 9. and 13.X.1991, Sample 6 and 7.—Sepilok Laut, on *Ixora* sp., 2.XI.1988, Sample 8.—Kabili-Sepilok, on *Ixora pyrantha*, 19.XI.1988, Sample 9. Occurring on leaves. Holotype: adult female from Sample 4.

Wax-secreting organs in adult females

Sample 6 is represented by 5 mounted adult females and Sample 7 by 1; these specimens are not good in general condition, and they are lumped together in the table below. Sample 8, represented by 1 mounted adult female, and 9, with 4 adult females, are also united together.

Spiracular disc pores.

<Sample 1>. Associated with each anterior spiracle: 4–6.0–11 [$n=32$]; with each posterior spiracle: 0 [2], 1–1.2–3 [30].

<2>. 4–5.5–8 [17]; 1 [17].

<3>. 4–6.5–9 [18]; 1 [15], 2 [5].

<4>. 3–6.1–10 [20]; 0 [5], 1 [13].

<5>. 5–10.2–18 [65]; 1–2.9–5 [68].

<6+7>. 4–10 [6]; 0 [1], 1 [1].

<8+9>. 5–8.8–11 [9]; 1 [1], 2 [8].

Perivulvar disc pores.

<Sample 1>. In median group: 7–11; in each anterolateral group: 11–23; in each posterolateral group: 9–18. Total: 50–70.9–88 [$n=18$].

<2>. 4–11; 12–20; 8–14. Total: 44–60.6–73 [10].

<3>. 7–11; 15–24; 9–16. Total: 58–74.2–87 [10].

<4>. 8–13; 17–26; 12–18. Total: 70–78.6–89 [11].

<5>. 7–16; 10–26; 11–25. Total: 62–83.8–105 [36].

<6+7>. 6–10; 7–16; 8–13. Total: 47–56.3–60 [6].

<8+9>. 6–8; 11–16; 10–15. Total: 50–58.8–63 [5].

Dorsal macroducts.

<Sample 1>. Submedian macroducts: 1–4 on abd III; 2–4 on IV; 1 [$n=9$], 2 [25] on V; 0 [1], 1 [32], 2 [1] on VI. Submarginal macroducts: 3–5 on III; 1–5 on IV; 1 [2], 2 [34] on V. Total: 25–34.4–42 [17].

<2>. 2–5 on III; 1–4 on IV; 1–3 on V; 1 [20] on VI. 2–5 on III; 1–3 on IV; 1 [2], 2 [16] on V. Total: 23–30.3–39 [9].

<3>. 1–7 on III; 2 [2], 4 [18] on IV; 1 [1], 2 [14], 3 [5] on V; 1 [20] on VI. 2–7 on III; 2–4 on IV; 2 [16], 3 [4] on V. Total: 27–42.1–53 [10].

<4>. 3–5 on III; 3 [6], 4 [16] on IV; 2 [18], 3 [2] on V; 0 [1], 1 [19] on VI. 3–6 on III; 3 [11], 4 [11] on IV; 2 [13], 3 [7] on V. Total: 37–42.0–47 [10].

<5>. 1–7 on III; 1–5 on IV; 1–3 on V; 0 [3], 1 [69] on VI. 2–6 on III; 2–5 on IV; 0 [1], 1–4 [71] on V. Total: 22–37.4–49 [36].

<6+7>. 2 [7], 3 [2] on III; 2 [8], 3 [1] on IV; 1 [4], 2 [5] on V; 0 [9] on VI. 3 [9] on III; 2 [4],

3 [5], 4 [1] on IV; 1 [1], 2 [8], 3 [1] on V. Total: 24–28 [4].

<8+9>. 0 [2], 1 [6], 2 [2] on III; 1 [3], 2 [7] on IV; 1 [9], 2 [1] on V; 0 [10] on VI. 0 [1], 1–3 [9] on III; 1–3 on IV; 1 [3], 2 [7] on V. Total: 12–20.0–23 [5].

Lateral macroducts. Occurring on mtth to abd III, also on msth in Sample 8 (in other samples, a few much smaller ducts often discernible on msth). Total: on mtth to III in Sample 1–<6+7>; on msth to III in <8+9>.

<Sample 1>. 2–6 on mtth; 4–8 on I; 5–7 on II; 3–6 on III. Total: 39–43.4–47 [$n=10$].

<2>. 3–6 on mtth; 5–7 on I; 5–7 on II; 4–6 on III. Total: 41–43.8–47 [8].

<3>. 5–8 on mtth; 3–8 on I; 5–8 on II; 4–6 on III. Total: 43–48.4–58 [9].

<4>. 4–7 on mtth; 5–8 on I; 4–7 on II; 3 [1], 4 [2], 5 [17] on III. Total: 42–45.2–48 [10].

<5>. 3–6 on mtth; 3–7 on I; 3–7 on II; 2–5 on III. Total: 24–34.5–41 [34].

<6+7>. 3 [1], 4 [2] on mtth; 3 [1], 4 [2], 5 [1] on I; 4 [3], 5 [1] on II; 3 [4] on III. Total: 29 [1].

<8+9>. 1–3 on msth; 3–6 on mtth; 3–6 on I; 3 [3], 4 [7] on II; 2 [4], 3 [5] on III. Total: 31–35 [4].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Sample 1>. 1–3 on I; 2–6 on II; 4–9 on III; 2 [$n=33$], 3 [1] on IV. Total: 21–29.4–37 [15].

<2>. 1–3 on I; 3–6 on II; 4–7 on III; 1 [1], 2 [15], 3 [1], 4 [1] on IV. Total: 23–29.2–33 [6].

<3>. 1–4 on I; 5–9 on II; 5–8 on III; 2 [20] on IV. Total: 29–33.9–43 [9].

<4>. 1–7 on I; 3–6 on II; 5–8 on III; 2 [19], 3 [1] on IV. Total: 27–31.2–37 [10].

<5>. 1–5 on I; 2–6 on II; 4–10 on III; 1 [2], 2 [70] on IV. Total: 21–28.4–38 [33].

<6+7>. 1 [1], 2 [1] on I; 3 [4] on II; 3 [4] on III; 2 [4] on IV. Total: 19 [1].

<8+9>. 0 [1], 1 [6], 2 [2], 3 [1] on I; 1–4 on II; 2 [1], 3 [8] on III; 2 [10] on IV. Total: 13–17.8–21 [4].

Recognition characters

Adult female. Median trullae in ‘normal form’ (see *Remarks*) larger or longer than mesal lobules of second and third trullae, sunken into apex of pygidium basally, divergent, with a pair of small basal sclerites, which are set close together or separated from each other and connected by a sclerotized band of derm. Marginal prominence associated with mesal marginal macroduct of abd IV usually with a small triangular spinous process or spur, which is doubled often in some samples; corresponding prominence of V with or without a similar process. Anterior spiracles each with several disc pores usually; posterior spiracles each with 1 or 2 disc pores, at times with none. Perivulvar disc pores in each group moderate in number. Submedian macroducts on abd III–V usually, 1 or 2 present or absent on VI. Submarginal macroducts on abd III–V usually. Lateral macroducts occurring at least on mtth to abd III. Marginal gland spines 1–4, usually 2, on abd IV.

Remarks

This species usually bears small triangular processes or spurs on the pygidial margin. In having this character it may be closely allied to *Myrtaspis marginalis*, from which it is easily distinguishable in having fewer marginal gland spines on the fourth and fifth abdominal segments. This difference is not attributable to local variation, because the sample of *M. marginalis* and Sample 1 and 2 of *M. calcarifera* were collected in the same locality and the occurrence of the fewer gland spines in *M. calcarifera* is stable through all the examined samples.

The samples referred to *M. calcarifera* are divisible into two groups in the state of

the spur on the fourth abdominal segment: Sample 1–4, occurring on the eastern coast of the Malay Peninsula and in seaside vegetations, have the spur single and usually well developed (Fig. 10, C; 11, C), whereas Sample 5 from Singapore and Sample 6–9 from northern Borneo (Sarawak and Sabah) have the spur smaller, sometimes indiscernible, and often doubled (Fig. 12, C, D; Fig. 13, C, D). Sample 8 and 9 differ from the other samples in host association, occurring on plants of *Ixora*, a non-myrtaceous genus. They differ also in the occurrence and numbers of some wax organs. In the present study, all these forms are referred to the same species rather tentatively.

The adult females mounted from Sample 1–3 have the trullae variable in size and shape and in Sample 1 and 2 especially remarkably and irregularly (Fig. 14, 15). On the other hand, the adult females mounted from Sample 4 are considerably stable and uniform in the state of the trullae in spite of the fact that the collection spot is not very far from the habitats of Sample 1–3 and may be similar to the latter in environmental conditions. The trullae in Sample 4 may be taken as representing the 'normal' ones of the species. In fact, trullae similar to the 'normal' trullae are found in Sample 1–3 in various proportions. Further comments on the variation of the trullae in this species are given in Section 7.

3.5. *Myrtaspis kedahana*, n.sp. (Fig. 16, 17)

Material examined

Collected on Tanjon Batu Hampur, Kedah, Malaya, on *Eugenia grandis*, Myrtaceae, 7.XI.1991. Mounted specimens include 14 adult females, one the holotype, all from leaves, lower surface.

Wax-secreting organs in adult females

Spiracular disc pores. Associated with each anterior spiracle: ca.(7–12.0–20) [$n=21$]; with each posterior spiracle: 1–2.6–6 [22].

Perivulvar disc pores. In median group: 6–16; in each anterolateral group: 10–23; in each posterolateral group: 8–19. Total: 50–74.4–95 [$n=13$].

Dorsal macroducts. Submedian macroducts: 0 [$n=2$], 1–7 [24] on abd III; 1–7 on IV; 0 [1], 1–7 [23] on V; 0 [15], 1 [10] on VI. Submarginal macroducts: 1–8 on III; 1–6 on IV; 1–4 on V. Total: 14–49.1–93 [11].

Lateral macroducts. 0 [$n=4$], 1–8 [19] on prth; 3–16 on msth; 4–17 on mtth; 4–15 on abd I; 3–7 on II; 0 [1], 1–4 [23] on III. Total: 34–73.8–123 [11].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. 0 [$n=1$], 1–4 [24] on I; 1–6 on II; 2–6 on III; 2 [24], 3 [1] on IV. Total on I–IV: 13–23.2–28 [12].

Recognition characters

Adult female. Median trullae robust, larger than mesal lobule of second trulla (even when the latter is well developed), parallel or nearly so to each other. Second and third trullae with lobules well developed or reduced to depressed processes. Anterior spiracles each with cluster of disc pores small to moderate in size; posterior spiracles each with a few to several disc pores. Perivulvar disc pores not numerous. Submedian macroducts usually on abd III–V, 1 sometimes present on VI; submarginal macroducts on III–V. Lateral macroducts on prth–abd III, at times lacking on prth and III. Lateral gland spines on abd I–III, at times lacking on III; 2 or occasionally 3 marginal gland spines on IV.

Remarks

This species may be related to the four species mentioned in Section 3.1–3.4. It may be distinguishable from all of them in the lateral macroducts well represented not only on the prepygidial postsoma but usually also on the prosoma as anteriorly as the prothorax.

This species as represented by the examined specimens is broadly variable in the median and lateral trullae, which show opposite extremes and two intermediates in the variation (Fig. 17). The trullae in these intermediates and especially in one of them (Fig. 17, B) may represent the ‘normal’ type of the species. Further comments on the variation of the trullae are given in Section 7.

3.6. *Myrtaspis longiloba*, n.sp. (Fig. 18–21)

Material examined

Collected in Malaya (Sample 1–5, 11), Sarawak (Sample 6–8), and Sabah (Sample 9, 10), on plants of the families Myrtaceae (Sample 1–10) and Hypericaceae (Sample 11).

Mt. Jasar, alt. ca.1300–1500m, Cameron Highlands, Pahang, on *Eugenia cerina*, 17.X.1986, Sample 1.—Ulu Kali, alt. ca.1700m, Pahang, on *Eugenia* sp., 5.X.1986, Sample 2.—Ulu Gombak, Selangor, on *Eugenia* sp., 20.VI.1990, Sample 3.—Bukit Nanas, Kuala Lumpur, on *Eugenia* sp., 3.VIII.1990, Sample 4.—Cape Rachado, Port Dickson, Negeri Sembilan, on *Eugenia* sp., 10.XI.1986, Sample 5.—Mt. Santubong, alt. ca.800m, on *Eugenia* sp., 24.X.1991, Sample 6.—Taman Bako, on *Eugenia chlorantha* and *Rhodamnia cinerea*, 10. and 14.X.1991, Sample 7 and 8.—Kundasang, alt. 1550m, Mt. Kinabalu, on *Eugenia* sp., 11.XI.1988, Sample 9.—Pinosuk Plateau, alt. ca.1500m, Mt. Kinabalu, on *Eugenia chrysantha*, 10.X.1988, Sample 10.—Tanah Rata, alt. ca.1400m, Cameron Highlands, Pahang, on *Cratoxylum arborescens*, 14.X.1986, Sample 11. Holotype, adult female, from Sample 2.

Females and males occurring on leaves, upper surface, usually; females also on petioles at times; females in Sample 11 on petioles.

Wax-secreting organs in adult females

Spiracular disc pores.

<Sample 1>. Associated with each anterior spiracle: 9–ca.17; with each posterior spiracle: 0 [$n=1$], 1–5 [13].

<2>. 7–ca.19; 1–3.7–6 [18].

<3>. ca.(6–13); 2–5 [7].

<4>. 2–4.5–6 [26]; 1 [24], 2 [2].

<5>. 3–4.8–7 [18]; 0 [4], 1 [15].

<6>. 1–2.9–6 [60]; 0 [26], 1 [30], 2 [1].

<7>. ca.(7–13); 1 [4].

<8>. 2–ca.7; 1 [4], 2 [1].

<9>. 4–5.5–8 [18]; 1 [8], 2 [11].

<10>. 2–3.6–7 [59]; 0 [35], 1 [18], 2 [2].

<11>. 7–ca.20; 1–2.4–5 [29].

Perivulvar disc pores

<Sample 1>. In median group: 11–16; in each anterolateral group: 20–29; in each posterolateral group: 16–22. Total: 89–100.1–109 [$n=11$].

<2>. 4–14; 15–27; 11–23. Total: 67–81.0–97 [12].

<3>. 6 [2], 8 [2]; 11–16; 9–13. Total: 47–61 [4].

- <4>. 7–9; 13–18; 10–15. Total: 57–64.8–70 [14].
 <5>. 5–8; 13–17; 8–14. Total: 41–57.4–63 [10].
 <6>. 4–9; 6–19; 4–15. Total: 28–54.9–72 [30].
 <7>. 6–9; 10–17; 7–14. Total: 57–64 [4].
 <8>. 8 [3]; 12–20; 12–14. Total: 52–73 [3].
 <9>. 8–13; 12–24; 11–16. Total: 60–72.4–85 [10].
 <10>. 6–8; 9–13; 9–13. Total: 46–53.6–57 [30].
 <11>. 9–15; 22–29; 14–24. Total: 86–94.9–104 [15].

Dorsal macroducts.

- <Sample 1>. Submedian macroducts: 2–5 on abd III; 2–4 on IV; 1–3 on V; 1 [$n=22$] on VI.
 Submarginal macroducts: 3–6 on III; 3–5 on IV; 2 [16], 3 [6] on V. Total: 30–39.5–47 [11].
 <2>. 0 [2], 1–4 [22] on III; 1–4 on IV; 1 [8], 2 [16] on V; 1 [24] on VI. 4–6 on III; 1–5 on IV; 2–4 on V. Total: 30–36.7–45 [12].
 <3>. 0 [7], 1 [1] on III; 0 [7], 1 [1] on IV; 1 [8] on V; 1 [8] on VI. 2 [7], 3 [1] on III; 2 [6], 3 [2] on IV; 1–3 on V. Total: 18–22 [4].
 <4>. 1–3 on III; 1–3 on IV; 1 [22], 2 [4] on V; 1 [26] on VI. 2–4 on III; 2–4 on IV; 2 [26] on V. Total: 20–27.8–35 [11].
 <5>. 1–3 on III; 1–3 on IV; 1 [13], 2 [7] on V; 1 [20] on VI. 2 [1], 3 [19] on III; 2 [6], 3 [14] on IV; 2 [20] on V. Total: 21–27.8–32 [10].
 <6>. 0 [24], 1–3 [36] on III; 0 [15], 1–3 [45] on IV; 0 [4], 1 [55], 2 [1] on V; 0 [17], 1 [43] on VI. 0 [5], 1–4 [55] on III; 0 [4], 1–3 [56] on IV; 0 [1], 1–3 [59] on V. Total: 1–17.9–28 [30].
 <7>. 2 [4], 3 [2] on III; 2 [6] on IV; 1 [4], 2 [2] on V; 1 [6] on VI. 2 [3], 3 [4] on III; 2 [4], 3 [3] on IV; 2 [7] on V. Total: 24–31 [3].
 <8>. 2–4 on III; 2 [4], 3 [2] on IV; 2 [6] on V; 1 [6] on VI. 3–5 on III; 3 [4], 4 [2] on IV; 2 [6] on V. Total: 31–40 [3].
 <9>. 1 [6], 2 [14] on III; 1 [1], 2 [19] on IV; 1 [13], 2 [7] on V; 1 [20] on VI. 2–4 on III; 2–4 on IV; 2 [7], 3 [13] on V. Total: 25–31.5–36 [10].
 <10>. 0 [51], 1 [9] on III; 0 [2], 1 [21], 2 [37] on IV; 0 [3], 1 [40], 2 [17] on V; 0 [60] on VI. 1–4 on III; 1–4 on IV; 0 [1], 1 [10], 2 [49] on V. Total: 9–19.9–26 [30].
 <11>. 2–4 on III; 2–4 on IV; 1 [5], 2 [25] on V; 1 [30] on VI. 3–7 on III; 3–5 on IV; 1 [1], 2 [24], 3 [5] on V. Total: 33–37.9–43 [15].

Lateral macroducts.

- <Sample 1>. 4–7 on mtth; 6–11 on abd I; 7–9 on II; 4–7 on III. Total: 50–56.3–61 [$n=11$].
 <2>. 3–8 on mtth; 7–11 on I; 6–11 on II; 5–8 on III. Total: 52–59.5–67 [11].
 <3>. 0 [4], 2–5 [4] on mtth; 6–9 on I; 7 [6], 8 [2] on II; 5 [6], 6 [2] on III. Total: 37–52 [3].
 <4>. 2–5 on mtth; 5–8 on I; 5–9 on II; 3–7 on III. Total: 37–43.7–48 [10].
 <5>. 0 [1], 1–5 [18] on mtth; 3–7 on I; 4–7 on II; 4–6 on III. Total: 29–39.8–41 [9].
 <6>. 0 [5], 1–6 [53] on mtth; 2–10 on I; 2–10 on II; 2–6 on III. Total: 15–40.7–55 [27].
 <7>. 5 [2], 6 [3] on mtth; 6–8 on I; 6 [1], 7 [5] on II; 4–6 on III. Total: 50 [1], 51 [1].
 <8>. 4–6 on mtth; 5–8 on I; 6 [2], 7 [4] on II; 4–6 on III. Total: 47 [2], 48 [1].
 <9>. 2–8 on mtth; 5–13 on I; 7–10 on II; 3–8 on III. Total: 42–56.3–71 [10].
 <10>. 4–9 on mtth; 4–8 on I; 3–6 on II; 2–5 on III. Total: 35–43.8–50 [30].
 <11>. 5–7 on mtth; 7–11 on I; 5–11 on II; 5–8 on III. Total: 53–57.1–61 [12].

Gland spines. Lateral on abd I–III, marginal on IV–VI II, single on V–VIII. Total: on I–IV.

- <Sample 1>. 2–4 on I; 3–6 on II; 4–6 III; 2 [$n=22$] on IV. Total: 26–29.7–34 [11].
 <2>. 1–5 on I; 5–10 on II; 6–12 on III; 2 [21], 3 [2] on IV. Total: 36–42.2–57 [9].
 <3>. 1 [7] on I; 3–5 on II; 3–6 on III; 2 [8] on IV. Total: 22–27 [3].

- <4>. 0 [1], 1–4 [23] on I; 2–6 on II; 4–6 on III; 2 [26]. Total: 24–28.0–33 [10].
- <5>. 1 [12], 2 [8] on I; 2–6 on II; 3–5 on III; 2 [20] on IV. Total: 18–24.1–27 [10].
- <6>. 0 [24], 1 [16], 2 [18] on I; 0 [1], 1–4 [56] on II; 2–6 on III; 0 [1], 1 [11], 2 [47] on IV. Total: 8–18.1–27 [27].
- <7>. 1 [1], 2 [5] on I; 3–5 on II; 5–7 on III; 2 [6] on IV. Total: 27 [1], 30 [1].
- <8>. 2 [6] on I; 3–5 on II; 4 [1], 5 [5] on III; 2 [6] on IV. Total: 23 [1], 27 [2].
- <9>. 0 [3], 1 [15], 2 [2] on I; 2–6 on II; 4–6 on III; 2 [20] on IV. Total: 19–22.7–29 [10].
- <10>. 0 [15], 1 [33], 2 [12] on I; 1–4 on II; 1–4 on III; 1 [1], 2 [59] on IV. Total: 9–15.4–23 [30].
- <11>. 1–5 on I; 5–7 on II; 5–9 on III; 2 [28] on IV. Total: 27–33.0–39 [12].

Recognition characters

Adult female. Median trullae much longer than mesal lobule of second trulla, deeply sunken into apex of pygidium, elongate, divergent, basally with a pair of small sclerites separated from each other by a narrow space and yoked together by a sclerotized band of derm. Second and third trullae with both lobules well represented. Anterior spiracles each with disc pores generally not numerous; posterior spiracles each with a few to several disc pores or none. Perivulvar disc pores moderate in number generally. Dorsal macroducts basically occurring on abd III–VI submedially and on III–V submarginally; few in each submedian and submarginal row on III–V; 1 submedian macroduct on VI, often lacking; very few in total at times. Lateral macroducts occurring on abd I–III and often also on mtth. Gland spines occurring on abd I–VIII and often also on mtth; usually 2 marginal gland spines on IV.

Remarks

This species and *Myrtaspis pinosukensis* (Section 3.7) are well characterized in having elongate median trullae. In *M. longiloba*, the state of the median trullae is considerably stable through all the samples, which were collected in a broad geographical extent and under various environmental conditions. On the other hand, the examined samples are variable in the occurrence and numbers of wax organs, especially of the dorsal macroducts. However, none of them have lateral macroducts on the mesothorax, and this character may be adopted as a diagnostic one in distinguishing this species from *M. pinosukensis*.

Sample 11 differs from the other samples in host association. However, it is closely similar to Sample 1 in the numbers of wax organs, both samples having been collected on the Cameron Highlands.

3.7. *Myrtaspis pinosukensis*, n.sp. (Fig. 22)

Material examined

Collected on the Pinosuk Plateau, alt. ca.1500m, Mt. Kinabalu, Sabah, on *Eugenia cephalantha*, Myrtaceae, 7.X.1988. Fourteen mounted adult females, one the holotype. Females were found on the upper surface, and male tests on the lower surface, of leaves.

Wax-secreting organs in adult females

Spiracular disc pores. Associated with each anterior spiracle: ca.(16–22.2–33) [$n=21$]; with each posterior spiracle: 4–6.7–9 [23].

Perivulvar disc pores. In median group: 8–13; in each anterolateral group: 19–28; in each posterolateral group: 19–24. Total: 76–88.6–104 [$n=12$].

Dorsal macroducts. Submedian macroducts: 1–6 on abd III; 2–5 on IV; 1–4 on V; 0 [$n=14$], 1 [14] on VI. Submarginal macroducts: 2–9 on III; 1–6 on IV; 1–5 on V. Total: 29–45.3–64 [14].

Lateral macroducts. 1–5 on msth; 4–11 on mth; 3–9 on abd I; 5–10 on II; 3–7 on III. Total: 38–53.4–76 [$n=11$].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. 1–8 on abd I; 3–9 on II; 3–9 on III; 2 [$n=5$], 3 [21] on IV. Total on I–IV: 24–34.2–46 [13].

Recognition characters

Adult female. Median trullae longer than mesal lobule of second trulla, elongate, deeply sunken into apex of pygidium and divergent, basally with a pair of small sclerites set close together. Second and third trullae with both lobules well developed. Anterior spiracles with a cluster of rather numerous disc pores; posterior spiracles each with a much smaller cluster. Perivulvar disc pores well represented. Dorsal macroducts few to several in each submedian and submarginal row on abd III–V; 1 or usually 2 submedian macroducts on VI. Lateral macroducts occurring on msth to abd III. Marginal gland spines on abd IV 2 or usually 3.

Remarks

M. pinosukensis is very close to *M. longiloba* (Section 3.6). So far as the examined samples are concerned, it is clearly distinguishable from the latter in having lateral macroducts on the mesothorax. The wax organs are variable in number among the samples of *M. longiloba*. The sample of *M. pinosukensis* and Sample 10 of *M. longiloba* are syntopic, and the former, in comparison with the latter, has distinctly more numerous wax organs except for the lateral macroducts, which also tend to be more numerous in *M. pinosukensis*. This may be due to the effect of character displacement, a phenomenon which occurs when closely related but distinct species come into contact with each other ecologically.

Tang (1986) described *Semichionaspis jambosicola* from southern China, and I (1999) transferred it to *Myrtaspis* (see Section 4). So far as based on his description and figure, it may be closely related to *M. longiloba* and *M. pinosukensis*, and especially to the last in having lateral macroducts on the mesothorax to the third abdominal segment. It has, however, the spiracular disc pores distinctly fewer and the dorsal macroducts tending to be more numerous than in *M. pinosukensis*. The exact relations among *M. jambosicola*, *M. longiloba*, and *M. pinosukensis* are left pending.

3.8. *Myrtaspis rhodamniae*, n.sp. (Fig. 23–25)

Material examined

Collected at 3 localities in Malaya on plants of 2 species belonging to the family Myrtaceae.

Mt. Jerai, alt. ca.930m, Kedah, on *Rhodamnia cinerea*, 5.XI.1991, Sample 1.—Ulu Kali, alt. ca.1700m, Pahang, on *Rhodamnia cinerea*, 15.XI.1986, Sample 2.—Air Terjun Kota Tinggi, Johor, on *Decaspermum fruticosum*, 20.VIII.1992, Sample 3. Holotype, adult female, from Sample 1. Females and males occurring on leaves, lower surface.

Wax-secreting organs in adult females

Spiracular disc pores.

<Sample 1>. Associated with each anterior spiracle: ca.(5–8.7–15) [$n=54$]; with each posterior spiracle: 1–1.8–4 [52].

<2>. 5–8.7–15 [35]; 1–2.1–5 [40].

<3>. 6–8.3–10 [13]; 1 [2], 2 [11].

Perivulvar disc pores.

<Sample 1>. In median group: 9–23; in each anterolateral group: 14–33; in each posterolateral group: 11–23. Total: 73–98.4–123 [$n=30$].

<2>. 14–25; 23–45; 20–39. Total: 114–140.7–174 [20].

<3>. 7–11; 17–26; 12–17. Total: 71–80.5–95 [6].

Dorsal macroducts.

<Sample 1>. Submedian macroducts: 2–11 on abd III; 3–8 on IV; 1–7 on V; 0 [$n=1$], 1 [59] on VI. Submarginal macroducts: 4–13 on III; 2–9 on IV; 1–6 on VI. Total: 33–60.3–93 [30].

<2>. 0 [1], 2–8 [42] on III; 2–7 on IV; 0 [1], 1–5 [42] on V; 0 [8], 1 [36] on VI. 3–12 on III; 3–10 on IV; 2–6 on V. Total: 40–59.5–87 [21].

<3>. 3–6 on III; 1–5 on IV; 2–4 on V; 0 [4], 1 [10] on VI. 4–7 on III; 3–5 on IV; 3 [12], 4 [2] on V. Total: 46–50.6–56 [7].

Lateral macroducts.

<Sample 1>. 0 [$n=1$], 1–5 [58] on msth; 4–11 on mtth; 4–9 on I; 4–9 on abd II; 2–5 on III. Total: 38–51.7–71 [26].

<2>. 1–5 on msth; 5–11 on mtth; 4–10 on I; 6–9 on II; 3–7 on III. Total: 48–60.0–67 [14].

<3>. 1–3 on msth; 3–7 on mtth; 4–7 on I; 4–7 on II; 3 [9], 4 [5] on III. Total: 37–45.7–49 [7].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Sample 1>. 1–4 on I; 2–8 on II; 3–8 on III; 1 [$n=3$], 2 [57] on IV. Total: 18–25.2–37 [28].

<2>. 1–5 on I; 2–8 on II; 3–10 on III; 2–5 on IV. Total: 28–37.1–52 [17].

<3>. 1 [8], 2 [6] on I; 3–5 on II; 5–8 on III; 1 [1], 2 [13] on IV. Total: 25–27.1–30 [7].

Recognition characters

Adult female. Median trullae much larger than second and third trullae, robust, largely sunken into apex of pygidium, divergent from bases, finely serrate marginally; with large basal sclerites, which are in contact or confluent with each other at their anteromesal corners. Second trullae well developed, with lateral lobule smaller than the mesal. Third trullae also well represented, with lateral lobule depressed into an oblique process. Anterior spiracles each with cluster of disc pores small to moderate in size; posterior spiracles with a much smaller cluster. Perivulvar disc pores moderately numerous. Dorsal macroducts well represented on abd III–V submedially and submarginally; 1 submedian macroduct usually present on VI. Lateral macroducts on msth, mtth, and abd I–III, occasionally absent on msth. Lateral gland spines on abd I–III; 1–5 marginal gland spines on IV.

Remarks

In the examined samples, the median trullae are variable in size and shape and their basal sclerites are also variable in development. In Sample 1, the trullae are roughly oblong, having the basal sclerites held in contact with each other at their anteromesal corners (Fig. 25, A). In Sample 2, the trullae are larger and nearly conical, with the basal sclerites also enlarged and confluent with each other through the anteromesal corners

(Fig. 25, C). In these features Sample 3 (Fig. 25, B) appears to be intermediate between Sample 1 and 2. In this way, the median trullae form a roughly graded series through the samples. In all the samples, and especially in Sample 1, these trullae are somewhat variable in size and shape, and it may be expected that further samples, especially from other localities and plants, will make the series more obviously continuous. In all these respects, there seems to be no good reason for interpreting the present samples as representing more than one species.

The localities where the three samples were collected are situated in northern (Sample 1), central (2), and southern (3) Malaya, thus being distant from each other, and at different altitudes, montane and lowland. The host plants belong to two genera of the Myrtaceae. It is not knowable at present which factor or factors among those mentioned above are responsible for the variation of the median trullae.

Some differences are observed among the samples in the numbers of the perivulvar disc pores. Examples in some other scale insects suggest the possibility that these differences reflect the altitudinal differences of the collection localities.

3.9. *Myrtaspis* sp.SRP (Fig. 26)

Material examined

Collected on Mt. Serapi, alt. ca.800m, Sarawak, on *Eugenia* sp., Myrtaceae, 3.X.1991. The dry material was very poor in condition. One individual of the adult female was mounted from the lower surface of a leaf; a pair of the first and second instar female exuvial casts were also mounted from the leaf, but they belong to another species probably of the genus *Pseudaulacaspis*.

Wax-secreting organs in the adult female specimen

Spiracular disc pores. Anterior spiracles each with a cluster of ca.30–35 disc pores; posterior spiracle on left side with 4 disc pores (disc pores on the other side invisible).

Perivulvar disc pores. In median group: 15; in each anterolateral group: 26, 28; in each posterolateral group: 20, 21.

Dorsal macroducts. Submedian macroducts: 1 on abd III–V each; 0 on VI. Submarginal macroducts: 1, 2 on III; 2 on IV and V each.

Lateral macroducts. Msth with 1 small lateral macroduct on right side, none on the left; 1, 1 on mth; 1, 3 on abd I; 2, 3 on II; 3, 4 on III.

Gland spines. Lateral gland spines: 1, 2 on abd II; 4, 5 on III. Marginal gland spines: 3, 3 on abd IV; single on V–VIII.

Recognition characters

Adult female. Median trullae larger than mesal lobule of second trulla, robust, parallel to each other, notched a few times on each side; basally separated from each other by a slit, which intrudes into a large round sclerosis situated anteriorly to the bases of the trullae. Second trullae with mesal lobule well developed, robust, with lateral margin slanting and serrate; lateral lobule much smaller, but well represented. Third trullae with both lobules depressed into broad slanting processes. Antennae with seta much elongated. Anterior spiracles each with a large cluster of disc pores; posterior spiracles with several disc pores. Perivulvar disc pores moderately numerous. Dorsal macroducts on abd III–V submedially and submarginally, few in each row. Lateral macroducts on mth to abd III, few on each segment. Lateral gland spins on abd II and

III; 3 marginal gland spines on IV.

Remarks

In the present study, no specimen of the first instar is available, so that the number of the antennal segments in this instar remains unknown. However, the antennal setae in the examined adult female are ca.36µm long, and this length may support the generic position adopted here (see Section 2). In addition, the host plant belongs to the Myrtaceae. This species is not formally named and referred to *Myrtaspis* rather tentatively.

3.10, *Myrtaspis lumbiniana*, n.comb. (Fig. 4)
=*Chionaspis lumbiniana* Takagi, 1985

Recognition characters

Median trullae robust, produced, and appressed together, basally with a prominent clavate sclerosis. Second and third trullae with mesal lobule roughly serrate on oblique margin; with lateral lobule reduced into a small pointed process. Submedian and submarginal macroducts on abd III–V; lateral macroducts on prth, msth, mtth, and abd I–III, at times absent on prth. Lateral gland spines on abd I–III; marginal gland spines 5–10 on abd IV; 1–4 on V.

Remarks

This species was collected in Lumbini, Terai lowland, Nepal, on *Syzygium cumini* (= *Eugenia cumini*), Myrtaceae. The females were found to be burrowing under the upper epidermal layer of branches. It was originally described as a member of *Chionaspis*. Later, it was excluded from that genus because of the antennae in the first instar which are not six- but five-segmented (Takagi, 1999). No alternative generic position, however, was proposed at that time.

This species has the median trullae very derivative in evolutionary state. However, it is now possible to connect these median trullae with the comparatively primitive median trullae of some other species (Section 3.1 to 3.7) by the intermediation of the variable median trullae of *M. rhodamniae* (3.8) and the fairly derivative median trullae of *M. sp.SRP* (3.9) (in this connection, see Section 1). All these species are associated with myrtaceous plants. In these respects, it seems that they form an indivisible taxonomic group and that *M. lumbiniana* is a good member of *Myrtaspis* (see Section 6). The antennal setae in the adult females of *M. lumbiniana* are somewhat variable in length, but sometimes they attain a length of about 35µm.

3.11. *Myrtaspis homalanthi*, n.sp. (Fig. 27, 28)

Material examined

Collected on the Pinosuk Plateau, alt. ca.1500m, Mt. Kinabalu, Sabah, on *Homalanthus alpinus*, Euphorbiaceae, 5.X.1988. Three adult females, one the holotype, and their exuvial casts were mounted. Each female was found in a small depression on the upper leaf surface, thus inhabiting a shallow pit gall and covering it with a round test.

Wax-secreting organs in adult females

Spiracular disc pores. Associated with each anterior spiracle: 12–ca.26; with each posterior spiracle: 3–7.

Perivulvar disc pores. In median group: 12, 14, 20; in each anterolateral group: 21–36; in each posterolateral group: 23–33. Total: 105, 112, 144.

Dorsal macroducts. Occurring on abd II–VI submedially, on II–V submarginally, occasionally 1 on VI anteriorly to marginal macroducts. Submedian macroducts: 9–14 on II; 8–14 on III; 7–12 on IV; 5 [*n*=5], 6 [1] on V; 3 [3], 4 [3] on VI. Submarginal macroducts: 14–22 on II; 13–18 on III; 5–12 on IV; 5–12 on V; 0 [4], 1 [2] on VI. Total: 166, 178, 203.

Lateral macroducts. 13–23 on abd I; 11–19 on II; 4–6 on III. Total: 65, 75, 85.

Gland spines. Lateral on abd II and III, marginal on IV–VIII, single on VI–VIII. Lateral gland spines: 10–14 on abd II; 11–16 on III. Marginal gland spines: 5–9 on IV; 1 [*n*=1], 2 [4], 3 [1] on V. Total on II–V: 67 [1], 71 [2].

Recognition characters

Adult female. Body broadly obovate at full growth. Median trullae small, as large as mesal lobules of second and third trullae, divergent; their bases widely separated from each other, having no distinct sclerites, confluent with a pair of thick sclerotized folds of ventral derm extending anteriorly. Second and third trullae with both lobules well developed. Anterior spiracles each with a moderately large cluster of disc pores; posterior spiracles each with a much smaller cluster. Perivulvar disc pores numerous. Dorsal macroducts abundant; submedian macroducts on abd II–VI, crowded in clusters, 3 or 4 on VI; submarginal macroducts on II–V, crowded on II and III, arranged in segmental rows on IV and V, occasionally 1 occurring anteriorly to marginal macroducts of VI. Abd III at times without marginal macroduct; IV with 2 marginal macroducts or more often with 1. Several dorsal microducts submedially on abd I. Lateral macroducts on abd I–III, numerous. Lateral gland spines on abd II and III, abundant; marginal gland spines 5–9 on IV, 1–3 on V, single on VI–VIII.

Remarks

This species is easily recognizable in having a broad body with abundant dorsal macroducts. In this respect it is specialized apparently in association with its gall-inhabiting behaviour, the gall being no more than a depression on the leaf surface. On the other hand, it has the lobes of the median trullae and lobules of the lateral trullae little differentiated among them in shape and size. In this character it is primitive or generalized, and is connectable with some species of the core group of *Myrtaspis* (for the core group, see Section 6) in spite of the body shape, which is extraordinary for a species of the genus, and the specialized host association.

3.12. *Myrtaspis cornuta*, n.sp. (Fig. 29)

Material examined

Collected at Sepilok, Sabah, on *Macaranga depressa* f. *glabra*, Euphorbiaceae, 13.XI.1988.

Mounted specimens include 7 adult females, one the holotype, mounted from the upper surface of leaves, Subsample f, and 7 adult females from twigs, Subsample r. Four specimens of the latter subsample poor in condition, mummified or having a pupa of a parasitic hymenopteron within. Male tests on both surfaces of leaves and also on petioles.

Wax-secreting organs in adult females

Spiracular disc pores.

<Subsample f>. Associated with each anterior spiracle: 6–13.3–16 [n=12]; with each posterior spiracle: 2–5.7–8 [14].

<r>. 9–12.3–20 [9]; 4–5.8–10 [11].

Perivulvar disc pores.

<Subsample f>. In median group: 8–17; in each anterolateral group: 10–36; in each posterolateral group: 14–24. Total: 75–87.7–109 [n=7].

<r>. 8–20; 12–23; 13–18. Total: 70–87.0–91 [7].

Dorsal macroducts.

<Subsample f>. Submedian macroducts: 2–6 on abd II; 3 [n=2], 4 [11] on III; 2–4 on IV; 2–4 on V; 1 [13] on VI. Submarginal macroducts: 1–5 on II; 1–6 on III; 3–5 on IV; 2 [2], 3 [11] on V. Total: 46–58.0–67 [6].

<r>. 3 [3], 4 [11] on II; 3–5 on III; 1–4 on IV; 2 [8], 3 [6] on V; 1 [14] on VI. 3 [7], 4 [7] on II; 3–6 on III; 2–6 on IV; 2 [2], 3 [12] on V. Total: 47–59.0–66 [7].

Lateral macroducts.

<Subsample f>. 3–6 on mth; 5–8 on abd I; 5–7 on II; 3 [n=6], 4 [6] on III. Total: 37–43.8–51 [6].

<r>. 1–7; 7–10; 5–8; 3 [6], 4 [8]. Total: 44–45.0–51 [6].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Subsample f>. 0 [n=3], 2 [7], 3 [1], 4 [1] on I; 4–7 on II; 4–6 on III; 3 [12] on IV. Total: 25–29.5–35 [6].

<r>. 1–4; 3–7; 3–7; 3 [12], 4 [2]. Total: 32–34.5–40 [4].

Recognition characters

Adult female. Median trullae much longer than mesal lobule of second trulla, deeply sunken into apex of pygidium, slender, divergent, a little curved laterally, with mesal margin roughly serrate; separated from each other by a space subbasally; with a pair of basal sclerites, which are set close together, united by a slender sclerotized band of derm. Second and third trullae with both lobules well represented. Antennae each with 2–4, usually 3, sclerotized spinous processes, and with seta extraordinarily elongated. Anterior spiracles each with a loose cluster of disc pores; posterior spiracles each with a much smaller cluster. Perivulvar disc pores moderately numerous. Dorsal macroducts on abd II–VI submedially and on II–V submarginally; submedian macroducts divided into anterior and posterior series on II–IV, each of these series and also row on V with a few macroducts, 1 macroduct on VI; a few to several submarginal macroducts in each segmental row. Lateral macroducts on mth to abd III. Lateral gland spines on abd I–III; marginal gland spines 2–4, usually 3, on IV.

Remarks

This species is characteristic in the antennae, which are provided with prominent spinous processes. It is also somewhat peculiar among the known species of the genus in having the slender and roughly serrate median trullae. The antennal setae attain 60µm in length and, in combination with the five-segmented antennae in the first instar, support the view that the species belongs to *Myrtaspis*.

I have failed to find any noteworthy differences in morphological characters between the foliicolous and ramicolous subsamples. Even in the numbers of wax organs these subsamples nearly or closely agree with each other in spite of their small sizes.

3.13. *Myrtaspis elaeocarpi*, n.sp. (Fig. 30)

Material examined

Collected on Mt. Kinabalu, Sabah, on *Elaeocarpus corneri*, Elaeocarpaceae, 29.IX.1988, alt. ca.2800m, Sample 1; alt. ca. 2600m, Sample 2. Holotype, adult female, from Sample 2. Occurring on leaves, females on the upper, and males on the lower, surface.

Wax-secreting organs in adult females

Spiracular disc pores.

<Sample 1>. Associated with each anterior spiracle: 2–4.7–9 [$n=58$]; with each posterior spiracle: 0 [50], 1 [3], 2 [4].

<2>. 1–4.8–7 [64]; 0 [64].

Perivulvar disc pores.

<Sample 1>. In median group: 9–17; in each anterolateral group: 14–35; in each posterolateral group: 15–30. Total: 78–112.0–141 [$n=30$].

<2>. 8–18; 23–36; 20–30. Total: 102–124.5–143 [32].

Dorsal macroducts. Occurring on abd III–VI submedially (rarely absent on VI) and on III–V submarginally. Submedian dorsal microducts strewn on II and often also on I.

<Sample 1>. Submedian macroducts: 4–10 on III; 4–9 on IV; 1–6 on V; 0 [$n=2$], 1 [8], 2 [46], 3 [4] on VI. Submarginal macroducts: 5–12 on III; 4–8 on IV; 3–7 on V. Total: 55–82.8–98 [30].

<2>. 4–11 on III; 4–9 on IV; 3–6 on V; 1 [13], 2 [49], 3 [2] on VI. 7–12 on III; 4–10 on IV; 4–7 on V. Total: 61–83.4–99 [32].

Lateral macroducts.

<Sample 1>. 0 [$n=53$], 1 [7] on mtth; 2–8 on abd I; 3–13 on II; 3–8 on III. Total: 23–41.7–57 [29].

<2>. 0 [63], 2 [1] on mtth; 1–7 on I; 6–14 on II; 4–10 on III. Total: 27–40.9–52 [32].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Sample 1>. 1–4 on I; 4–10 on II; 4–11 on III; 3–5 on IV. Total: 29–40.4–51 [$n=29$].

<2>. 1–4 on I; 4–11 on II; 6–10 on III; 2–6 on IV. Total: 31–40.9–51 [31].

Recognition characters

Adult female. Body elliptical, with pygidium broadly rounded marginally. Median trullae deeply sunken into apex of pygidium, gently divergent; basally with a pair of sclerites, which are set close together and appear to be connected by dermal sclerotization; each lobe of the trullae elongate, with subapical margins converging toward apex, which is angulate rather narrowly, and with free margins minutely serrate. Second and third trullae with both lobules well developed. Anterior spiracles each with a small cluster of disc pores: posterior spiracles usually without disc pores, rarely with a few. Perivulvar disc pores numerous in total. Dorsal macroducts numerous in total, mostly arranged in single segmental rows; submedian macroducts on abd III–VI, 1–3, usually 2, on VI; submarginal macroducts on III–V. Lateral macroducts on abd I–III, at times also on mtth. Lateral gland spines on abd I–III; 2–6 marginal gland spines on IV.

Remarks

This species is peculiar in having the median trullae angulated apically. It is not connectable with any other species of the genus.

3.14. *Myrtaspis perseae*, n.sp. (Fig. 31–33)

Material examined

Collected in Malaya on plants of the families Lauraceae (Sample 1–3) and Rutaceae (Sample 4).

Mt. Jasar, alt. 1300–1400m, Cameron Highlands, Pahang, on *Persea* sp., 17.X.1986, Sample 1.—Bukit Larut, alt. ca.1250m, Perak, on *Phoebe grandis*, 8.X.1986, Sample 2.—Bukit Fraser, alt. ca.1200m, Pahang, on *Cinnamomum* sp., 30.X.1986, Sample 3.—Ulu Kali, alt. ca.1700m, Pahang, on *Euodia roxburghiana*, 15.VI.1990, Sample 4.

In Sample 1, females were collected from the upper surface of leaves (Subsample 1f) and from twigs (1r); in Sample 2–4, from leaves, usually upper surface. Males, when present, on leaves, upper surface. Holotype, female, from Subsample 1f.

Wax-secreting organs in adult females

Spiracular disc pores.

<Subsample 1f>. Associated with each anterior spiracle: 2–5.4–9 [n=62]; with each posterior spiracle: 0 [5], 1 [47], 2 [10].

<1r>. 5–6.2–8 [20]; 1 [16], 2 [3], 3 [1].

<Sample 2>. 3 [3], 4 [5]; 0 [1], 1 [7].

<3>. 3–4.8–7 [24]; 1 [17], 2 [7].

<4>. 3–6.2–8 [34]; 1 [14], 2 [24].

Perivulvar disc pores.

<Subsample 1f>. In median group: 4–11; in each anterolateral group: 10–22; in each posterolateral group: 9–16. Total: 60–72.6–86 [n=31].

<1r>. 9–14; 8–24; 14–16. Total: 74–81.7–90 [10].

<Sample 2>. 8 [4]; 12–20; 12–15. Total: 61 [1], 65 [1], 74 [1].

<3>. 8–13; 15–22; 9–17. Total: 67–75.8–85 [12].

<4>. 6–14; 16–25; 14–18. Total: 73–85.4–96 [19].

Dorsal macroducts.

<Subsample 1f>. Submedian macroducts: 0 [n=22], 1 [35], 2 [1] on abd III; 0 [1], 1 [33], 2 [28] on IV; 0 [2], 1 [47], 2 [13] on V; 0 [62] on VI. Submarginal macroducts: 0 [1], 1 [9], 2 [46], 3 [6] on III; 1 [2], 2 [50], 3 [6], 4 [4] on IV; 1 [14], 2 [46], 3 [2] on V. Total: 13–18.4–26 [29].

<1r>. 0 [3], 1 [15], 2 [2] on III; 1 [13], 2 [7] on IV; 1 [17], 2 [3] on V; 0 [20] on VI. 1 [2], 2 [16], 3 [2] on III; 2 [15], 3 [5] on IV; 1 [5], 2 [15] on V. Total: 12–18.9–23 [10].

<Sample 2>. 0 [8] on III; 0 [2], 1 [6] on IV; 1 [8] on V; 0 [8] on VI. 1 [7], 2 [1] on III; 1 [8] on IV; 1 [8] on V. Total: 8 [1], 10 [2], 11 [1].

<3>. 0 [14], 1 [10] on III; 1 [17], 2 [7] on IV; 1 [20], 2 [4] on V; 0 [24] on VI. 0 [2], 1 [8], 2 [13], 3 [1] on III; 1 [2], 2 [19], 3 [3] on IV; 1 [14], 2 [10] on V. Total: 8–15.8–22 [12].

<4>. 0 [18], 1 [16], 2 [4] on III; 1 [6], 2 [30], 3 [2] on IV; 0 [1], 1 [6], 2 [31] on V; 0 [38] on VI. 1–4 on III; 2–5 on IV; 1–3 on V. Total: 18–23.8–30 [19]. In some specimens of this sample, dorsal microducts occurring submedially on abd III and IV and submarginally on III and even also on II and I.

Lateral macroducts. Occurring on mth and abd I–III, exceptionally also on msth and IV.

Subsample 1f>. 0 [n=61], 2 [1] on msth; 1–4 on mth; 3–11 on I; 2–8 on II; 2–4 on III. Total: 26–39.2–46 [31].

<1r>. 0 [20] on msth; 1 [6], 2 [9], 3 [4], 4 [1] on mth; 5–12 on I; 4–7 on II; 2 [1], 3 [17], 4 [2] on III. Total: 30–39.7–44 [10].

<Sample 2>. 0 [8] on msth; 2 [4], 3 [4] on mtth; 5–12 on I; 5–7 on II; 3 [7], 4 [1] on III. Total: 37 [2], 38 [1], 46 [1].

<3>. 0 [24] on msth; 0 [1], 1 [8], 2 [11], 3 [3] on mtth; 5–9 on I; 4–6 on II; 3 [23], 4 [1] on III. Total: 27–34.6–40 [11].

<4>. 0 [38] on msth; 1–8 on mtth; 7–15 on I; 5–9 on II; 2–9 on III; 0 [37], 1 [1] on IV. Total: 38–47.0–57 [19].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Subsample 1f>. 1–4 on I; 1–6 on II; 2–5 on III; 1 [*n*=1], 2 [61] on IV. Total: 14–22.4–33 [31].

<1r>. 1 [1], 2 [12], 3 [6], 4 [1] on I; 2–5 on II; 2–6 on III; 2 [19], 3 [1] on IV. Total: 19–23.2–29 [10].

<Sample 2>. 1 [7], 2 [1] on I; 1 [2], 2 [3], 3 [3] on II; 2 [1], 3 [7] on III; 2 [8] on IV. Total: 15 [2], 17 [1], 18 [1].

<3>. 1 [8], 2 [6], 3 [8], 4 [1] on I; 1–6 on II; 2–5 on III; 1 [1], 2 [23] on IV. Total: 12–22.2–30 [11].

<4>. 1–5 on I; 3–8 on II; 3–9 on III; 1 [2], 2 [34], 3 [1] on IV. Total: 23–28.8–43 [18].

Recognition characters

Median trullae shorter than marginal macroducts of abd VII, thickened, set close together subbasally; basally sunken into apex of pygidium and united together by a distinct sclerosis. Second and third trullae represented by both lobules. Anterior spiracles each with a small cluster of disc pores; posterior spiracles each with a few disc pores, occasionally with none. Perivulvar disc pores moderately numerous. Submedian macroducts usually present on abd III–V and few on each segment, at times absent on III and occasionally also on IV and V, none on VI; submarginal macroducts few on III–V, occasionally absent on III. Lateral macroducts on mtth and abd I–III, rarely also on msth and IV. Lateral gland spines on abd I–III; 1–3, usually 2, marginal gland spines on IV.

Remarks

This species is somewhat variable in the shape and size of the median and lateral trullae, which form a continuous series of variations through the examined individuals (for further comments on the variation, see Section 7).

3.15. *Myrtaspis aquilariae*, n.sp. (Fig. 34–36)

Material examined

Collected in Malaya on plants of the families Thymelaeaceae (Sample 1, 2), Rutaceae (Sample 3), and Oxalidaceae (Sample 4).

Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, on *Aquilaria malaccensis*, 30.VII.1990, Sample 1.—Bukit Nanas, Kuala Lumpur, on *Aquilaria malaccensis*, 23.VIII.1990, Sample 2.—Bukit Nanas, Kuala Lumpur, on *Euodia glabra*, 3.VIII.1990, Sample 3.—Desaru, Johor, on *Sarcotheca laxa*, 19.VIII.1990, Sample 4.

In Sample 1 and 2, females were mounted from the upper surface of leaves (Subsample 1f, 2f), and from twigs (1r, 2r); in Sample 3, from leaves, mostly from the upper surface; in Sample 4, from the lower surface of leaves. Male tests were found mostly on the upper surface of leaves in Sample 1 and 3. Holotype, adult female, from Subsample 1f.

Wax-secreting organs in adult females

Spiracular disc pores.

<Subsample 1f>. Associated with each anterior spiracle: 1–3.7–6 [$n=78$]; with each posterior spiracle: 0 [5], 1 [68], 2 [9].

<1r>. 2–4.3–8 [96]; 0 [5], 1 [48], 2 [37], 3 [2].

<2f>. 2–3.7–5 [26]; 0 [2], 1 [19], 2 [5].

<2r>. 2–3.8–6 [37]; 0 [2], 1 [35], 2 [12].

<Sample 3>. 2–3.6–5 [64]; 0 [3], 1 [47], 2 [15].

<4>. 4 [1], 5 [5]; 1 [6], 2 [1].

Perivulvar disc pores.

<Subsample 1f>. In median group: 6–12; in each anterolateral group: 8–23; in each posterolateral group: 5–15. Total: 48–61.4–83 [$n=44$].

<1r>. 5–13; 11–22; 6–19. Total: 53–65.9–78 [47].

<2f>. 5–13; 7–17; 8–14. Total: 49–58.2–69 [13].

<2r>. 6–10; 10–18; 8–14. Total: 48–59.7–73 [23].

<Sample 3>. 7–13; 11–26; 8–16. Total: 49–61.5–76 [34].

<4>. 6 [1], 8 [3]; 12–15; 9–16. Total: 49, 57, 58, 68.

Dorsal macroducts.

<Subsample 1f>. Submedian macroducts: 0 [$n=80$], 1 [3], 2 [1] on abd III; 0 [20], 1 [49], 2 [14] on IV; 0 [3], 1 [53], 2 [28] on V; 0 [84] on VI. Submarginal macroducts: 0 [2], 1 [39], 2 [41], 3 [2] on III; 0 [2], 1 [19], 2 [61], 3 [2] on IV; 0 [1], 1 [24], 2 [59] on V. Total: 5–14.4–24 [41].

<1r>. 0 [97], 1 [3], 2 [1] on III; 0 [36], 1 [59], 2 [6] on IV; 0 [2], 1 [81], 2 [18] on V; 0 [106] on VI. 0 [2], 1 [63], 2 [32], 3 [4] on III; 0 [2], 1 [37], 2 [60], 3 [2] on IV; 0 [2], 1 [67], 2 [32] on V. Total: 7–12.4–21 [50].

<2f>. 0 [25], 1 [1] on III; 0 [16], 1 [10] on IV; 0 [3], 1 [17], 2 [6] on V; 0 [26] on VI. 0 [2], 1 [20], 2 [3] on III; 1 [12], 2 [14] on IV; 1 [16], 2 [10] on V. Total: 6–11.2–18 [12].

<2r>. 0 [50] on III; 0 [27], 1 [23] on IV; 0 [1], 1 [49] on V; 0 [50] on VI. 0 [1], 1 [48], 2 [1] on III; 0 [1], 1 [33], 2 [16] on IV; 0 [1], 1 [41], 2 [8] on V. Total: 7–9.8–13 [25].

<Sample 3>. 0 [69], 1 [1] on III; 0 [19], 1 [49], 2 [2] on IV; 0 [3], 1 [65], 2 [2] on V; 0 [70] on VI. 0 [1], 1 [52], 2 [17] on III; 0 [1], 1 [21], 2 [48] on IV; 1 [44], 2 [26] on V. Total: 8–12.1–19 [35].

<4>. 0 [8] on III; 0 [8] on IV; 0 [1], 1 [7] on V; 0 [8] on VI. 0 [1], 1 [7] on III; 1 [4], 2 [4] on IV; 1 [7], 2 [1] on V. Total: 8 [2], 9 [1], 10 [1].

Lateral macroducts.

<Subsample 1f>. 0 [$n=3$], 1 [67], 2 [10], 3 [1] on mtth; 4–10 on I; 4–8 on II; 2–5 on III. Total: 23–31.4–38 [36].

<1r>. 0 [4], 1 [60], 2 [24], 3 [7] on mtth; 3–10 on I; 4–9 on II; 2–7 on III. Total: 26–34.4–46 [45].

<2f>. 1 [23], 2 [1] on mtth; 4–8 on I; 4–7 on II; 2 [2], 3 [22] on III. Total: 25–29.3–37 [10].

<2r>. 0 [2], 1 [40], 2 [7] on mtth; 4–8 on I; 4–6 on II; 2 [2], 3 [43], 4 [3] on III. Total: 23–30.0–35 [22].

<Sample 3>. 0 [6], 1 [60], 2 [3] on mtth; 4–8 on I; 3–6 on II; 1 [1], 2 [9], 3 [57], 4 [2] on III. Total: 24–28.5–33 [33].

<4>. 1 [8] on mtth; 4 [1], 5 [7] on I; 3–5 on II; 2–4 on III. Total: 25 [1], 26 [3].

Gland spines. Lateral on abd I–III, marginal on IV–VIII, single on V–VIII. Total: on I–IV.

<Subsample 1f>. 1–4 on I; 1–5 on II; 0 [$n=1$], 2–6 [75] on III; 1 [2], 2 [73]. Total: 12–19.6–28 [31].

<1r>. 0 [2], 1 [54], 2 [34], 3 [8], 4 [1] on I; 1–5 on II; 3–5 on III; 1 [1], 2 [96], 3 [1] on IV.

Total: 15–18.9–25 [46].

<2f>. 0 [2], 1 [14], 2 [7], 3 [1] on I; 1–4 on II; 1–4 on III; 2 [25] on IV. Total: 10–16.5–22 [10].

<2r>. 0 [6], 1 [40], 2 [1] on I; 1–3 on II; 0 [1], 1–4 [46] on III; 2 [50] on IV. Total: 11–14.4–18 [20].

<Sample 3>. 0 [6], 1 [48], 2 [13] on I; 1 [12], 2 [37], 3 [20] on II; 2 [24], 3 [40] on III; 1 [2], 2 [67] on IV. Total: 11–15.5–20 [31].

<4>. 0 [1], 1 [7] on I; 1 [3], 2 [5] on II; 2 [6], 3 [1] on III; 1 [1], 2 [7] on IV. Total: 11 [1], 13 [1], 14 [1].

Recognition characters

Adult female. Median trullae large, as long as or longer than marginal macroducts of abd VII, basally sunken into apex of pygidium for their most or large part and united by a sclerosis. Second and third trullae represented by both lobules. Anterior spiracles each with a small cluster of disc pores; posterior spiracles each with a few disc pores, occasionally with none. Perivulvar disc pores moderately numerous. Dorsal macroducts very few; submedian macroducts absent on abd III usually, on IV frequently, on V at times, and on VI always; submarginal macroducts occurring on III–V usually. Lateral macroducts on mth and abd I–III, at times absent on mth. Lateral gland spines on abd I–III, occasionally absent on I and II; 1–3, usually 2, marginal gland spines on IV.

Remarks

In this species the trullae, especially the median pair, are remarkably variable in shape, forming a broad continuous series of variations through the examined individuals (for further comments on the variation, see Section 7).

4. SPECIES REFERABLE TO *MYRTASPIS*

The three species mentioned below are known to me only through literature. According to the descriptions and figures, their adult females are provided with well-elongated antennal setae. Two of them (4.1; 4.2) have five-segmented antennae in the first instar nymphs, and in 1999 I transferred them into *Myrtaspis*.

4.1. *Myrtaspis jambosicola*

=*Semichionaspis jambosicola* Tang, 1986

This species was described from Guangdong Province, southern China, as occurring on *Syzygium jambos* (= *Eugenia jambos*), Myrtaceae. It seems to be particularly closely related to *Myrtaspis longiloba* and *M. pinosukensis* (see *Remarks* under Section 3.7).

4.2. *Myrtaspis putianensis*

=*Semichionaspis putianensis* Tang, 1986

This species was described from Fujian Province, southern China; the host plant was not identified. It is characteristic in having the median trullae widely separated from each other basally.

4.3. *Myrtaspis ramakrishnai*, n.comb.

=*Chionaspis ramakrishnai* Rao, 1953

This species was described from Coonoor, the Nilgiri Hills, South India, and from

Eugenia calophyllifolia, Myrtaceae. So far as based on the description, it is very close to *Myrtaspis lumbiniana*, and I have little doubt that it belongs to *Myrtaspis* (in this connection, see Section 3.10).

The altitude of the collection spot was not mentioned in the original description. I (1985, p. 20) gave an altitude of ca.1800m to the locality on the basis of my surveys around the towns of Coonoor (in this connection, see Correction given at the end of this paper).

5. SPECIES POSSIBLY REFERABLE TO MYRTASPIS

Williams and Watson (1988) described three species from New Guinea and three others from Fiji as members of *Chionaspis* 'for the time being' (for comments on these species, see Takagi, 2019, p. 33). The figures given by the authors for these species show that the antennal setae in the adult females of the following two species from New Guinea are much longer than those in the other species. Provided all these figures of the antennae are drawn at the same magnification, they should reflect the real differences in length. Now that the more or less outstanding elongation of antennal setae in the adult female is adopted in the present study as an auxiliary generic character of *Myrtaspis* (see Section 2), the possibility may not be excluded that the two species from New Guinea are members of *Myrtaspis*.

5.1. *Chionaspis broughae* Williams and Watson, 1988

Trobriand Is., Papua New Guinea, on stem of an undetermined dicotyledon.

5.2. *Chionaspis comys* Williams and Watson, 1988

Sentani, near Jayapura, Irian Jaya, on leaves of an undetermined tree.

6. REACHING POINT

Eighteen species in total, including three in literature, are recognized as members of *Myrtaspis*. Fourteen species occur in Malaya, Singapore, Sarawak, and Sabah, and one of them also in the Indian Subcontinent; the other four species are known from the Indian Subcontinent and southern China. The possibility is also suggested that two species described from New Guinea belong to the genus. If these two species are really members of *Myrtaspis*, the distribution of the genus should expand over the phytogeographical region Malesia, which covers the Ice Age landmass Sundaland and the biogeographical divisions Wallacea and Papuasias.

In the Malay Peninsula and northern Borneo, the scale insects of this genus inhabit a broad spectrum of environments including seaside vegetations and montane forests, the highest altitude in the collection records being 2800m on Mt. Kinabalu.

Twelve species of the genus, two thirds of the known species, are associated with plants of the family Myrtaceae mainly or exclusively. It seems that they form a good group, which contains primitive, derivative, and intervening forms concerning the state of the trullae. This group may have been the core of the genus and have given rise to other species on plants of other families.

The *Myrtaspis* species occurring in Malaysia are well contrasted with the sympatric species of *Chionaspis* in habitat and host association. These *Chionaspis* species are

restricted to montane oak forests, with a remarkable concentration of their host plants on the family Fagaceae, and they are reasonably assumed to have originated from the northern fauna inhabiting temperate environments (Takagi, 2019). If the supposition that *Myrtaspis* occurs over Malesia is not erroneous, this genus should disagree with *Chionaspis* significantly in biogeography and, therefore, in evolutionary history.

After all, *Myrtaspis* should be a good unit biologically. Morphologically, the adult females are generally closely similar to those of *Chionaspis* species probably owing to the frequent occurrence of homoplasy.

7. FROM ABNORMALITY TO POLYPHENISM

Among the species treated in the present study, the four given below are noteworthy in having the trullae, especially the median pair, in the adult females varying in their own manners, presenting four peculiar cases of variation. It is possible to interpret these cases to represent some stages in the emergence of polyphenism in the trullae in association with different feeding sites on the plant body.

Case 1: Myrtaspis calcarifera (Section 3.4)

Nine samples were collected in Malaya, Singapore, Sarawak, and Sabah, and all the examined adult females were mounted from the leaves. Sample 1–4 were collected on the eastern coast of the Malay Peninsula, at spots all located within a distance of 120km, and from seaside vegetations. The trullae are variable remarkably in Sample 1 and 2 and less remarkably in Sample 3, and not variable in Sample 4, whereas these samples differ in their host plants, which belong to four genera of the family Myrtaceae. Sample 5–7 were obtained on low hills in Singapore and Sarawak from myrtaceous plants, and Sample 8 and 9 in lowland forests in Sabah from *Ixora*, family Rubiaceae.

In Sample 4, 11 mounted adult females have been examined. The median and lateral trullae are stable in size and shape through them (Fig. 11, B; Fig. 15, D), and should exhibit their ‘normal’ characters in the species. In Sample 1, 18 adult females have been examined, and 15 of them have the trullae which, though somewhat variable in shape, may belong to the ‘normal’ type (Fig. 10, B; Fig. 14, A, C, E). In two other individuals the median trullae are widely separated basally from each other (Fig. 14, D). In the remaining one (Fig. 14, B), the median trullae are apparently enlarged, somewhat asymmetrical in shape between them, and widely separated from each other basally; the space between the bases of the trullae is striate longitudinally, without a sclerotized band of derm connecting the bases; the lobules of the second and third trullae, especially of the third, are narrowed toward the apex, which is not rounded but pointed apically.

In Sample 2, 10 adult females have been available. Four of them have ‘normal’ trullae (Fig. 14, F), while the other six are similar to the last-mentioned individual (Fig. 14, B) of Sample 1, having enlarged median trullae. These trullae are irregular in shape, even tending to be monstrous, and set close together basally (Fig. 14, G–J). In Sample 3, 10 individuals have been examined. The trullae are ‘normal’ in only one (Fig. 15, A) of them; in the other nine specimens the median trullae are apparently enlarged, but rather uniform in shape (Fig. 15, B, C). In Sample 5–9, the trullae are ‘normal’ or a little variable in shape (Fig. 12, B; Fig. 13, B; Fig. 15, E–G).

Case 2: Myrtaspis kedahana (Section 3.5)

The sample of this species was collected on the western coast of the Malay Peninsula and from *Eugenia grandis*, Myrtaceae, growing in a seaside vegetation. Fourteen adult females were mounted from the leaves. They are variable in the state of the trullae extraordinarily. In the median trullae they are divisible into four types, which are connectable in a roughly graded series (Fig. 17). At one end of the series, represented by one individual, the median trullae are separated from each other by a good space, having no basal sclerites, and the lobules of the second and third trullae are well developed and rounded apically (Fig. 17, A). One of the intermediate forms, represented by eight adult females, is similar in the state of the median trullae to some other species occurring on myrtaceous plants, and may represent the 'normal' form of the species (Fig. 17, B). In this form, the median trullae are set close together and provided with distinct basal sclerites; the second and third trullae are similar to those in the preceding type. Three other individuals have the median trullae set closer and the second and third trullae depressed into low processes (Fig. 17, C). At the opposite end of the series, represented by the remaining two adult females, the median trullae are appressed together and yoked together basally through well-developed basal sclerites and a sclerotized band of derm across the narrow interspace; the lobules of the second and third trullae are depressed into low processes as in the preceding form (Fig. 17, D).

Case 3: Myrtaspis perseae (Section 3.14)

Four samples were collected in the Malay Peninsula at altitudes of 1200–1700m on plants of the families Lauraceae, Sample 1–3, and Rutaceae, Sample 4. Adult females were mounted from the leaves and twigs in Sample 1, and from the leaves in Sample 2–4. The trullae are variable in similar pattern through all these samples and, in Sample 1, irrespective of the feeding sites on the plant, forming a continuous series of variations in each sample or feeding site subsample. At one end of the series, the median trullae are divergent and the second and third trullae have the lobules well developed and rounded apically (Fig. 31, E; Fig. 32, A, B, D; Fig. 33, A, C). At the opposite end, the median trullae are robust, parallel to each other, and more or less produced at the apex of the pygidium; the lateral trullae, especially the third, have the lobules reduced into pointed processes (Fig. 32, C, E, F; Fig. 33, D, E).

Case 4: Myrtaspis aquilariae (Section 3.15)

Samples were collected on lowlands of the Malay Peninsula from plants of the families Thymelaeaceae, Sample 1 and 2, Rutaceae, Sample 3, and Oxalidaceae, Sample 4. Adult females were mounted from the leaves and twigs in Sample 1 and 2 and from the leaves in Sample 3 and 4. These samples as a whole are greatly variable in the shape of the median trullae and in the development of the second and third trullae, forming a continuous series of variations (Fig. 34, E; Fig. 35, 36). At one end, End I, of the series, the median trullae are deeply sunken into the apex of the pygidium, elongate, and divergent, and the second and third trullae have both lobules well developed. At the opposite end, End II, the median trullae are largely produced at the apex of the pygidium, robust, and parallel to each other, and the second and third trullae are much reduced in size and represented by pointed or low processes.

In the foliicolous subsample of Sample 1, with 45 mounted adult females, and that of Sample 2, with 14 individuals, all or most individuals are referable or similar to the

type End I. However, in Sample 3, only two out of the 35 examined adult females, which are all foliicolous, represent that type definitely, the other 33 individuals belonging to the type End II or being transitional between End I and II. (Sample 1 and 2 were collected at different localities but on plants of the same species; Sample 2 and 3 were collected at the same locality but on plants of different families.) Sample 4 has only 4 mounted adult females, which are foliicolous and referable to the type End I.

The ramicolous subsample of Sample 1 is represented by 53 mounted adult females. Of them, 23 have the median trullae deeply sunken into the apex of the pygidium and are referable to the type End I, whereas the other 30 belong to the type End II or are transitional between these types. The ramicolous subsample of Sample 2 has 25 individuals, of which only three belong to the type End I and the other 22 belong to the type End II or are transitional

Myrtaspis calcarifera, representing Case 1, and *M. kedahana*, Case 2, belong to the core group of the genus, and are relatively primitive species in the group (Section 6). They are similar in the mesobasal structure of the median trullae, so far as their 'normal' types of the trullae are concerned. In the variations of these trullae, they also have in common another type of the trullae, which are separated from each other mesobasally by a good space and have no basal sclerites (Fig. 14, D; Fig. 17, A). The median trullae of this type are also found and stable in *Myrtaspis breviloba* (Fig. 6, B), which is, in this respect, the most primitive species in the genus. In this understanding, the occurrence of the median trullae of this type in *M. calcarifera* and *M. kedahana* should be atavistic. In opposition to this atavistic variation, the enlarged median trullae in *M. calcarifera* are irregular in shape and even tend to be monstrous in appearance, and this fact suggests abnormality rather than any ordinary variation. In *M. kedahana*, the median trullae positioned opposite to the atavistic variation are closely appressed together, and provided with well-developed basal sclerites (Fig. 17, D). In contrast with the monstrous median trullae of *M. calcarifera*, they are neatly shaped, suggesting that they have been well adjusted adaptively. When the abnormal median trullae in *M. calcarifera* continues to appear for generations, they may be expected to be refined to take a stable adaptive form ultimately.

Myrtaspis perseae, representing Case 3, and *M. aquilariae*, Case 4, are derivative species of the genus, and are associated with non-myrtaceous plants. In Sample 1 of *M. perseae* and Sample 1 and 2 of *M. aquilariae*, the females occur not only on the leaves but also on the twigs. In either species, the adult females have the trullae variable in shape and size, forming a continuous series of variations. In *M. perseae* no obvious difference is recognized between the leaf- and twig-feeding individuals in the occurrence of the variations. In *M. aquilariae*, the trullae are greatly variable and, in Sample 1 and 2, show some tendency toward differentiation between the leaf- and twig-feeding individuals in the occurrence of the variations.

It seems that Case 1–4, when connected in the mentioned order to make a series, suggest how the polyphenism of the trullae arises in association with feeding sites on the host plant. It should begin with polymorphism consisting of trullae formed through the responses of genetic-developmental processes in scale insects to uneven or unsettled physiological conditions in host leaves. The trullae thus formed should include crude, irregular, or even monstrous ones, which, when appearing for generations continuously, are to be refined adaptively in accord with the minute structures on the leaf surface (in

this connection, see Section 1). The improvement of the trullae on the leaf surface may enhance the expansion of feeding onto another or other parts of the plant body, followed by further adaptive refinements of the trullae on the new sites and, ultimately, by the emergence of polyphenism in the trullae in association with different feeding sites.

It should be added here that, in various diaspidids, polyphenism associated with different feeding sites may also occur in the numbers of some wax-secreting organs, though the cases in which the variations have been analysed statistically on the basis of sufficiently large feeding site subsamples are still limited. There has been available no clue for knowing whether this phenomenon has any adaptive significance or it is simply resulted from physiological responses in those scale insects to different body parts of the host plant. Variations in the numbers of wax organs have also been observed among supposedly conspecific samples occurring under some different abiotic conditions, for example at different altitudes in the same area. If there should be a causative factor common to all these variations, whether the conditions they are immediately associated with are biotic or abiotic, the only possible one may be photosynthesis with its product in the host plants.

Supplementary notes. Sondhi (1961) proposed a model to explain the origin of 'neomorphs' in terms of a 'prepattern', which should be unvarying, and a 'precursor', which, being some substance, must be present in the required amount if a neomorph could arise during morphogenesis. According to my interpretation, 'neomorphs' should stand not only for new features but also for new characters, a 'prepattern' may be understood as a set of potential pathways of genetic and developmental processes organized into modules, and these pathways, when resulting in phenotypes, are also to be adjusted adaptively. The amount of a 'precursor' may be subject to external and internal factors. In this connection, the possible occurrence of physiological diversity within the same plant individuals should not be ignored. According to Cherfas (1985), a large tree carrying something between 10,000 and 100,000 meristems should be a 'genetic mosaic', because mutations are expected to occur in those tissues at rates around one in 10,000 ordinarily and thus, for example, within a single tree 'one branch may be genetically distinct from the next'. A tree, therefore, should be a physiological mosaic, and it grows under the influence of a local environment and a fluctuating microenvironment.

ADDITIONAL NOTES

Narayanaspis eugeniae was first found in the Terai lowland, Nepal, on *Eugenia* sp., Myrtaceae. In the adult female, it has the lobes of the median trullae and the lobules of the second and third trullae undifferentiated among them, each of them being well developed and provided with a pair of slender scleroses basally. In the first instar, it has six-segmented antennae. It was supposed to represent or approximate an ancestral form of *Chionaspis* (Takagi, 1985).

N. eugeniae occurs also in Malaya on *Eugenia* spp., and it is probably distributed broadly in tropical and subtropical Asia (Takagi, 1999). So far as the adult females are concerned, it is possible to suppose that *Narayanaspis* is ancestral not only to *Chionaspis* but also to *Myrtaspis*. This supposition requires that the six-segmented antennae in the first instar should have changed to the five-segmented ones at the emergence of *Myrtaspis*. However, the morphogenesis and evolutionary changes of the antennae in the first instar are still undeveloped subjects in diaspidid taxonomy, no helpful knowledge

having been built up. It is still uncertain whether the difference in the number of the antennal segments in the first instar is always or generally of generic value or may arise even among species which should be congeneric in all other respects.

In *N. eugeniae*, the antennal setae in the adult female are apparently elongated, being often over 30µm and occasionally over 40µm long, and this observation may support the view that *Narayanaspis* has a close relation with *Myrtaspis*. No explanation, however, is available at present for the biological significance of the elongated antennal setae.

It should be added that some other setae have been adopted for recognizing genera. Many *Pseudaulacaspis* species having the adult females fusiform at full growth were treated for a long time as members of *Phenacaspis*, an artifact produced at first from a misconception about the foliicolous form of a *Chionaspis* species. They were transferred to *Pseudaulacaspis* by the adoption of well-developed marginal setae occurring between the mesal bases of the median trullae as a diagnostic feature of the genus. In fact, studies on nymphs of the second instar male have shown that the genus *Pseudaulacaspis* thus recomposed belongs not to the Chionaspidina but to the Fioriniina. In this case, too, nothing is known about the significance of these well-developed marginal setae in the life of the scale insects provided with them.

REFERENCES

- Cherfas, J., 1985. When is a tree more than a tree? New Scientist 20 June 1985: 42–45.
- Rao, V. P., 1953. Some new diaspidine scale insects from India. Proceedings of the Royal Entomological Society of London (B) 22: 61–69.
- Sondhi, K. C., 1961. The evolution of a pattern. Evolution 16: 186–191.
- Takagi, S., 1985. The scale insect genus *Chionaspis*: A revised concept (Homoptera: Coccoidea: Diaspididae). Insecta Matsumurana New Series 33.
- Takagi, S., 1999. For a better understanding of *Aulacaspis*: The *calcarata* species group (Homoptera: Coccoidea: Diaspididae). Insecta Matsumurana New Series 55: 133–180.
- Takagi, S., 2003. Some burrowing diaspidids from eastern Asia (Homoptera: Coccoidea). Insecta Matsumurana New Series 60: 67–173.
- Takagi, S., 2019. *Chionaspis* in the tropics (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana New Series 75: 29–79.
- Tang, F.-t., 1986. The Scale Insects of Horticulture and Forest in China. III. Shanxi Agricultural University.
- Williams, D. J. and Watson, G. W., 1988. The Scale Insects of the Tropical South Pacific Region, Part I, The Armoured Scales (Diaspididae). C·A·B International Institute of Entomology.

CORRECTION

Takagi, S., 2019. *Chionaspis* in the tropics (Sternorrhyncha: Coccoidea: Diaspididae). *Ins. Matsum. n. s.* 75: 29–79, p. 33, line 6 from bottom.

Correct the phrase ‘at an altitude of about 1000m on the Nilgiris’ to ‘at an altitude of about 1800m on the Nilgiris’.

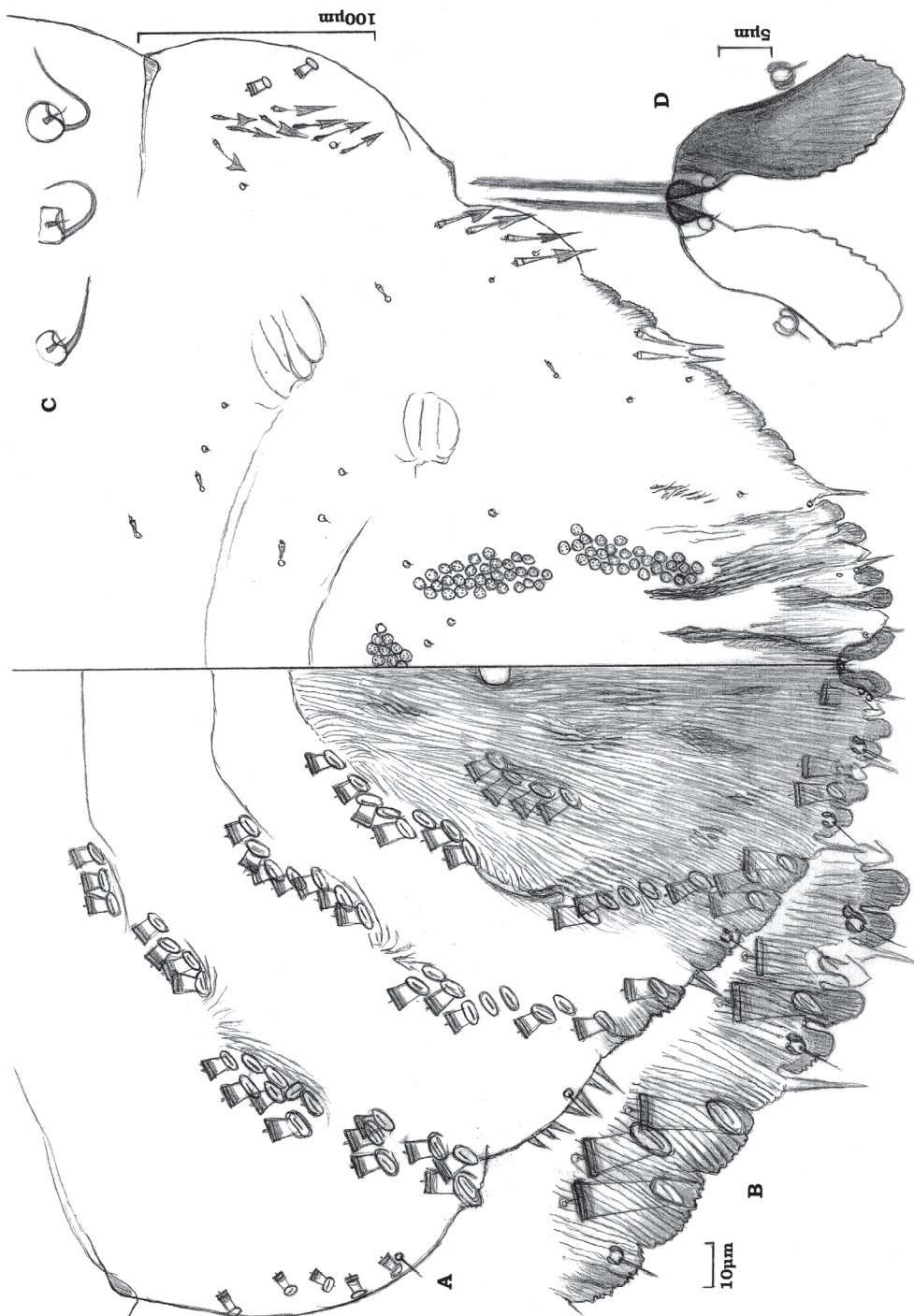


Fig. 1. *Chionaspis trochodendri* (= *Phenacaspis trochodendri*), adult female. Ali-Shan, Taiwan, on *Trochodendron aralioides*, leaf. A: pygidium; B: pygidial margin, dorsal surface, second and third trullae, pore prominences on abd V; C: antennae; D: median trullae, ventral surface. Scale bars: 100µm for A; 10µm for B, C; 5µm for D.

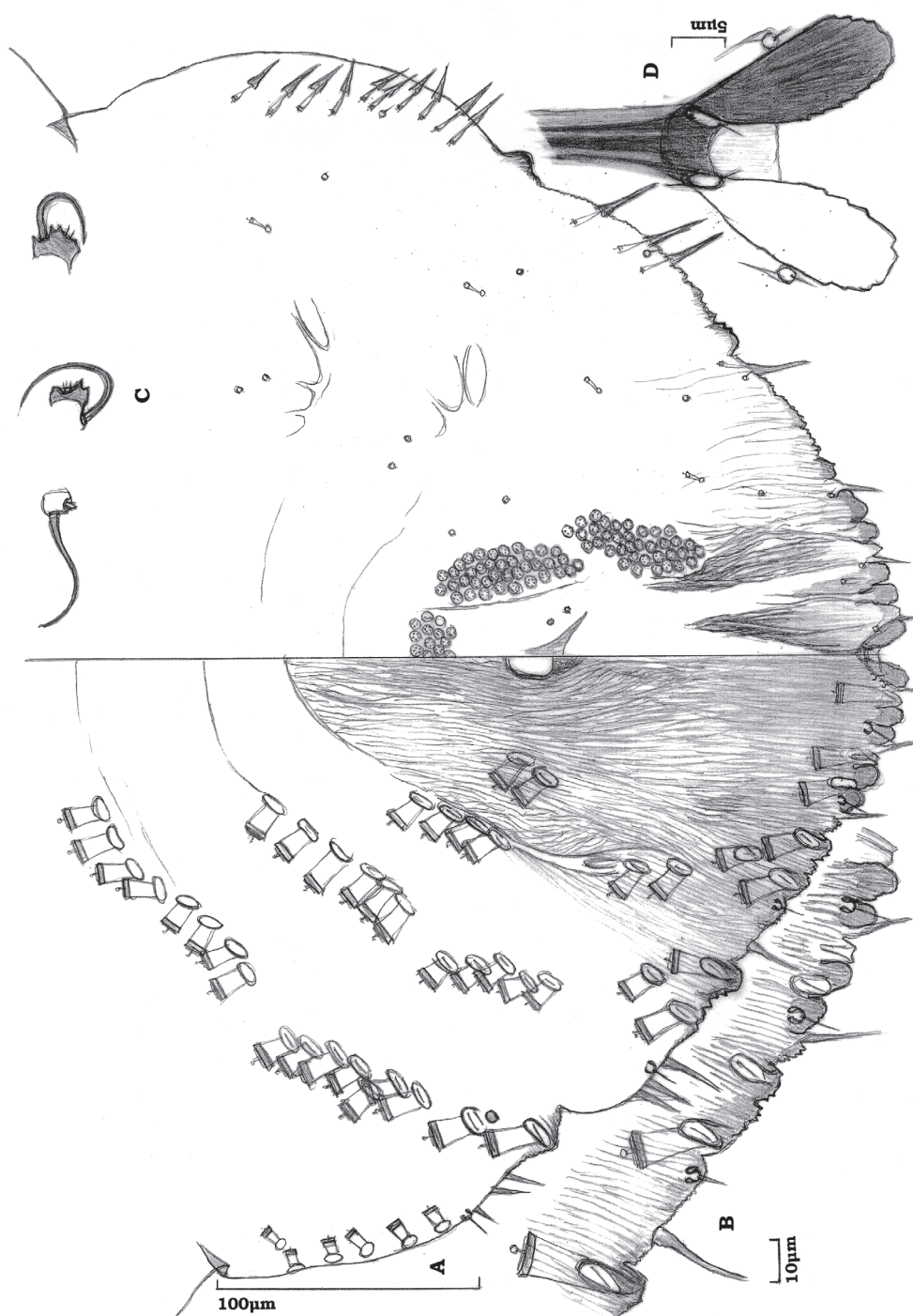


Fig. 2. *Chionaspis syzygii*, now *Myrtaspis syzygii*, adult female. Kanepokhari, Kosi, Nepal, on *Cleistocalyx operculatus*, leaf. A: pygidium; B: pygidial margin, dorsal surface, second and third trullae, pore prominences on abd V; C: antennae; D: median trullae, ventral surface. Scale bars: 100µm for A; 10 µm for B, C; 5µm for D.

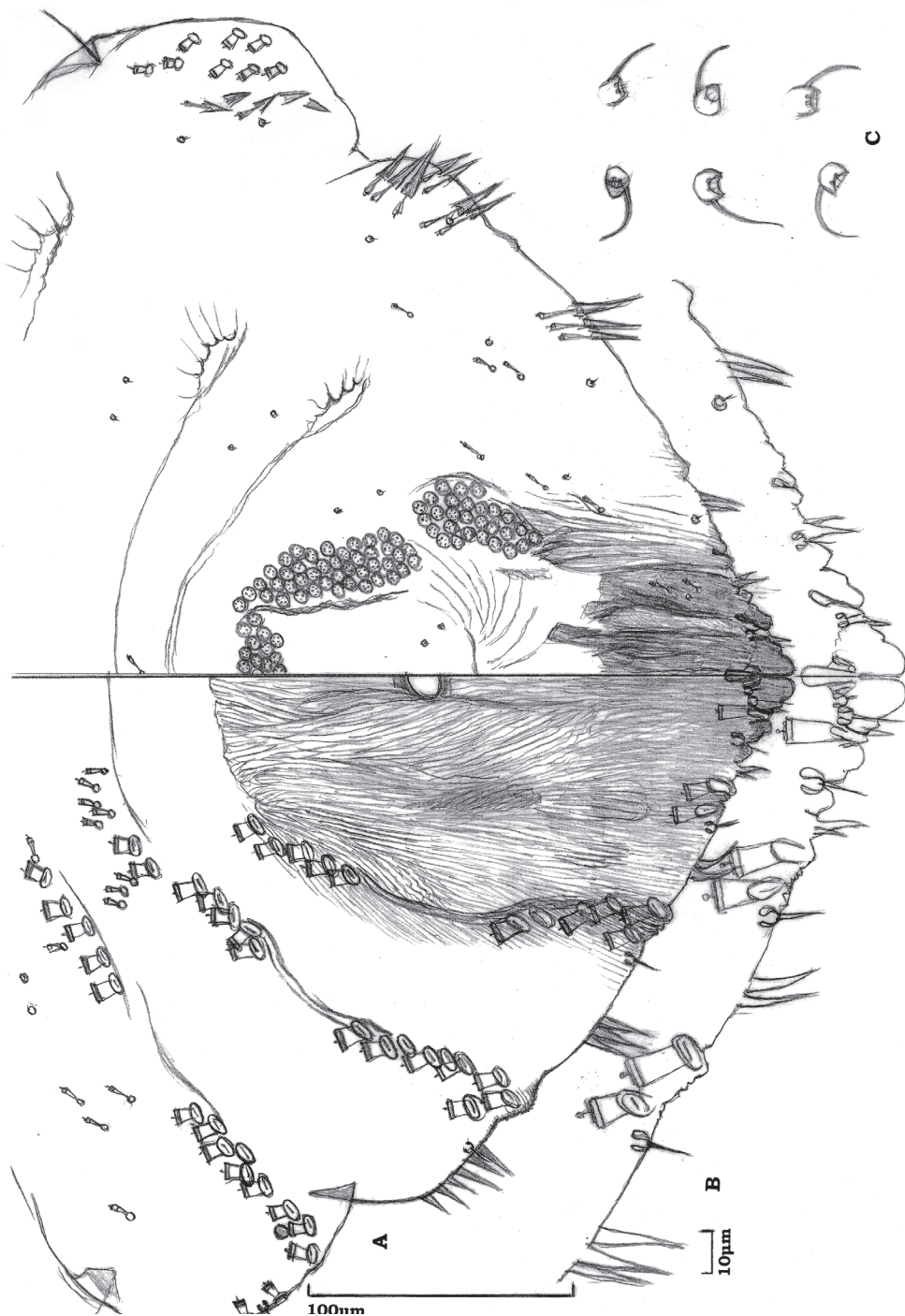


Fig. 3. *Chionaspis americana*, adult female. Cuyahoga County, Ohio, U.S.A., on *Ulmus americana*, branch. A: pygidium; B: pygidial margin; C: antennae, three pairs, each on opposite sides of body. Scale bars: 100µm for A; 10µm for B, C.

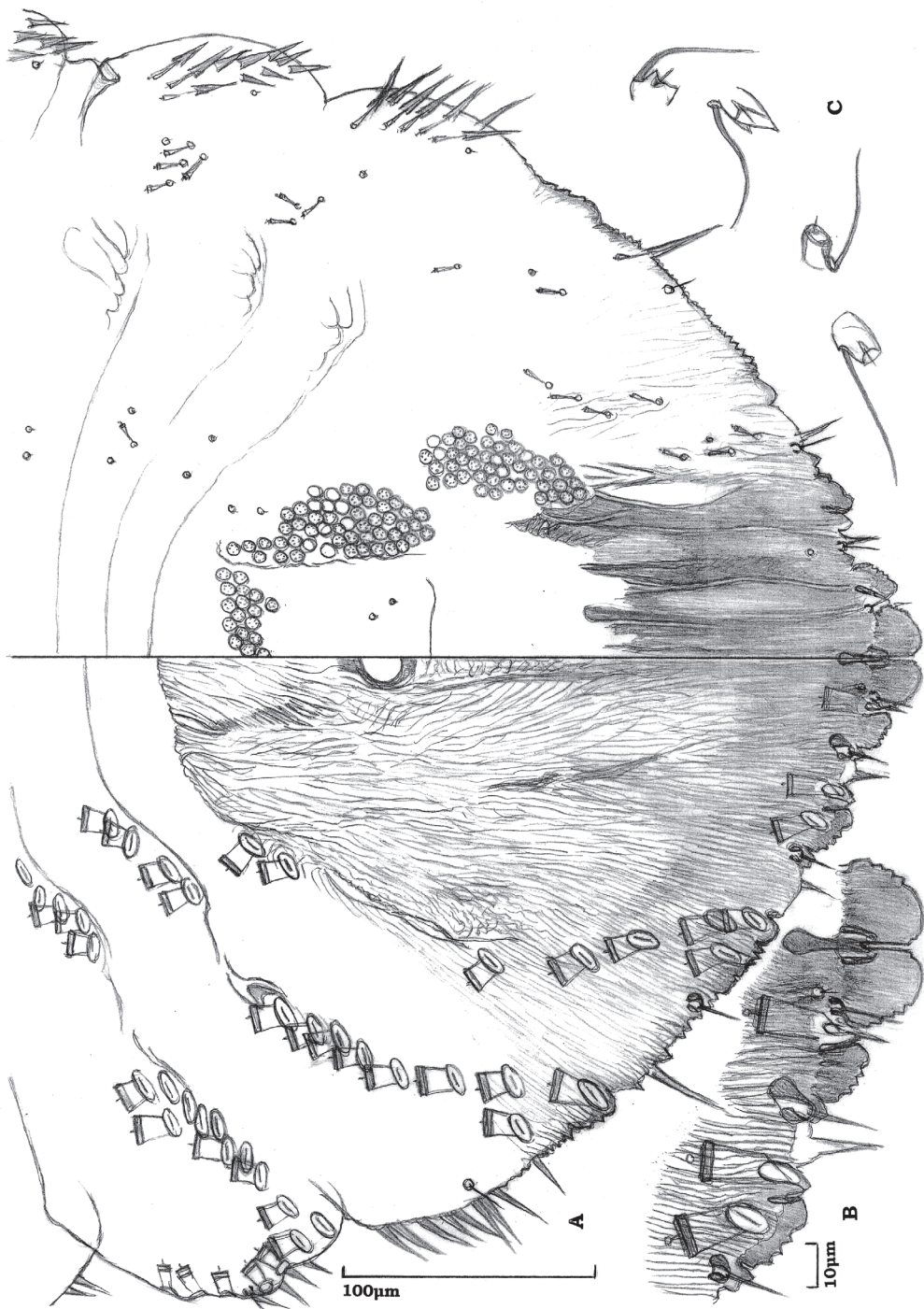


Fig. 4. *Chionaspis lumbiniana*, now *Myrtaspis lumbiniana*, adult female. Lumbini, Nepal on *Eugenia cumini*, branch. A: pygidium; B: trullae, dorsal surface; C: antennae, 2 pairs, each on opposite sides of body. Scale bars: 100µm for A; 10µm for B, C.

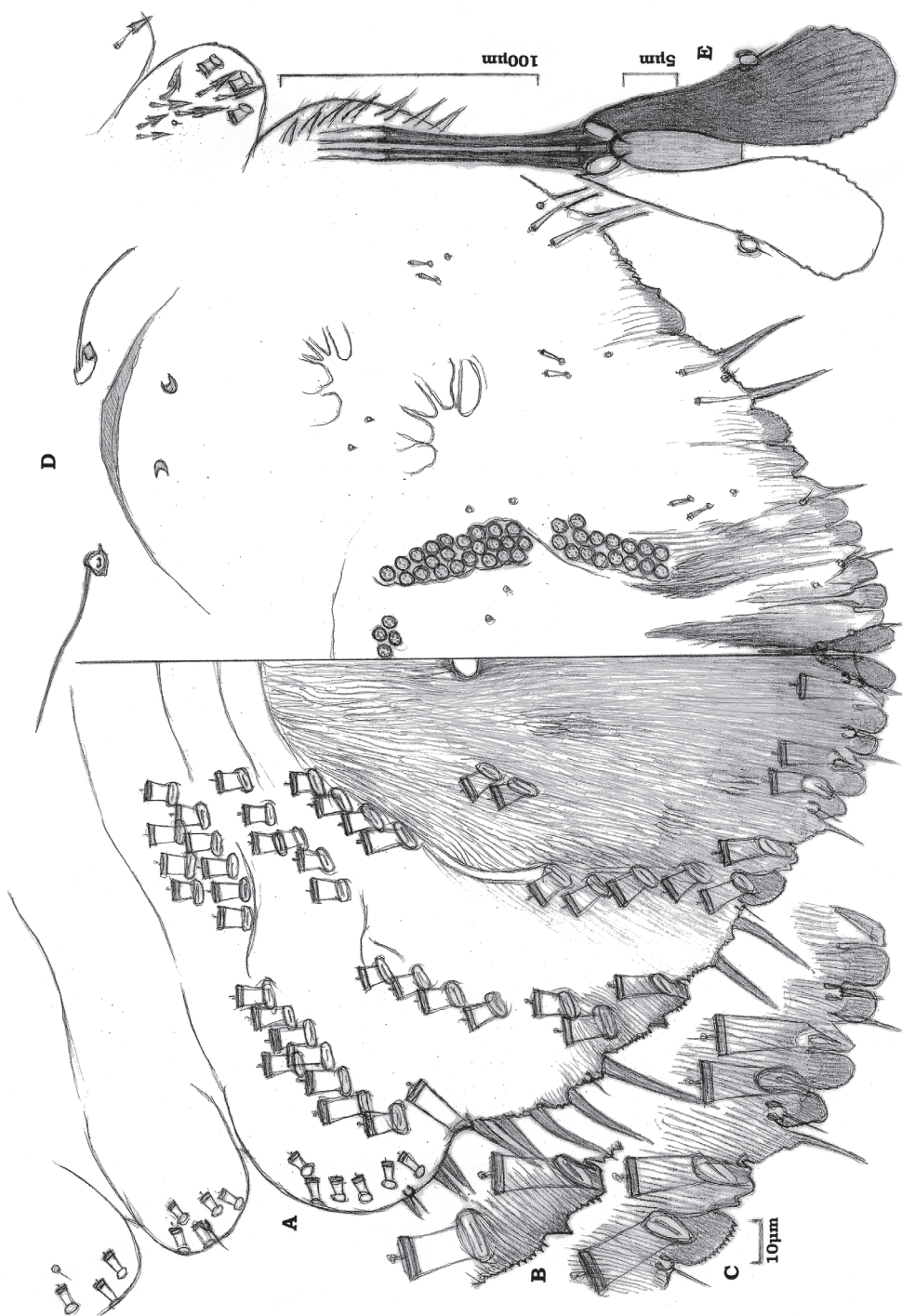


Fig. 5. *Myrtaspis marginalis* adult female. Rantau Abang, Terengganu, Malaya, on *Eugenia grandis*, leaf. A: pygidium; B: pygidial margin, dorsal surface, spur on abd IV; C: pygidial margin, dorsal surface, second and third trullae, pore prominences on abd V; D: antennae, frontal prominence, and derm pockets in a set; E: median trullae, ventral surface. Scale bars: 100µm for A; 10µm for B–D; 5µm for E.

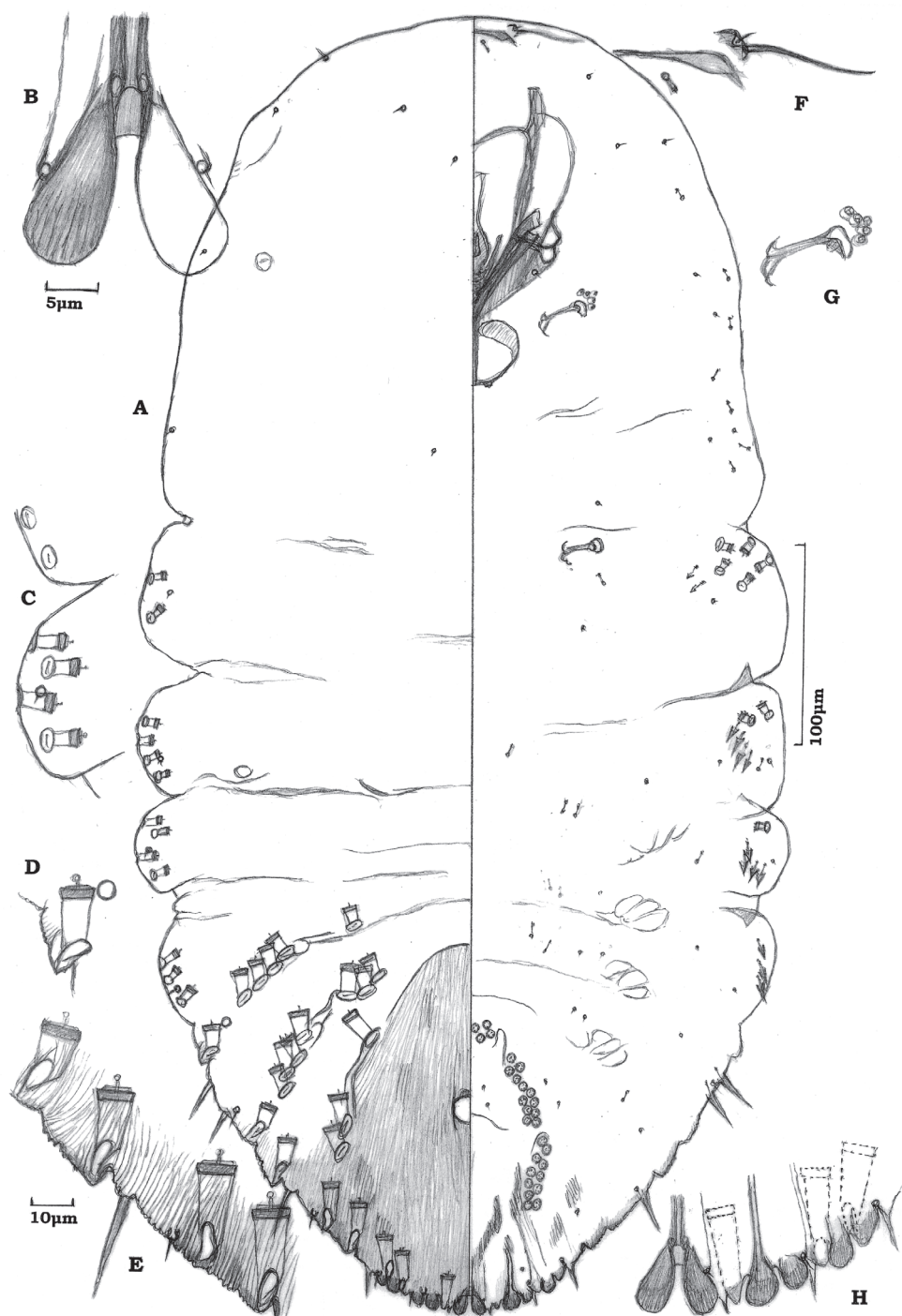


Fig. 6. *Myrtaspis breviloba*, adult female. Cape Rachado, Port Dickson, Negeri Sembilan, Malaya, on *Eugenia glauca*, twig. B: median trullae, ventral surface; C: lateral macroducts on abd II; D: marginal macroduct and dorsal boss on abd III; E: pygidial margin, dorsal surface, abd IV and V; F: antenna and frontal prominence; G: anterior spiracle; H: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C-H; 5µm for B.



Fig. 7. *Myrtaspis syzygii*, adult female. Tanjong Gelang, Kuantan, Malaya, on *Eugenia cumingiana*, leaf, Sample 1. B: median trullae, ventral surface; C: lateral macroducts on abd II; D: marginal macroduct on abd III; E: pygidial margin, dorsal surface, abd IV and V; F: antennae on opposite sides of body; G: anterior spiracle; H: lateral macroducts on mesothorax; I: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–I; 5µm for B.

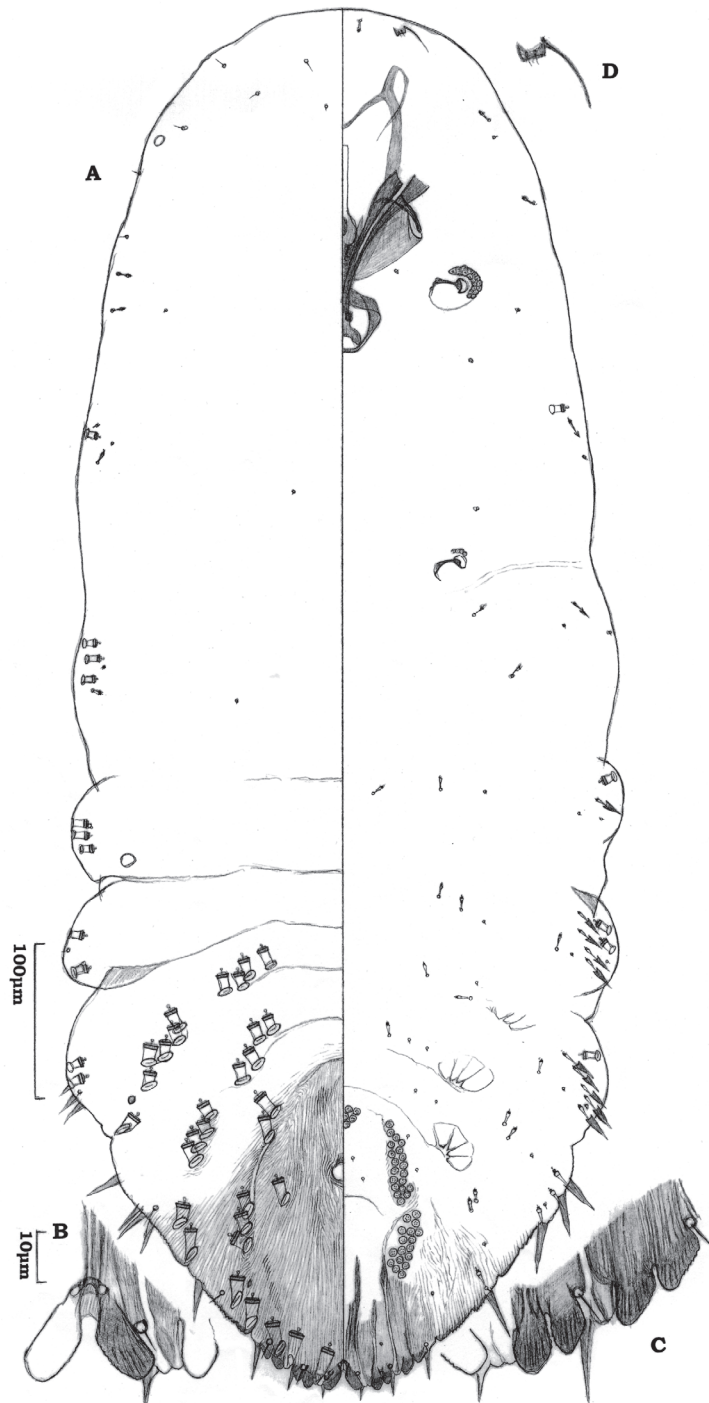


Fig. 8. *Myrtaspis syzygii*, adult female. Mt. Kinabalu, ca. 1500m, Sabah, on *Tristania obovata*, leaf, Sample 2. B and C: pygidial margin, ventral surface, trullae; D: antenna. Scale bars: 100µm for A; 10µm for B–D.

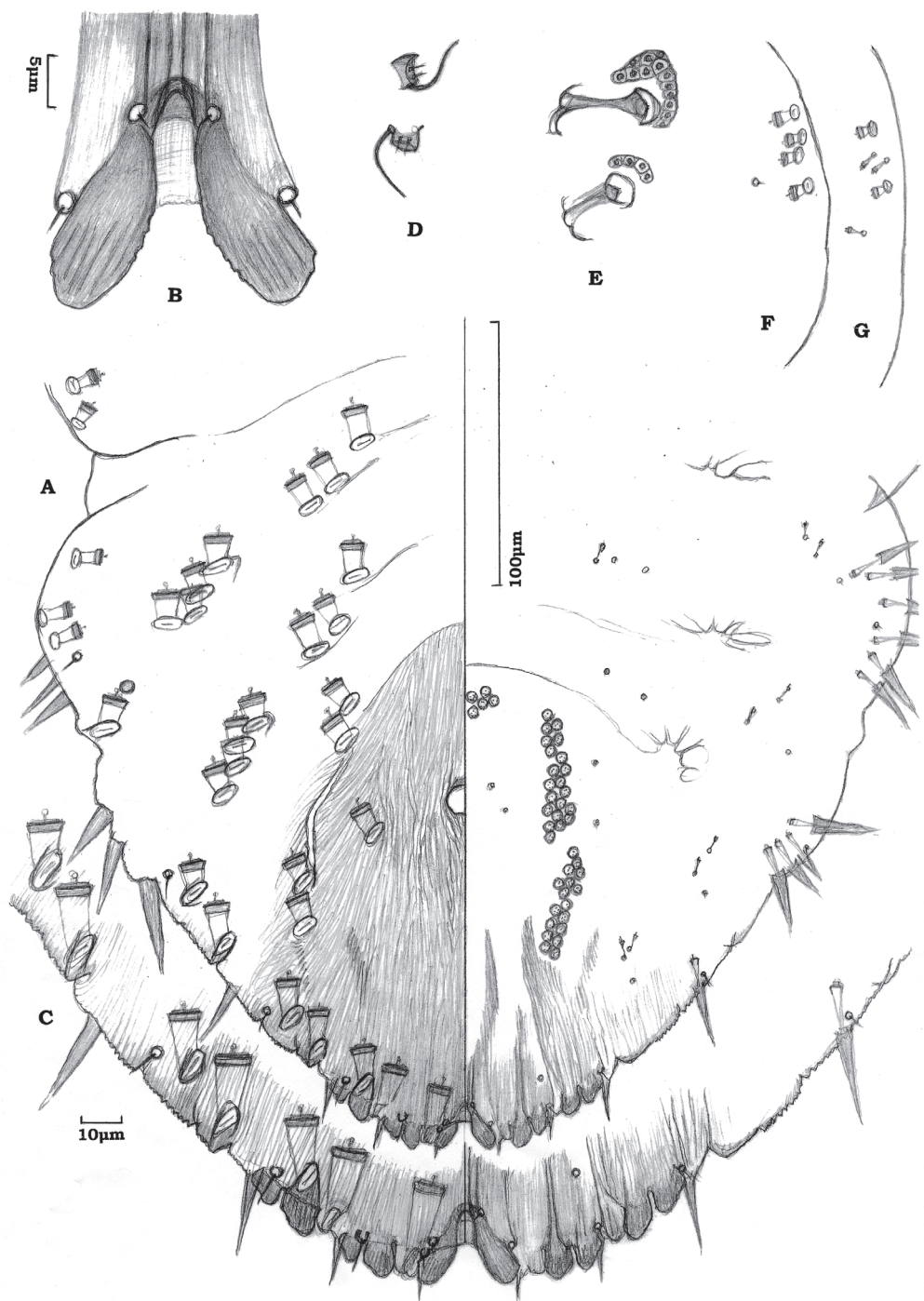


Fig. 9. *Myrtaspis syzygii*, adult female. Mt. Kinabalu, ca. 1500m, Sabah, on *Tristania obovata*, leaf, Sample 2. A: pygidium; B: median trullae, ventral surface; C: pygidial margin; D: antennae on opposite sides of body; E: anterior and posterior spiracles; F and G: lateral macroducts on meta- and mesothorax. Scale bars: 100µm for A; 10µm for C–G; 5µm for B.



Fig. 10. *Myrtaspis calcarifera*, adult female. Rantau Abang, Terengganu, Malaya, on *Melaleuca cajuputi*, leaf, Sample 1. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antenna; E: anterior spiracle; F: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–F; 5µm for B.

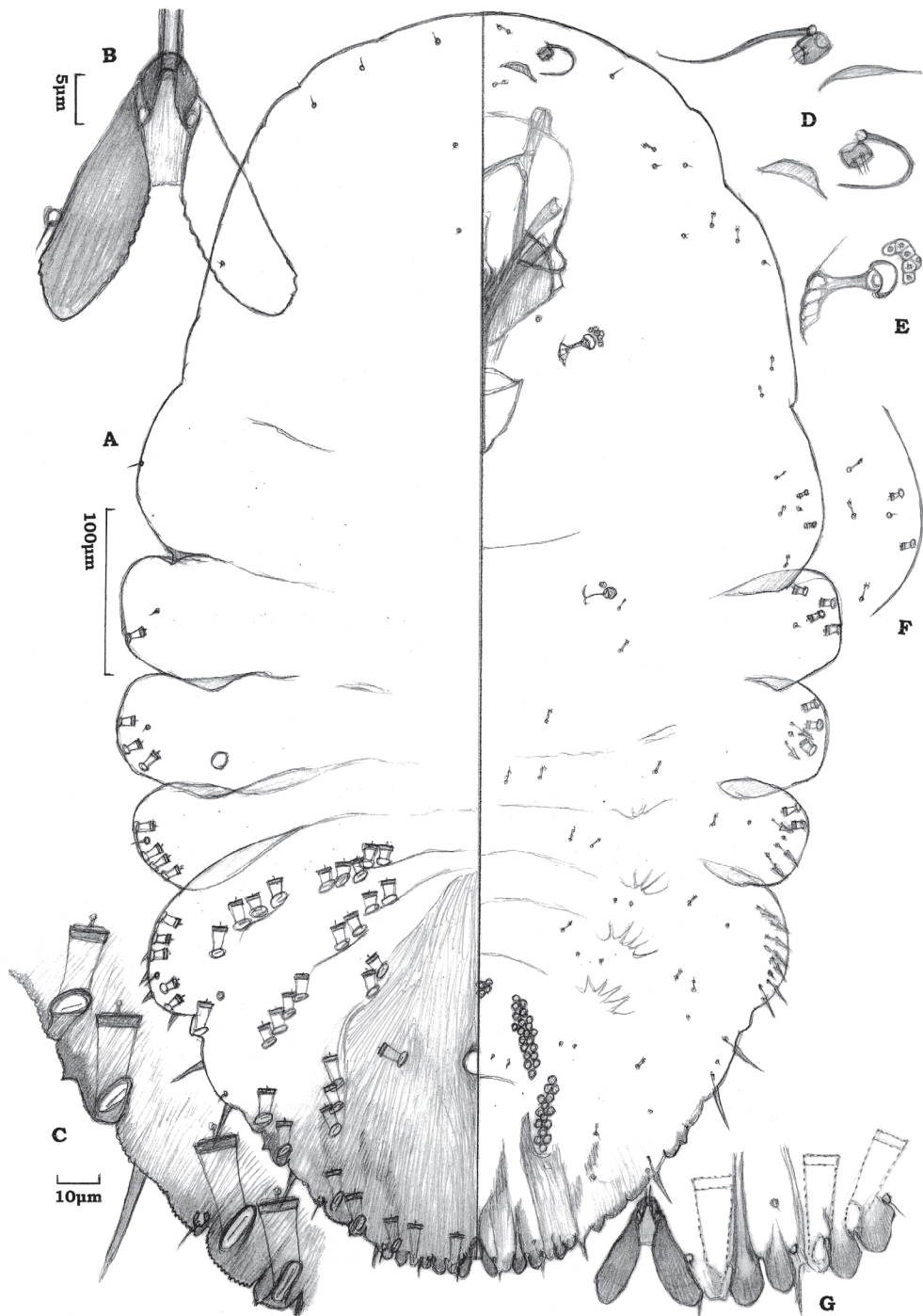


Fig. 11. *Myrtaspis calcarifera*, adult female. Telok Cempedak, Kuantan, Pahang, Malaya, on *Eugenia* sp., leaf, Sample 4. B: Median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antennae and frontal prominence (divided into a pair of swellings) on opposite sides of body; E: anterior spiracle; F: lateral macroducts on mesothorax; G: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–G; 5µm for B.



Fig. 12. *Myrtaspis calcarifera*, adult female. Bukit Timah, Singapore, on *Eugenia longiflora*, leaf, Sample 5. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: pygidial margin, abd IV, with spur doubled; E: antenna; F: anterior and posterior spiracles; G: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–G; 5µm for B.

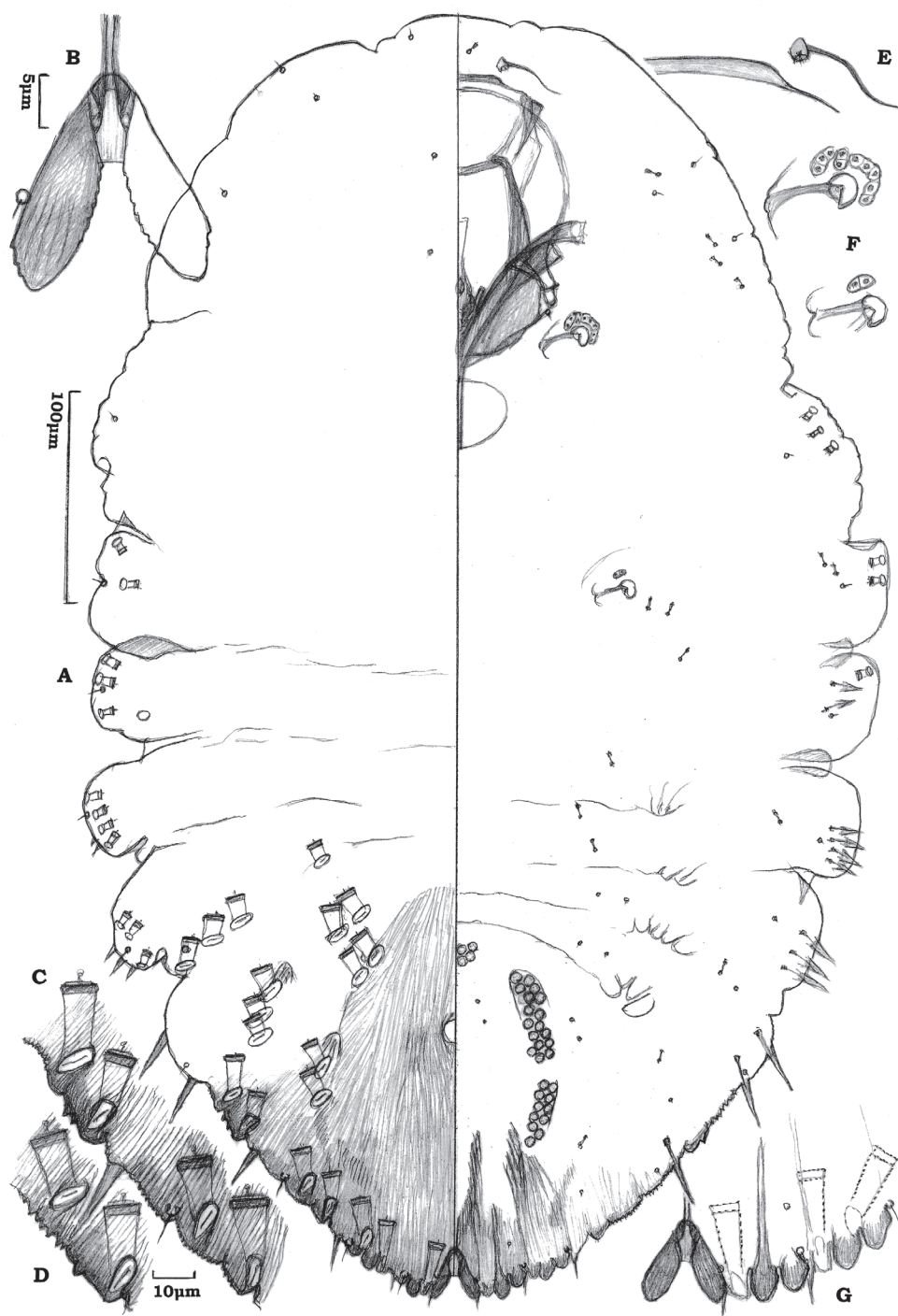


Fig. 13. *Myrtaspis calcarifera*, adult female. Kabili-Sepilok, Sabah, on *Ixora pyrantha*, leaf, Sample 9. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: pygidial margin, abd IV; E: antenna and frontal prominence; F: anterior and posterior spiracles; G: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–G; 5µm for B.

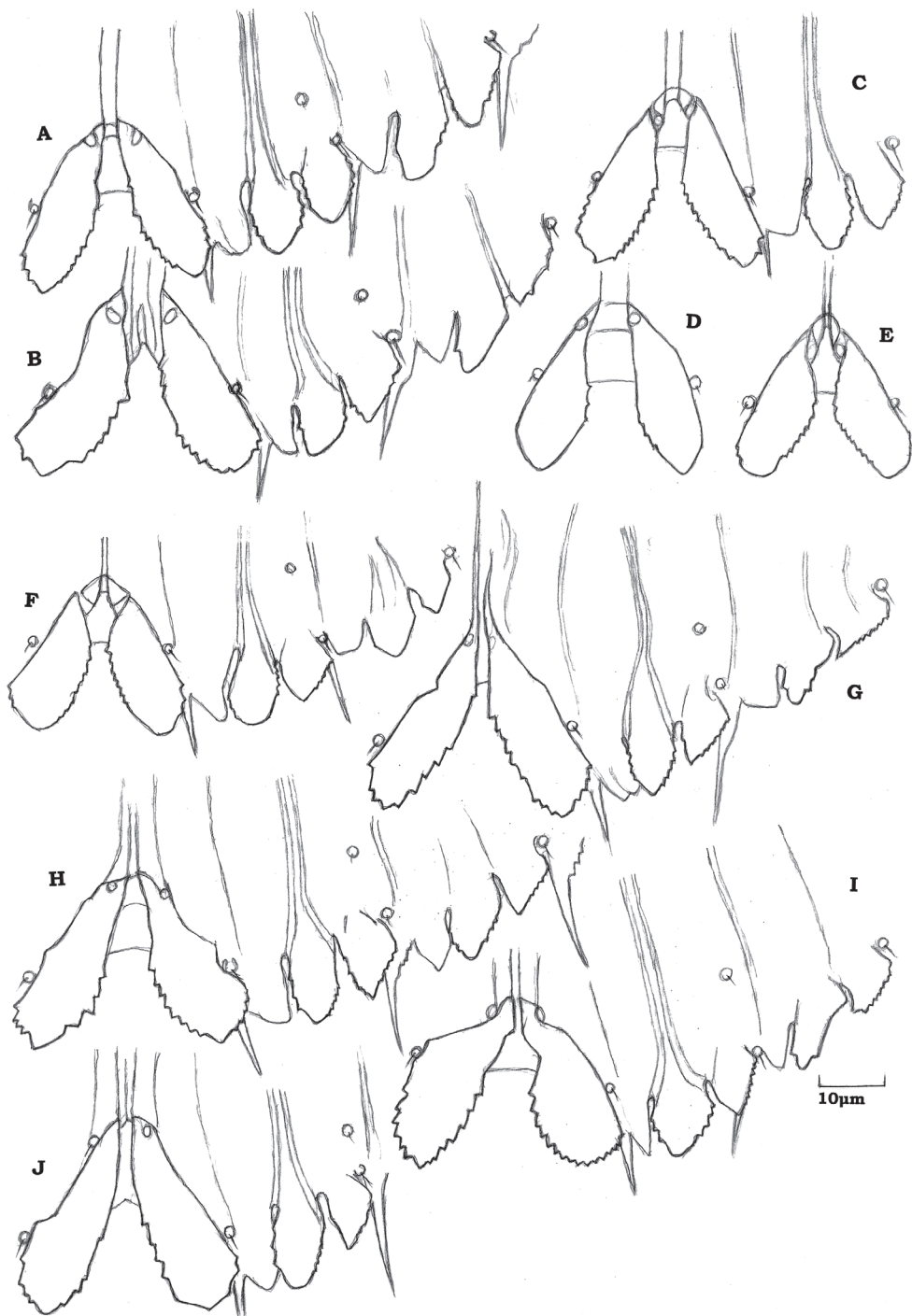


Fig. 14. *Myrtaspis calcarifera*, adult female. Trullae, ventral surface. A–E: Rantau Abang, Terengganu, Malaya, on *Melaleuca cajuputi*, leaf, Sample 1; F–J: Rantau Abang, on *Rhodomyrtus tomentosus*, leaf, Sample 2. Scale bar: 10µm for A–J.

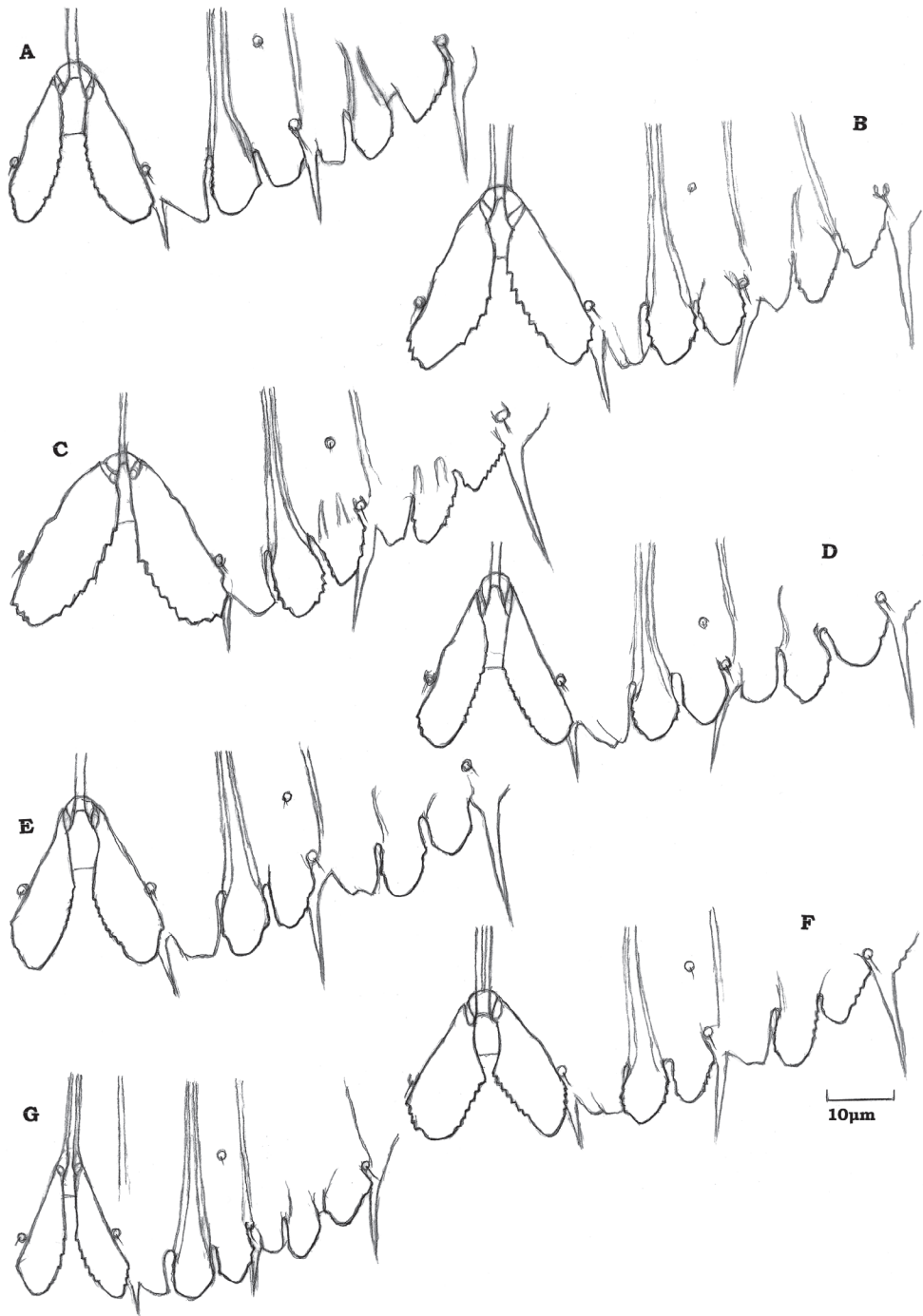


Fig. 15. *Myrtaspis calcarifera*, adult female. Trullae, ventral surface. A–C: Tanjong Gadung, Terengganu, Malaya, on *Rhodamnia cinerea*, leaf, Sample 3; D: Telok Cempedak, Kuantan, Pahang, Malaya, on *Eugenia* sp., leaf, Sample 4; E, F: Bukit Timah, Singapore, on *Eugenia longiflora*, Sample 5; G: Taman Bako, Sarawak, on *Eugenia tecta*, Sample 6. Scale bar: 10µm for A–G.

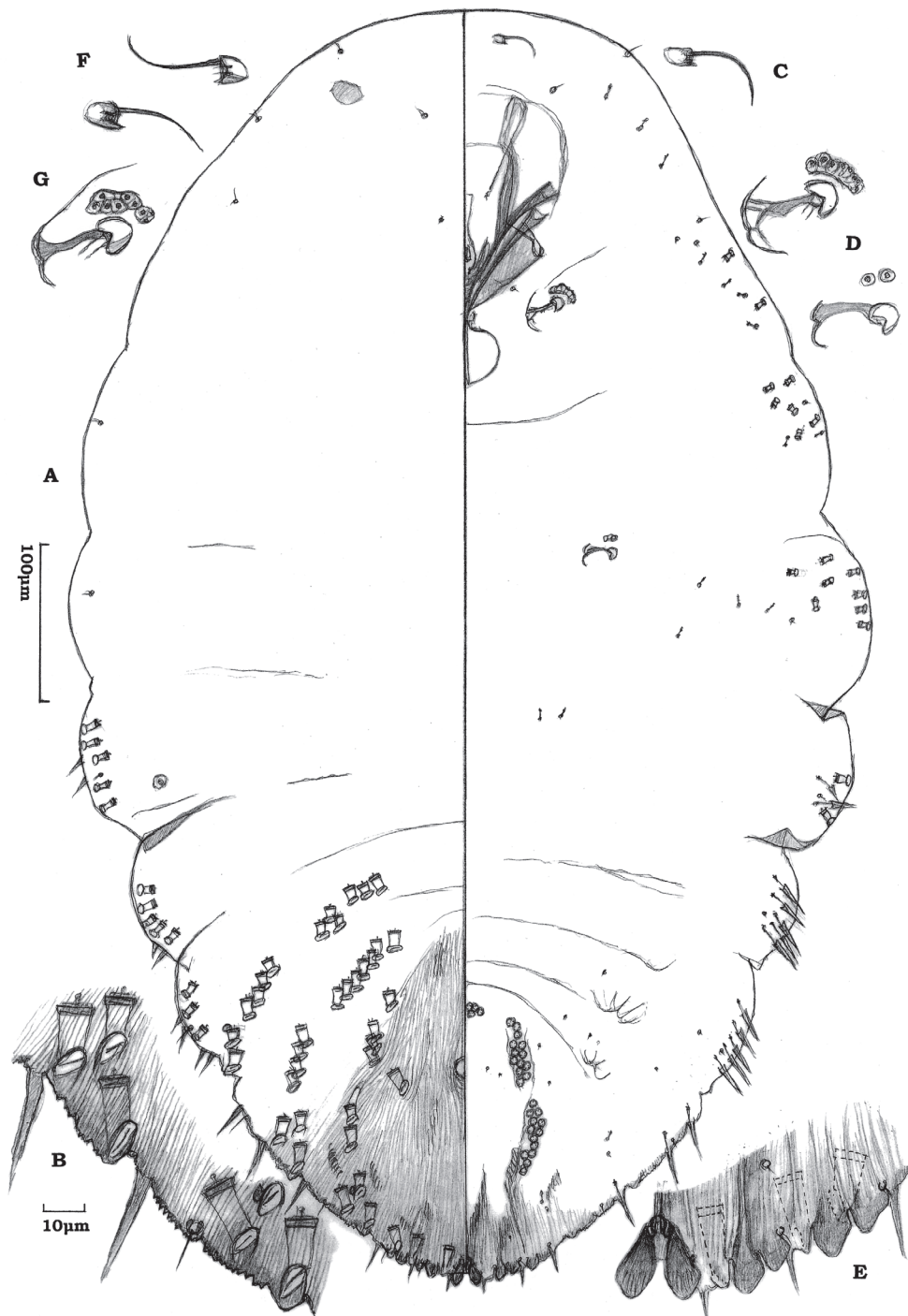


Fig. 16. *Myrtaspis kedahana*, adult female. Tanjong Batu Hampur, Kedah, Malaya, on *Eugenia grandis*, leaf. B: pygidial margin, dorsal surface; C: antenna; D: anterior and posterior spiracles; E: trullae, abd IV and V, ventral surface; F: antennae on opposite sides of body; G: anterior spiracle [F and G: another individual]. Scale bars: 100µm for A; 10µm for B–G.

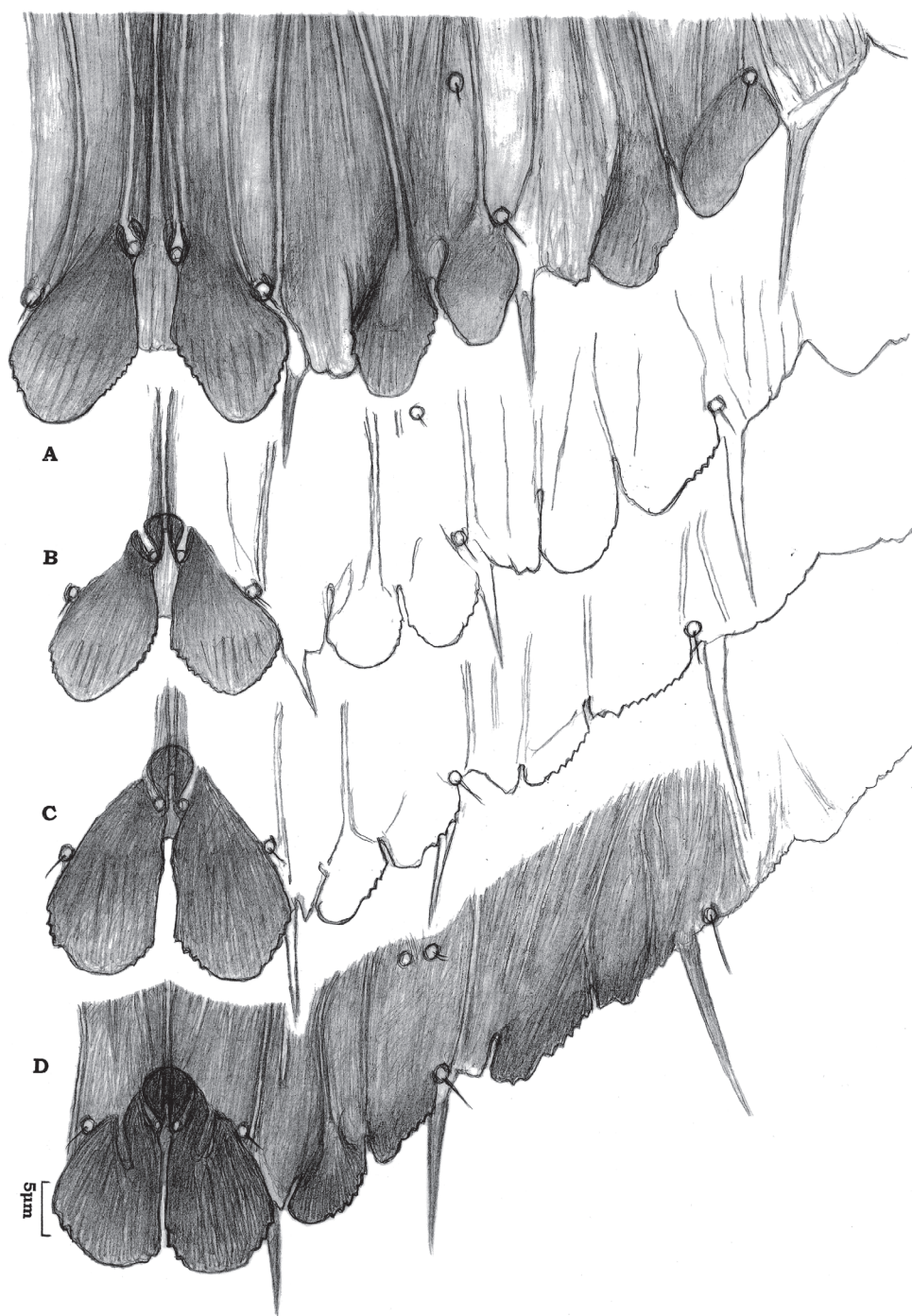


Fig. 17. *Myrtaspis kedahana*, adult female. Tanjong Batu Hampur, Kedah, Malaya, on *Eugenia grandis*, leaf. A–D: Trullae, ventral surface. Scale bar: 5μm for A–D.



Fig. 18. *Myrtaspis longiloba*, adult female. Ulu Kali, ca.1700m, Pahang, Malaya, on *Eugenia* sp., petiole, Sample 2. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antenna; E: anterior and posterior spiracles; F: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–F; 5µm for B.



Fig. 19. *Myrtaspis longiloba*, adult female. Mt. Santubong, 807m, Sarawak, on *Eugenia* sp., leaf, Sample 6. B: trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antenna and frontal prominence; E: anterior spiracle; F: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C-F; 5µm for B.

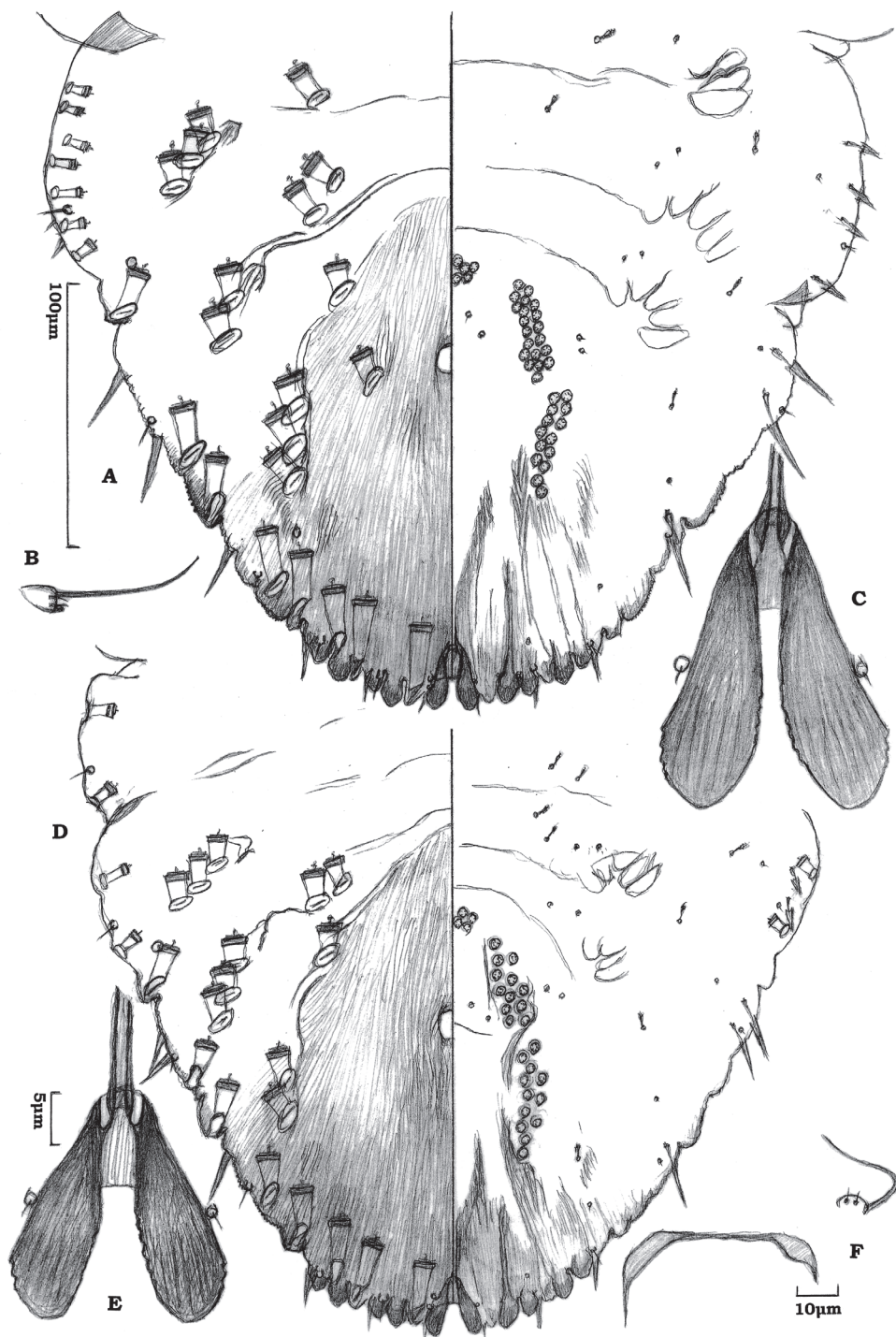


Fig. 20. *Myrtaspis longiloba*, adult female. A–C: Kundasang, 1550m, Mt. Kinabalu, Sabah, on *Eugenia* sp., leaf, Sample 9; D–F: Pinosuk Plateau, ca.1500m, Mt. Kinabalu, on *Eugenia chrysantha*, leaf, Sample 10. A, D: pygidium; C, E: median trullae, ventral surface; B: antenna; F: antenna and frontal prominence. Scale bars: 100µm for A, D; 10µm for B, F; 5µm for C, E.

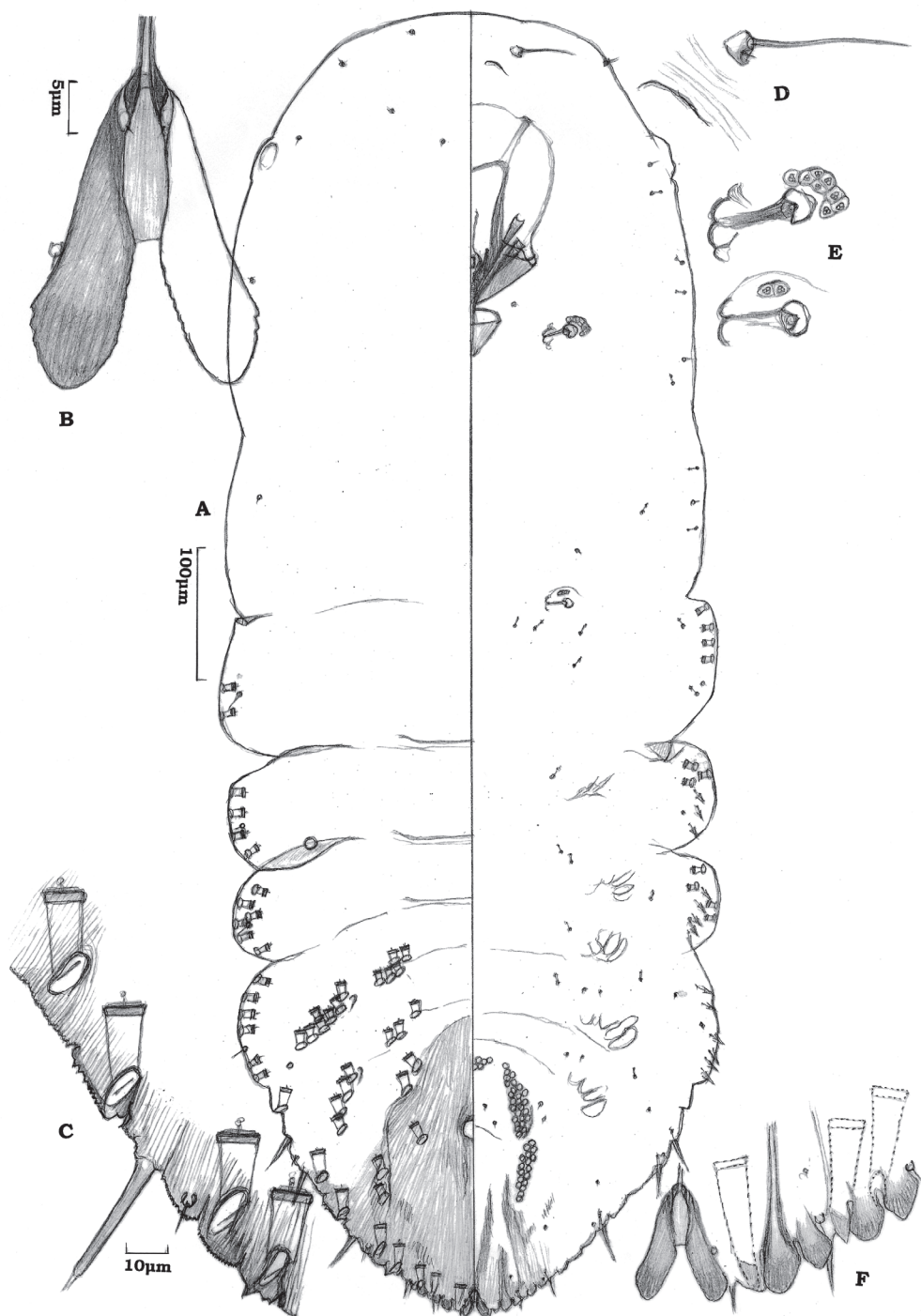


Fig. 21. *Myrtaspis longiloba*, adult female. Tanah Rata, ca.1400m, Cameron Highlands, Pahang, Malaya, on *Cratoxylon arborescens*, petiole, Sample 11. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antenna and frontal prominence (reduced to a trace); E: anterior and posterior spiracles; F: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–F; 5µm for B.



Fig. 22. *Myrtaspis pinosukensis*, adult female. Pinosuk Plateau, ca.1500m, Mt. Kinabalu, Sabah, on *Eugenia cephalantha*, leaf. A: pygidium; B: pygidial margin; C: median trullae, ventral surface; D: antennae; E: spiracles, both pairs; F: lateral macroducts on meso- and metathorax. Scale bars: 100µm for A; 10µm for B, D–F; 5µm for C.

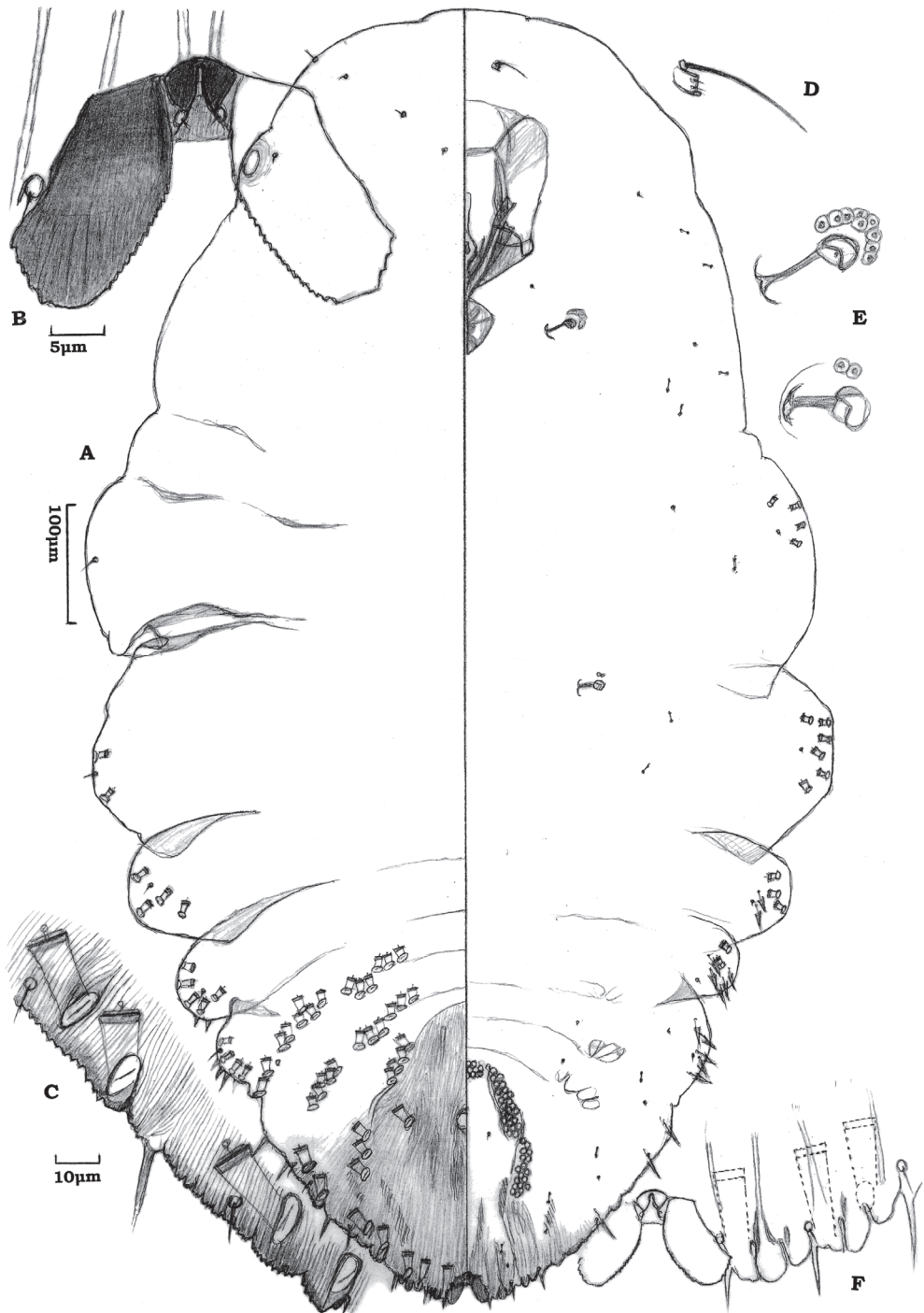


Fig. 23. *Myrtaspis rhodamniae*, adult female. Mt. Jerai, 930km, Kedah, Malaya, on *Rhodamnia cinerea*, leaf, Sample 1. B: median trullae, ventral surface; C: pygidial margin, dorsal surface, abd IV and V; D: antenna; E: anterior and posterior spiracles; F: trullae, ventral surface. Scale bars: 100µm for A; 10µm for C–F; 5µm for B.

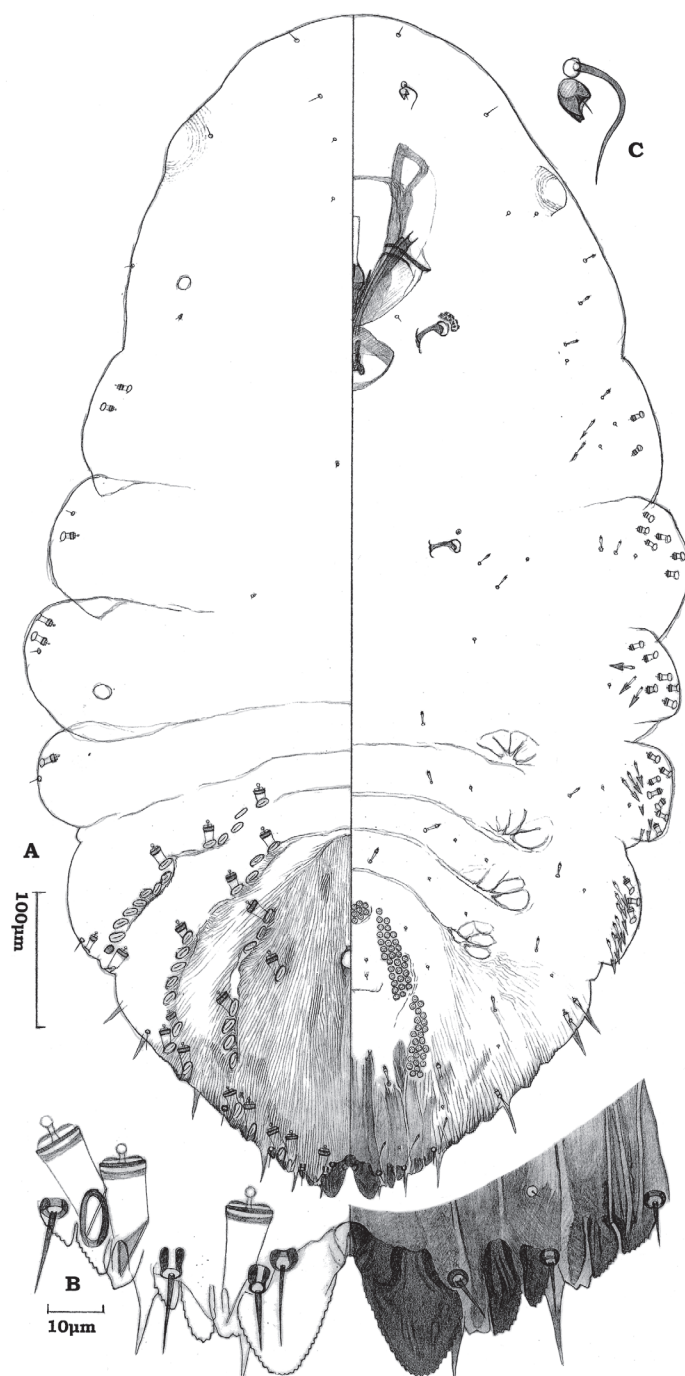


Fig. 24. *Myrtaspis rhodamniae*, adult female. Ulu Kali, ca.1700m, Pahang, Malaya, on *Rhodamnia cinerea* leaf, Sample 2. B: pygidial margin; C: antenna. Scale bars: 100µm for A; 10µm for B, C.

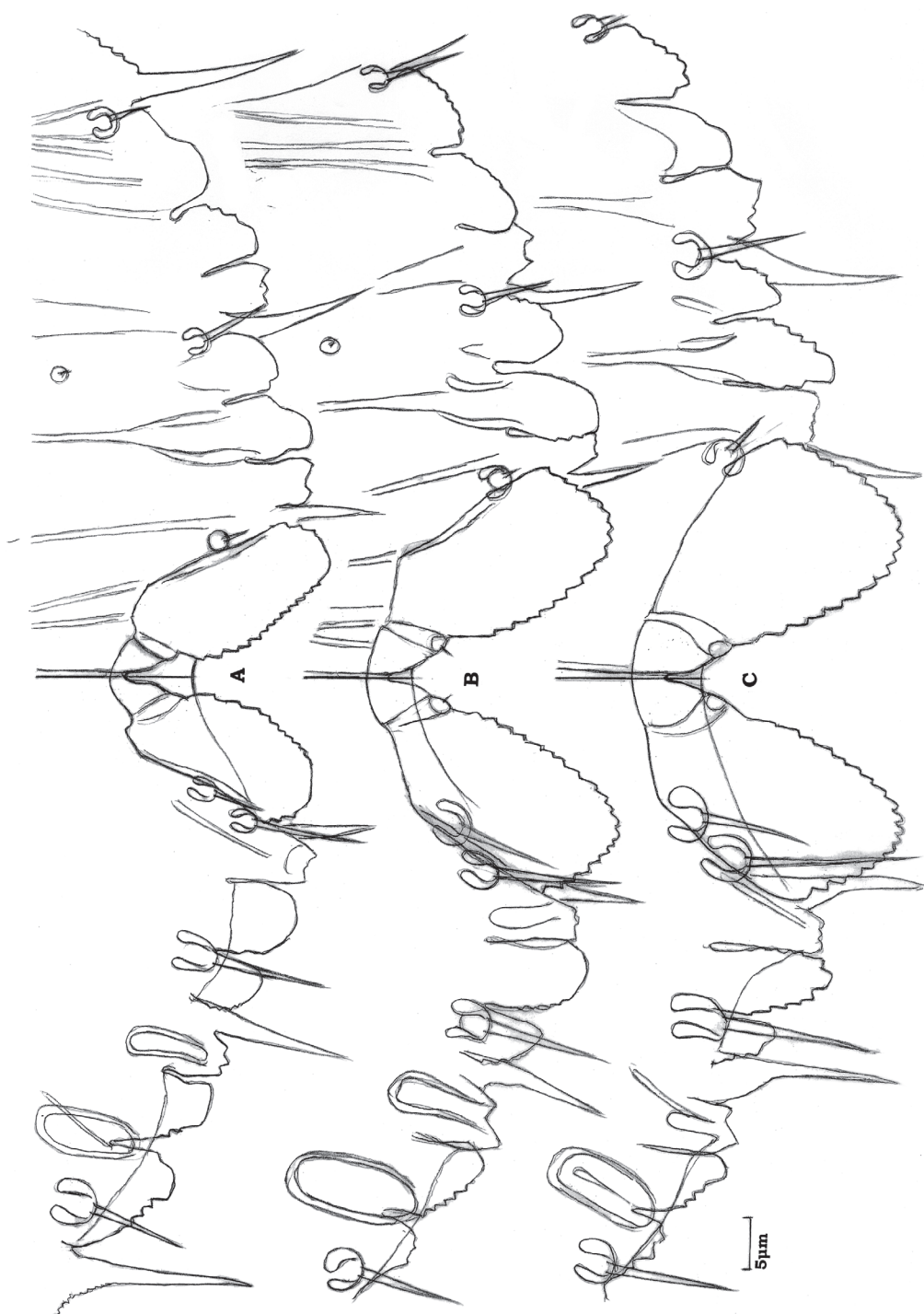


Fig. 25. *Myrtaspis rhodamniae*, adult female. Trullae. A: Mt. Jerai, 930m, Kedah, Malaya, on *Rhodamnia cinerea*, leaf, Sample 1; B: Air Terjun Kota Tinggi, Johor, Malaya, on *Decaspermum fruticosum*, leaf, Sample 3; C: Ulu Kali, ca. 1700m, Pahang, Malaya, on *Rhodamnia cinerea*, leaf, Sample 2. Scale bar: 5µm for A–C.

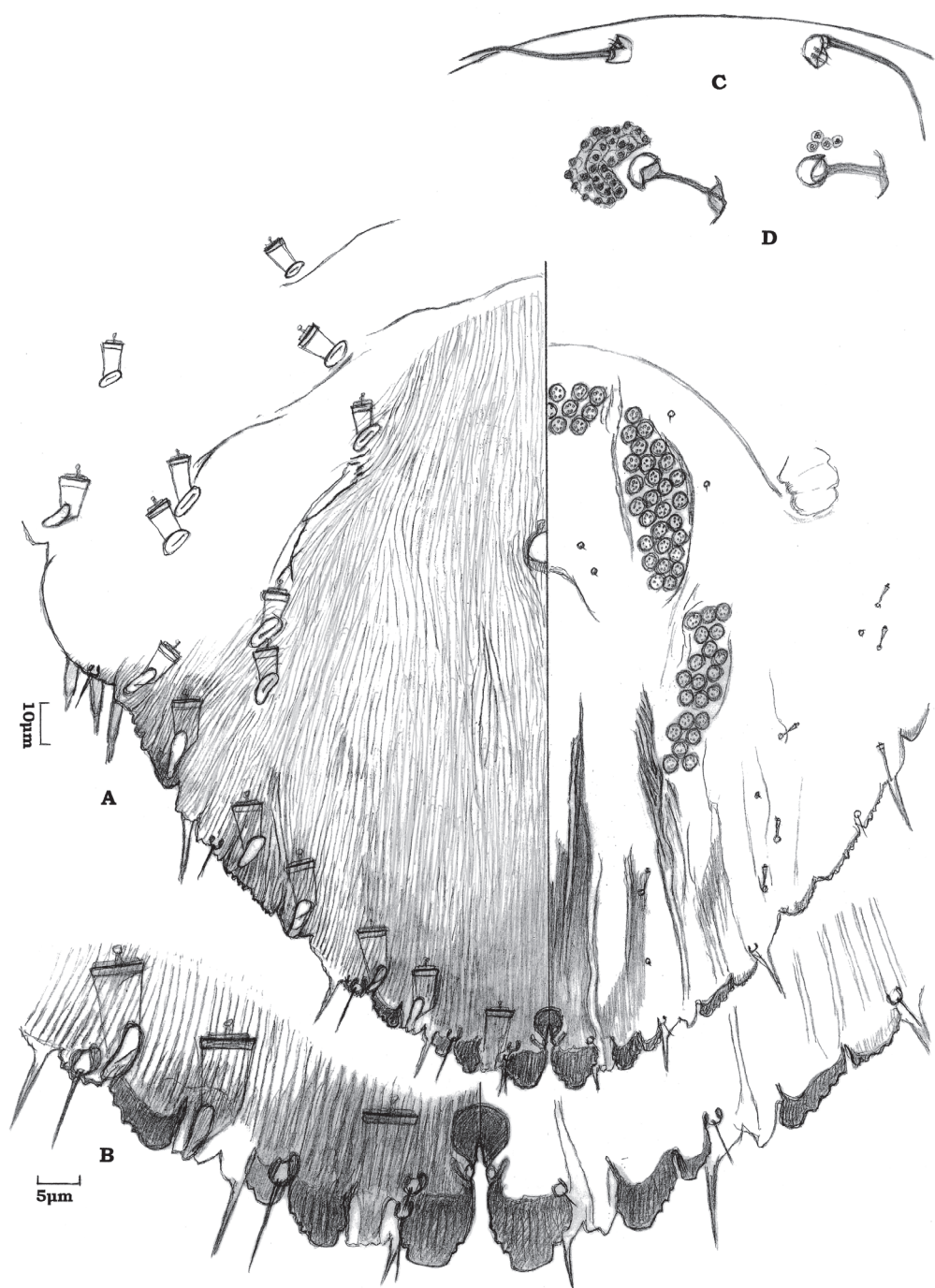


Fig. 26. *Myrtaspis* sp.SRP, adult female. Mt. Serapi, ca.800m, Sarawak, on *Eugenia* sp., leaf. A: pygidium; B: pygidial margin; C: antennae; D: anterior and posterior spiracles. Scale bars: 10µm for A, C, D; 5µm for B.



Fig. 27. *Myrtaspis homalanthi*, adult female. Pinosuk Plateau, ca.1500m, Mt. Kinabalu, Sabah, on *Homalanthus alpinus*, leaf. B: median trullae, ventral surface; C: antenna; D: second and third trullae, ventral surface. Scale bars: 100µm for A; 10µm for C, D; 5µm for B.



Fig. 28. *Myrtaspis homalanthi*, adult female. Pinosuk Plateau, ca.1500m, Mt. Kinabalu, Sabah, on *Homalanthus alpinus*, leaf. A: pygidium, dorsal surface; B: median trullae, ventral surface; C: antenna; D: anterior and posterior spiracles; E: pygidial margin, dorsal surface, abd VI, showing the occurrence of a submarginal macroduct. Scale bars: 100µm for A; 10µm for C–E; 5µm for B.

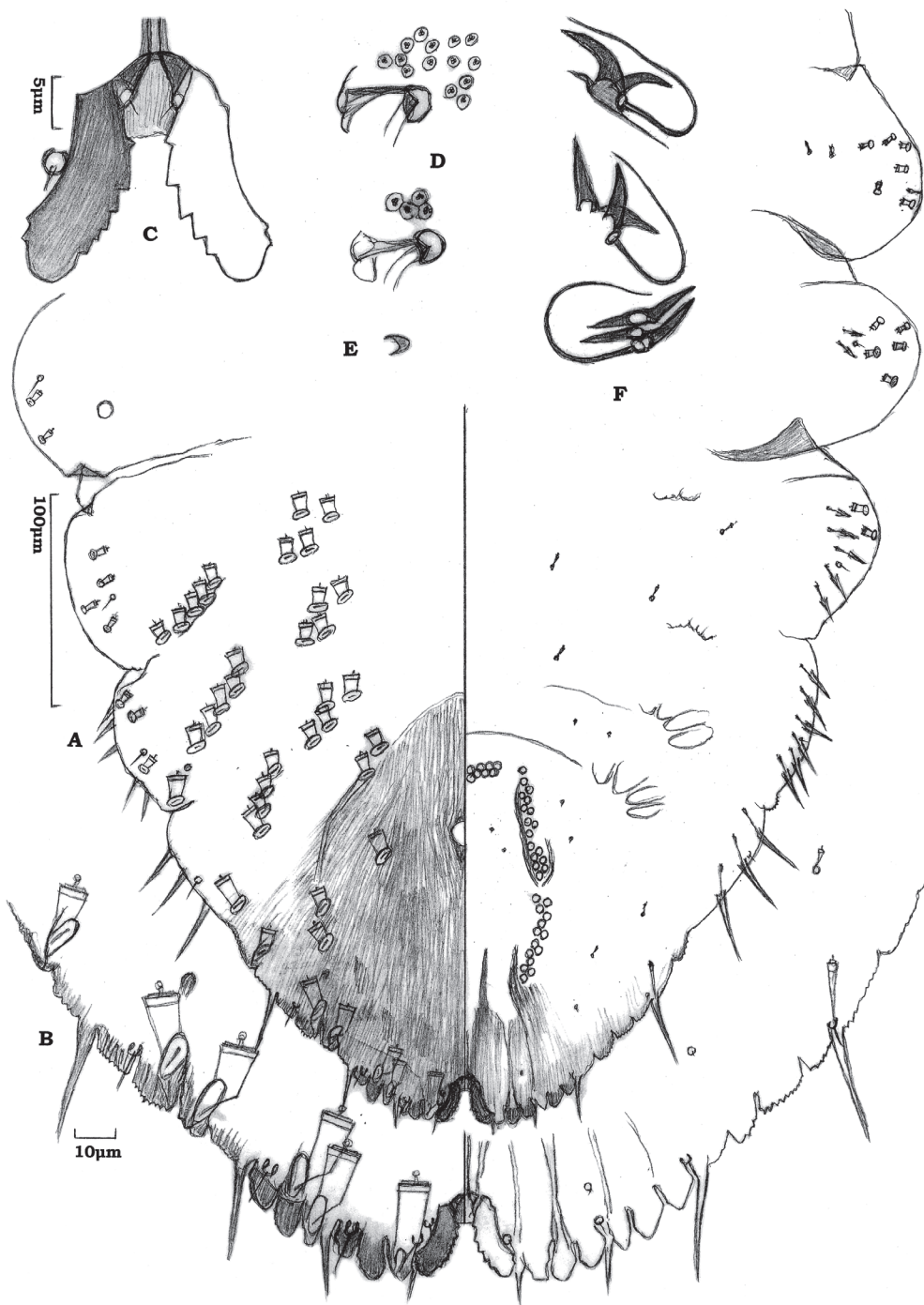


Fig. 29. *Myrtaspis cornuta*, adult female. Sepilok, Sabah, on *Macaranga depressa* f. *glabra*, leaf. A: abdomen; B: pygidial margin; C: median trullae, ventral surface; D: anterior and posterior spiracles; E: derm pocket on frontal area; F: antennae. Scale bars: 100µm for A; 10µm for B, D–F; 5µm for C.



Fig. 30. *Myrtaspis elaeocarpi*, adult female. Mt. Kinabalu, ca.2600m, Sabah, on *Elaeocarpus corneri*, leaf, Sample 2. B: median trullae, ventral surface; C: antenna; D: second and third trullae, ventral surface. Scale bars: 100µm for A; 10µm for B–D.



Fig. 31. *Myrtaspis perseae*, adult female. Mt. Jasar, 1300–1400m, Cameron Highlands, Pahang, Malaya, on *Persea* sp., leaf, Sample 1. B: antennae, frontal prominence, and derm pockets in a set; C: anterior spiracle; D: posterior spiracle; E: trullae, ventral surface. Scale bars: 100µm for A; 10µm for B–E.

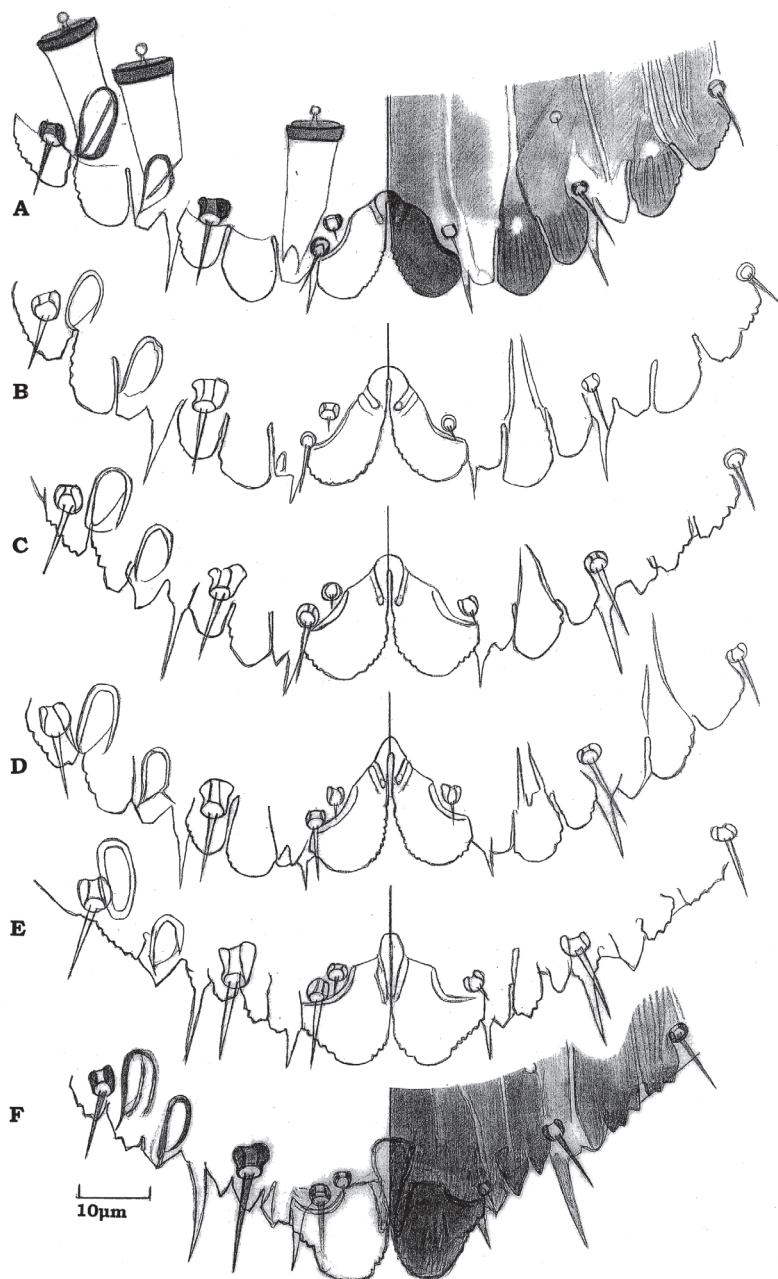


Fig. 32. *Myrtaspis perseae*, adult female. Trullae. A–C: Mt. Jasar, 1300–1400m, Cameron Highlands, Pahang, Malaya, on *Persea* sp., leaf (A), twig (B, C), Sample 1; D–F: Bukit Fraser, ca.1200m, Pahang, Malaya, on *Cinnamomum* sp., leaf, Sample 3. Scale bar: 10µm for A–F.



Fig. 33. *Myrtaspis perseae*, adult female. Ulu Kali, ca.1700m, Pahang, Malaya, on *Euodia roxburghiana*, leaf, Sample 4. A: abdomen, abd II to pygidium; B: antennae, frontal prominence, and derm pockets in a set; C–E: trillae; F: anterior spiracle. Scale bars: 100µm for A; 10µm* for C–E; 10µm for B, F.

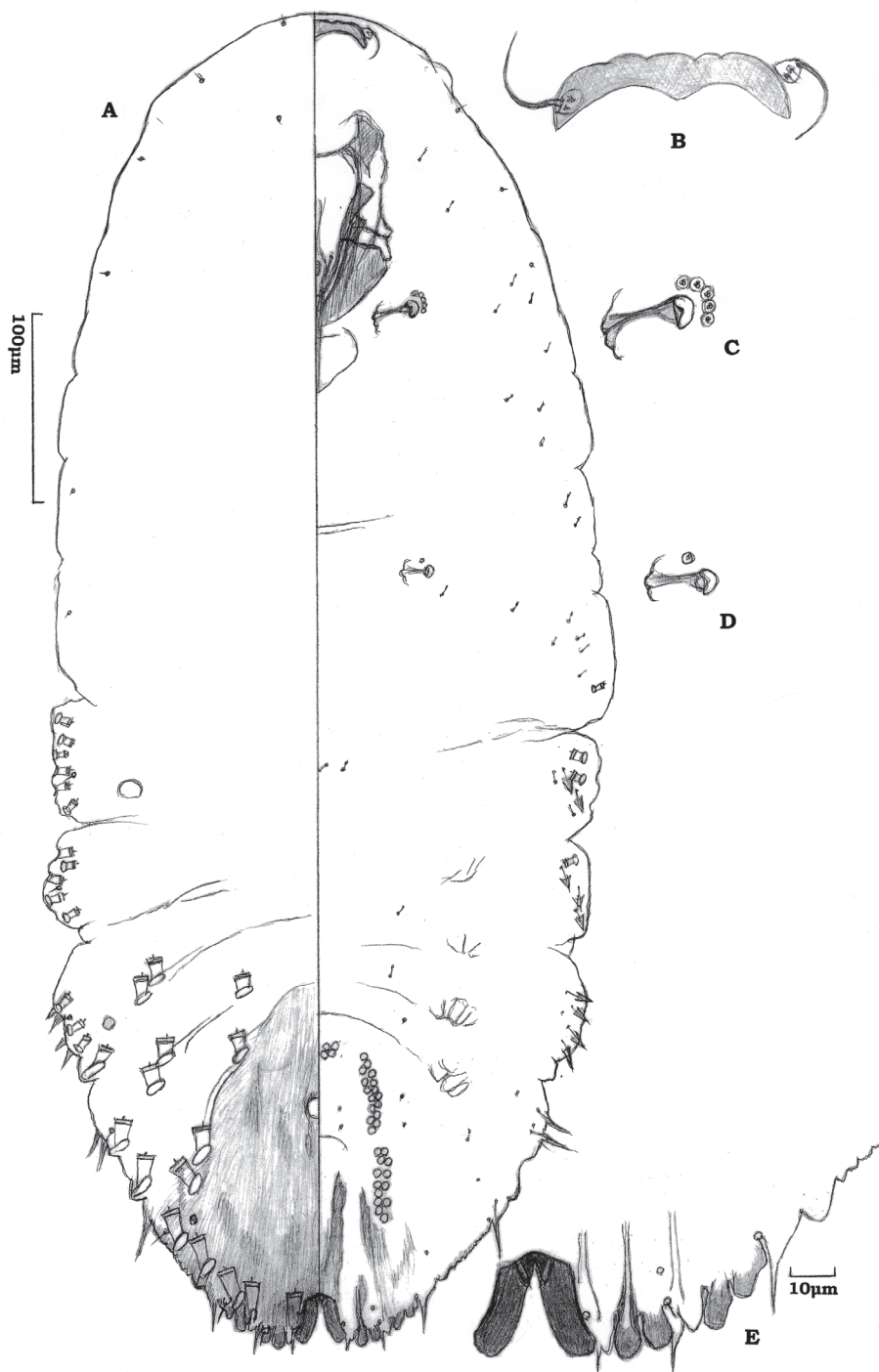


Fig. 34. *Myrtaspis aquilariae*, adult female. Kepong, Kuala Lumpur, Malaya, on *Aquilaria malaccensis*, leaf, Sample 1. B: antennae and frontal prominence; C: anterior spiracle; D: posterior spiracle; E: trillae, ventral surface. Scale bars: 100µm for A; 10µm for B–E.

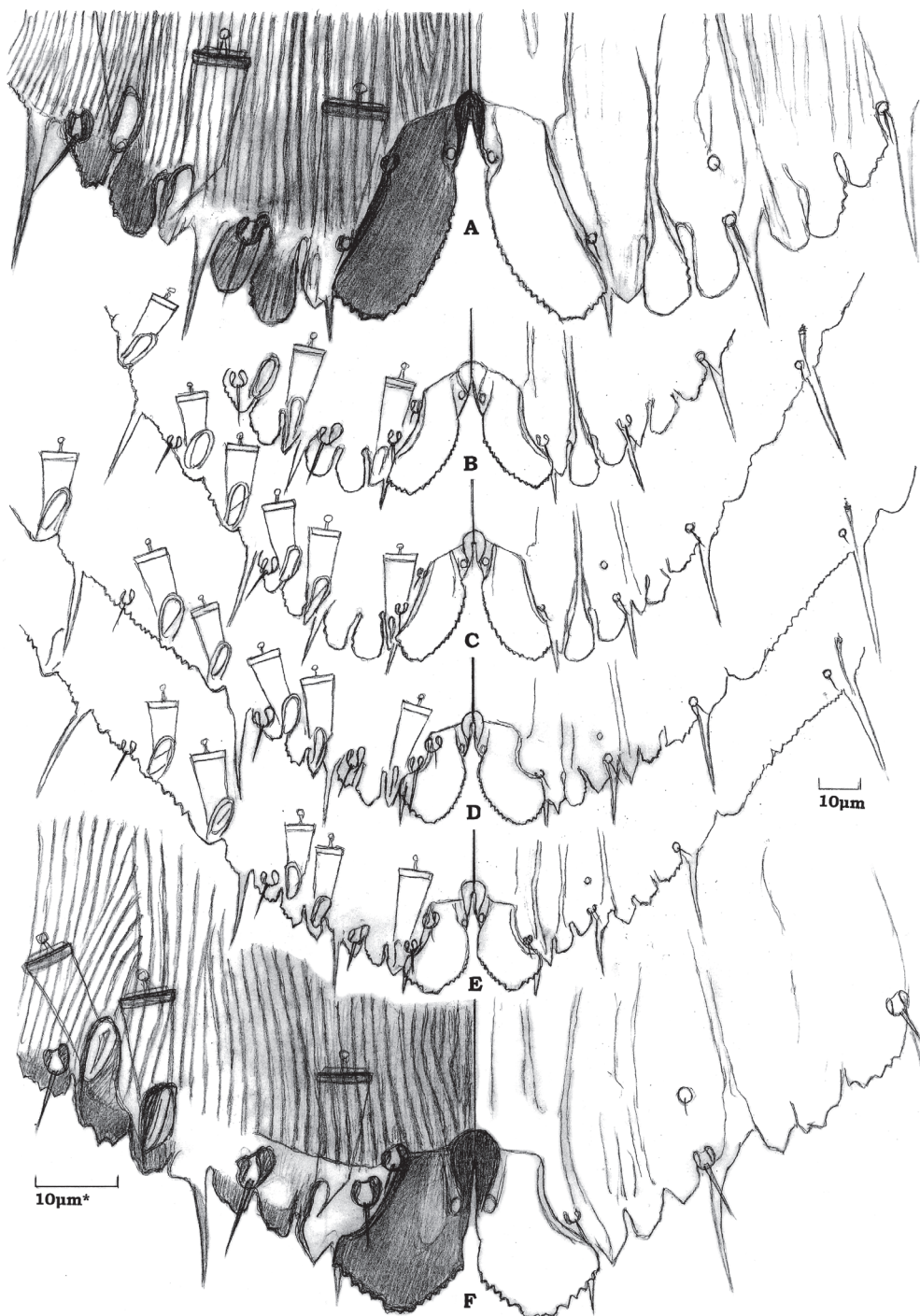


Fig. 35. *Myrtaspis aquilariae*, adult female. Kepong, Kuala Lumpur, Malaya, on *Aquilaria malaccensis*, Sample 1. Trullae. A: on leaf; B–F: on twig. Scale bars: 10µm* for A, F; 10µm for B–E.

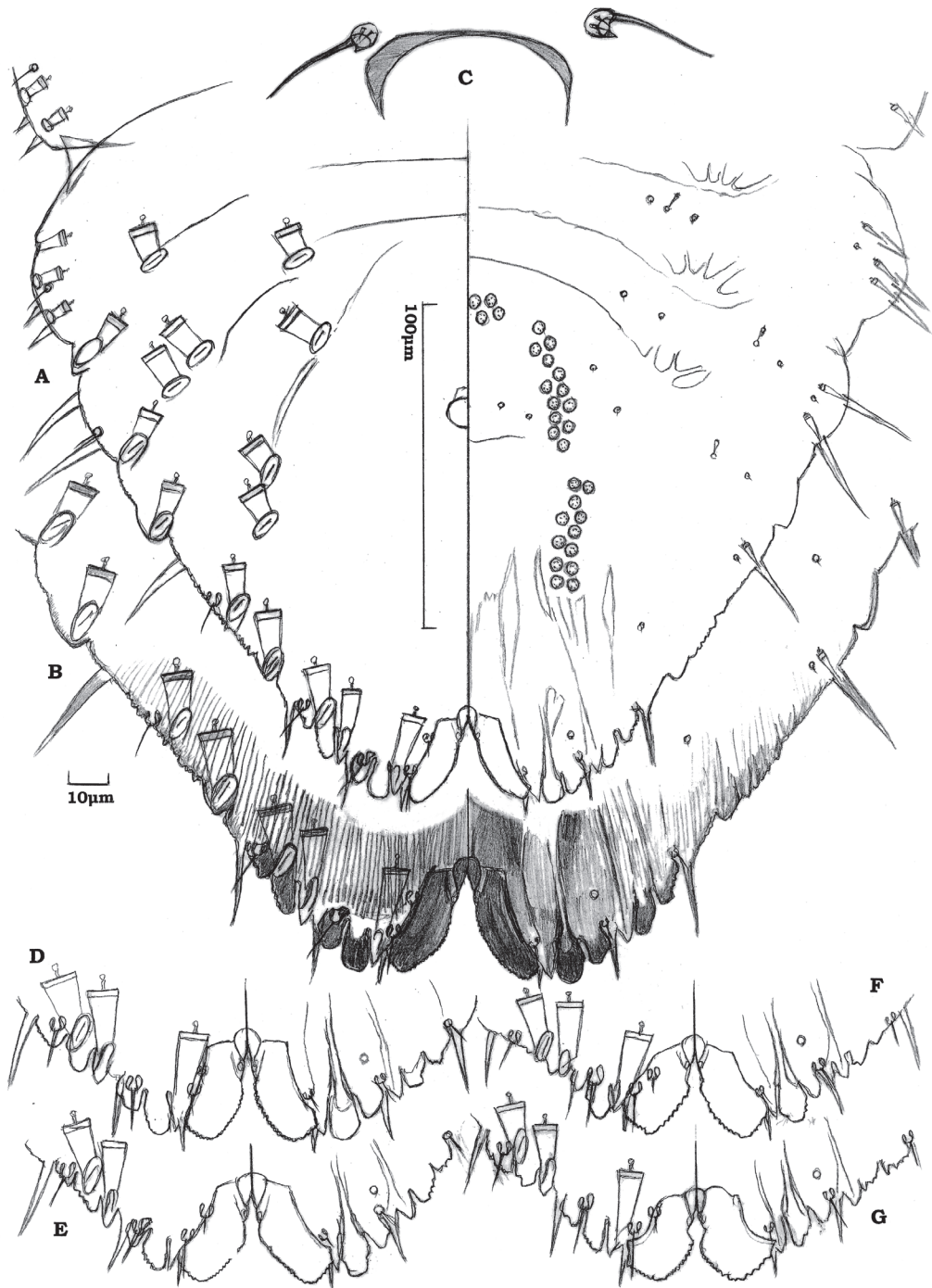


Fig. 36. *Myrtaspis aquilariae*, adult female. Bukit Nanas, Kuala Lumpur, Malaya, on *Euodia glabra*, leaf, Sample 3. A: pygidium; B: pygidial margin; C: antennae and frontal prominence; D–G: trullae. Scale bars: 100µm for A; 10µm for B–G.

