INSECTA MATSUMURANA

NEW SERIES 70: 89–151 OCTOBER 2014

THE YABUNIKKEI COMPLEX AND SOME OTHER SPECIES OF AULACASPIS OCCURRING ON LAURACEAE (STERNORRHYNCHA: COCCOIDEA: DIASPIDIDAE)

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Abstract

TAKAGI, S., 2014. The *yabunikkei* complex and some other species of *Aulacaspis* occurring on Lauraceae (Sternorrhyncha: Coccoidea: Diaspididae). *Ins. matsum. n. s.* 70: 89–151, 2 tables (divided on 10 pages), 28 figs.

'*Aulacaspis yabunikkei*' or the *yabunikkei* complex of *Aulacaspis* comprises three distinct species including two new ones in Japan: *A. yabunikkei* Kuwana associated with *Cinnamomum* spp., *A. neolitseae* occurring on *Neolitsea sericea* usually and on *Cinnamomum japonicum* occasionally, and *A. sirodamo* collected from *N. sericea*. The grounds adopted for recognizing the three species are explained. A small sample from Taiwan agrees with the revised concept of *A. yabunikkei*; two other samples collected in Taiwan and Hong Kong are referred to *A. sirodamo* tentatively. Seven other species of *Aulacaspis*, all occurring on Lauraceae but not particularly related to the *yabunikkei* complex, are described: *Aulacaspis ferrisi* Scott, originally described from 'Kwangtung', China, and represented in the present study by samples collected in the Kowloon Peninsula, Malay Peninsula, Kathmandu Valley, and South India, and six new species occurring in the Malay Peninsula, *A. obconica*, *A. ulukaliana*, *A. medangena*, *A. kedahana*, *A. cinnamomorum*, and *A. jeraiana*.

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*Scientific report 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

1. Introduction

Kuwana (1926) described *Aulacaspis yabunikkei* on the basis of specimens collected in Japan on the lauraceous plant '*Cinnamomum pedunculatum*' or *Cinnamomum japonicum* (called Yabu-nikkei in Japan). At that time, he mentioned and figured another form obtained in Formosa (Taiwan) on *Cinnamomum camphora*. The 'Formosan form' was similar to the specimens from Japan, but differed from the latter in the shape of the median trullae; his figures of these forms also showed that they differed in the shape of the body. He took the view that these forms were referable to the same species in spite of the apparent differences. Scott (1952) adopted the same view ('the two may be regarded as the same species'), and what he described under the name *A. yabunikkei* from Taiwan was probably the same as Kuwana's Formosan form. Up to the present, *A. yabunikkei* has been recorded from many localities in eastern Asia and from various Lauraceae and even plants of several other families, but it is certain that not all the records were based on the same form. Even in Japan, apparently different forms have been dealt with under the name. However, no study has been made in a convincing manner to clear up the question what the forms treated as *A. yabunikkei* really represent. They may compose 'the *yabunikkei* complex', requiring a careful study on their taxonomic relationships.

The *yabunikkei* complex has been one of my pending problems. Samples of the complex collected in Japan have been accumulated at hand. In examining these samples, I have managed to recognize in them three species, of which two should be new. The material of the complex collected outside Japan and available for my study is very meagre, and totally insufficient for a further study. In a broader geographical extent, therefore, the problem of the *yabunikkei* complex has not been settled. The published records of *A. yabunikkei* probably included misidentified species, which may have no concern with the *yabunikkei* complex and should be outside the scope of the present study.

I take this opportunity to describe seven other species of *Aulacaspis* all associated with Lauraceae. None of them appear to be closely related to the *yabunikkei* complex. Six of them are described as new.

Terms, numbers of wax organs, and measurements. In the present paper, the term 'trullae' is used in place of 'pygidial lobes' in authors; the term 'dorsal macroducts' means submedian and submarginal macroducts combined (though three of the newly described species usually have no submedian macroducts). In my recent papers I use the abbreviations 'abd I'–'abd IX' for the first to the ninth abdominal segment. (For the terms 'the *rosae*-type', 'the *vitis*-type', 'interantennal tubercle', 'interantennal swellings', 'interantennal derm pockets', and 'peribuccal scleroses', see my recent papers on *Aulacaspis*, especially Takagi, 1999, and Takagi, 2012).

The numbers of wax-secreting organs are given for each side of the body except for the total number of the dorsal macroducts and that of the perivulvar disc pores. The length of the pygidium means the distance measured along the midline between the anterior margin of the fifth abdominal segment and the level of the apices of the median trullae, and the width means the distance measured between the basal angles of the fourth abdominal segment (that is, just caudad of the marginal macroducts of the third abdominal segment).

Samples and subsamples. A 'sample' is composed of conspecific specimens mounted, in principle, from the same lot of material, which was obtained from the same

plant individual at the same time. A sample may have specimens mounted from different plant parts or 'feeding sites'; in the present study, 'foliicolous' (leaf-inhabiting) and 'ramicolous' (twig- or branch-inhabiting) specimens of the adult female are available in some samples. Specimens mounted from different feeding sites should be separated into different 'subsamples', which are not always similar and sometimes remarkably different in morphological characters. Teneral specimens of the adult female included in a sample should also be separated into their own subsample, because they may represent a generation succeeding to the fully grown ones in the same sample and may not be similar to the latter in some features, above all, in the numbers of some wax-secreting organs (when the population has more than one generation a year and inhabits a region where the seasons remarkably change in climate). In the present study, teneral specimens were mounted in some samples, but they are very few in most of those samples. In this paper, small feeding-site or generation subsamples, each with less than five specimens, are not mentioned for their numerical data. (The subsamples of teneral adult females are excluded from Table 1 and 2 except for Sample 6 of *A. neolitseae* because of their small sizes. Foliicolous and ramicolous specimens are available in Sample 3 of *A. ferrisi*, but they are not distinguished for a certain reason.)

Depositories of the holotypes. The holotypes of the two new species of the *yabunikkei* complex are deposited in the collection of the Laboratory of Systematic Entomology, Hokkaidô University, Sapporo, Japan, and those of the six new species, all described from the Malaysian region of the Malay Peninsula, are preserved in the collection of the Entomology Division, Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia.

2. Recognizing Species in the Yabunikkei Complex

2.1. Grouping the samples occurring in Japan

The host plants of the *yabunikkei* complex in Japan belong to the lauraceous genera *Cinnamomum* (*C. japonicum* and three other species) and *Neolitsea* (*N. sericea*), and the samples are largely divisible into two groups according to the host plant genera.

In *Aulacaspis*, the body shape, the median trullae, and the arrangement of the dorsal macroducts have generally been adopted as taxonomic features of primary importance. The samples are divisible into two groups according to the body shape in the fully grown adult females, which are relatively 'slender-bodied' in one group and rather 'stout-bodied' in the other (Section 2.2). On the other hand, the samples are divisible into three groups by the use of the median trullae, which are variable in size and shape and also in their 'relative height' to the 'side macroducts' (Section 2.3). In the arrangement of the dorsal macroducts, the samples are not different practically.

The *Cinnamomum*-associated samples except one (Section 3.2.1, Sample 6) have slender-bodied adult females and belong to one of the three groups based on the median trullae (Group 1). The *Neolitsea*-associated samples are divided into two groups. One of these groups has slender-bodied adult females and coincides with another one of the three groups based on the median trullae (Group 2). The sample mounted from *Cinnamomum japonicum* and excluded from Group 1 (Section 3.2.1, Sample 6) belongs to Group 2 on the basis of the body shape and the median trullae. The other *Neolitsea*-associated samples have stout-bodied adult females and belong to the remaining one of the three groups based on the median trullae (Group 3).

Morphologically, Group 1 and 2 are distinguished by the use of the median trullae, but the differences appear trifling; Group 3 is clearly distinguishable from them in the body shape and the median trullae. The assumption is made that these groups represent three distinct species. If it is not false, it should find support in further observations (Section 2.4). These assumed species are provisionally accepted in Section 2.2–2.4, and the name *A. yabunikkei* is applied to Group 1 on circumstantial evidence (no specimens from the Kuwana collection having been examined) but with considerable reason (Section 3.1.3), and Group 2 and 3 are called *A. neolitseae* and *A. sirodamo*, respectively. *A. yabunikkei* is associated with *Cinnamomum*, *A. neolitseae* occurs on *Neolitsea* usually and on *Cinnamomum* occasionally, and *A. sirodamo* is known only from *Neolitsea*.

2.2. Body shape

The fully grown adult females of *A. yabunikkei* and *A. neolitseae* have the prosoma moderately swollen and the prepygidial region of the postsoma roughly parallel on the lateral sides ('slender-bodied' in Section 2.1). *A. sirodamo* at full growth is relatively stout, with the prosoma and postsoma more broadened and the metathorax and first two abdominal segments more strongly lobed laterally than in the other two species ('stout-bodied').

2.3. Median trullae

Some figures of the median trullae are shown on one chart (Fig. 10) for comparison. First of all, *A. sirodamo* may easily be recognized at a glance through the chart. This species has the median trullae larger than in *A. yabunikkei* and *A. neolitseae* and gradually attenuating apically; the basal zygotic sclerite of the median trullae is well developed, and produced anteriorly beyond the bases of the trullae; the marginal macroducts occurring on the seventh abdominal segment and situated on the sides of the median trullae do not extend anteriorly beyond the bases of the trullae. (In this paper, these macroducts are called 'side macroducts', and the 'relative height' of the median trullae to them is adopted in distinguishing the species of the *yabunikkei* complex.) On the other hand, *A. yabunikkei* and *A. neolitseae* are very similar to each other in the median trullae: in *A. yabunikkei* these trullae are nearly of the same width throughout and definitely exceeded by the side macroducts in height; *A. neolitseae* differs from *A. yabunikkei* in the median trullae slightly attenuating subapically and scarcely exceeded by the side macroducts in height. The characters of the median trullae (including the development of the basal zygotic sclerite and the relative height to the side macroducts) are considerably stable in each of the three species, and may afford 'primary diagnostic characters' (regardless of the growth of the body) in sorting specimens. Sample 6 of *A. neolitseae* is, thus, referred to the species in spite of the host plant, which is not *Neolitsea sericea* but *Cinnamomum japonicum*, and this determination finds no contradiction in further observations.

2.4. Numbers of wax-secreting organs

Each of the three assumed species is broadly variable in the numbers of the main wax-secreting organs in the examined samples (Table 1a–d). The samples of *A. yabunikkei*, assembled into a lump, overlap with those of *A. neolitseae*, also lumped together, in various degrees in both the ranges and the means of these numbers. The samples of *A. sirodamo*, lumped together, overlap with those of *A. yabunikkei* or *A.*

neolitseae or both, also lumped together in each species, except for the means of the numbers of a few wax organs.

The observed numbers of the wax organs should, as a whole, involve local genetic differentiation, local ecophenotypic variation, feeding-site variation, and seasonal variation. In this regard, it is almost useless to make comparisons among the lumped samples of the assumed species for detecting any taxonomically significant differences in the numbers of the wax organs. It is essential here to find out how to make comparisons.

2.4.1. Comparisons between syntopic, synchronic, and foliicolous samples of *A. yabunikkei* and *A. neolitseae*

A sample of *A. yabunikkei* (Section 3.1.1, Sample 4) and a sample of *A. neolitseae* (3.2.1, Sample 3) were collected in the same locality and at the same spot (on Takatori-yama, a hillock), on the same date, and from the leaves of *Cinnamomum japonicum* and *Neolitsea sericea*, respectively. These two samples show between them statistically significant differences in the means of the numbers of the wax organs given in Table 1 except for 'Total perivulvar disc pores', 'Lateral macroducts on abd III', and 'Lateral gland spines on abd III'; the differences are sufficiently significant in 'Total dorsal macroducts', 'Anterior spiracular disc pores', and 'Lateral gland spines on abd II' (Fig. 1). These samples show different tendencies in the occurrence of submedian macroducts on the sixth abdominal segment and in the number of the marginal gland spines on the fourth segment (Section 2.4.3). It is also noteworthy that these samples make a cross-over between them in the numbers of some wax organs: the sample of *A. yabunikkei* tends to have more spiracular disc pores and dorsal macroducts, whereas that of *A. neolitseae* has larger mean values of the numbers of the lateral macroducts and gland spines on the second abdominal segment and tends to have more marginal gland spines on the fourth segment. Local differentiation and variation, seasonal variation, and feeding-site variation are excluded from these comparisons, because the compared samples are 'syntopic' and 'synchronic' with each other (having been collected at the same spot and on the same day) and are both foliicolous. The possibility that *A. yabunikkei* and *A. neolitseae* are conspecific forms differing merely phenotypically owing to their feeding on the different plant species is also ignored, because the *Cinnamomum*-feeding form of *A. neolitseae* (Section 3.2.1, Sample 6) is known and not distinguishable from the *Neolitsea*-associated form in the observed features. After all, the comparisons in the numbers of the wax organs strongly support the view that the two samples belong to different populations, which should represent different species.

Statistical comparisons between samples collected under similar or the same microenvironmental conditions are required also for the other pairs of species (especially for *A. yabunikkei* and *A. sirodamo*, which are not clearly distinguishable from each other in the comparison made in Section 2.4.4). None of the available samples of *A. yabunikkei* and *A. neolitseae*, however, was collected together with a sample of *A. sirodamo* in the same locality and in the same season. In consideration of the known distributions, there is a good probability that the three species occur together in some areas (*Supplementary notes 2*). If *A. neolitseae* and *A. sirodamo* occur syntopically somewhere, their concurrence is of particular interest, because these species share the same host plant species, *Neolitsea sericea*. (In this connection, these two species show obvious differences in Section 2.4.3 and 2.4.4.)

2.4.2. Comparisons between samples of *A. yabunikkei* from the same locality

Sample 7 and 8 of *A. yabunikkei* (Section 3.1.1) were collected in the same locality (Simoda) on the leaves of *Cinnamomum japonicum* but in different seasons and different years (October, 1967, and March, 1984). They agree very closely or even almost exactly with each other in both the ranges and the means of the numbers of the main wax-secreting organs (Table 1a) in spite of the different collection seasons and the long time (17 years) between the collection years. (Although these samples were collected in the different seasons, they may have belonged both to the overwintering generation.)

In another example, Sample 28 and 29 (Section 3.1.1) were collected in the same locality (Nakizin) and in the same season but at different spots, and both of them on the leaves and branches of *C. japonicum*. These samples are compared between the foliicolous and between the ramicolous subsamples. They are different but not much in 'Total dorsal macroducts' (in which the foliicolous subsamples are different significantly but the ramicolous subsamples are not) and 'Total perivulvar disc pores' (in which the differences are not significant in both subsamples), and are very close in the numbers of the other wax organs (Table 1c). (In Sample 28, the foliicolous and ramicolous subsamples, both sufficiently large for a statistical comparison, are more remarkably different from each other than between the same feeding-site subsamples of Sample 28 and 29: see *Supplementary notes 3*.)

The samples of *A. yabunikkei* compared above, each pair having been collected in the same locality, are very close or not different in most or all of the numbers of the wax organs. This fact gives a sidelight on the taxonomic significance of the comparisons (Section 2.4.1) made between the syntopic, synchronic, and foliicolous samples of *A. yabunikkei* and *A. neolitseae* (unless it is a matter of mere coincidence).

2.4.3. Wax-secreting organs on specified body parts

In diaspidids the numbers of wax organs on specified parts of the body are sometimes helpful in distinguishing and identifying species. The samples of the three species show some tendencies in the occurrence of 'Submedian macroducts on abd VI' and in the number of 'Marginal gland spines on abd IV' (Table 2a–c). Usually *A. yabunikkei* has one submedian macroduct on each side of the sixth abdominal segment, whereas *A. neolitseae* has none on that segment, but there are some exceptional samples especially in *A. yabunikkei*. In *A. sirodamo* the presence and absence of one submedian macroduct on each side of the sixth segment occur in various proportions. The number of the marginal gland spines on the fourth segment has a marked tendency in each species and may be useful in identifying the species when sufficiently large samples are available: these gland spines on each side of the segment are usually two or three (mode=2) in *A. yabunikkei*, three or four (mode=3) in *A. neolitseae*, and three to five (mode=4 or 5) in *A. sirodamo*.

2.4.4. Correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores

This correlation in the three species is shown in two scatter diagrams (Fig. 2). In many Diaspidinae, the dorsal macroducts occur in the submedian and submarginal areas of some abdominal segments, and the perivulvar disc pores, occurring on the other surface of the body, occupy the median, submedian, and submarginal areas around the vulva. The numbers of these wax organs, when combined, may reflect the body

organization to a considerable degree as compared with the other wax organs, which are restricted to much smaller body parts. In this expectation, a scatter diagram drawn for the relationship between the total numbers of these wax organs may present a simple but useful device for comparing diaspidine samples.

On the field of the upper scatter diagram in Fig. 2, the samples referred to *A. neolitseae* form its own cluster, which is almost clearly separated from the cluster formed by *A. yabunikkei*. It should be mentioned that the *Cinnamomum*-associated sample of *A. neolitseae* (Sample 6) joins well with the other samples of the species in forming the cluster. On the other hand, the samples of *A. sirodamo* overlap with those of *A. yabunikkei*, the former forming a small cluster situated in the midst of the much larger cluster formed by the latter.

The obvious difference between *A. yabunikkei* and *A. neolitseae* on the diagram is especially noteworthy when contrasted with the close similarity between the two in the primary diagnostic characters. It should be emphasized that this difference is not attributable to any geographical differentiation or variation, because these species are broadly sympatric (*Supplementary notes 2*) and occasionally even syntopic (Section 2.4.1).

The diagram fails to show a clear difference between *A. yabunikkei* and *A. sirodamo* in spite of the fact that they are remarkably different in the primary diagnostic characters. However, the clusters formed by these species differ so greatly in size and extent that they are far from conforming with each other. It should be mentioned here that, if further samples of *A. sirodamo* were available in a good number, especially from Taiwan and the Asian continent (see Section 3.3.1, 3.3.4), they would be strewn broadly on the field of the lower diagram, only a small part of the cluster formed by them overlapping with the cluster of *A. yabunikkei* shown in the upper diagram. (This assumption is made on the premise that the forms occurring in Taiwan and continental Asia really belong to *A. sirodamo*: see Section 3.3.3, 3.3.4.)

2.5. Summary and conclusion

Three groups of samples are formed in the *yabunikkei* complex of *Aulacaspis* occurring in Japan primarily on the basis of the host plants, the body shape at full growth, and the median trullae. The assumption is adopted that these groups represent three species, *A. yabunikkei* and two new species, *A. neolitseae* and *A. sirodamo*. The differences in the primary diagnostic characters appear trifling between *A. yabunikkei* and *A. neolitseae*, whereas sufficiently clear in distinguishing *A. sirodamo* from the other two. A statistical comparison made between syntopic, synchronic, and foliicolous samples of *A. yabunikkei* and *A. neolitseae* in the numbers of the main wax-secreting organs shows significant differences between them, supporting the view that these two species are distinct from each other. A comparison in the correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores enhances the view that *A. neolitseae* is distinct from *A. yabunikkei* as well as from *A. sirodamo*. This comparison, however, is not satisfactory for the detection of any distinct difference between *A. yabunikkei* and *A. sirodamo* probably owing to the insufficient material, especially of *A. sirodamo*. Other comparisons show that the three species have different tendencies in the occurrence or number of certain wax organs on specified body parts. After all, the assumption that the *yabunikkei* complex of *Aulacaspis* comprises the three distinct species in Japan is not to be rejected. The published descriptions and records

made under the name *A. yabunikkei* should be revised from the new viewpoint, and a careful study on abundant material from a broad region of eastern Asia is required for an exhaustive settlement of the *yabunikkei* problem.

Supplementary notes 1–4

Supplementary notes 1. A small sample from Taiwan is referable to *A. yabunikkei* (Section 3.1.1); one sample from Taiwan and another one from Hong Kong are referred to *A. sirodamo* tentatively (3.3.1). These samples are excluded from the examinations made in Section 2.1–2.4.

Supplementary notes 2. The available collection data are still insufficient to show the distribution ranges of the three species in Japan to a considerable extent. So far as based on the material examined in this study (Section 3.1.1, 3.2.1, 3.3.1), *A. yabunikkei* and *A. neolitseae* are sympatric on the Pacific coast of Honsyû; *A. neolitseae* was collected also in northern Kyûsyû once in a locality, and it should occur together with *A. sirodamo* at least in that area. The data offer the prospects of a broader range for *A. yabunikkei*, which probably occurs together with *A. sirodamo* or with both *A. sirodamo* and *A. neolitseae* in some areas in western Honsyû to northern Kyûsyû. As a general principle, closely related forms that have their geographical ranges overlapping only partly should be distinct from each other at the species level.

Supplementary notes 3. Phenotypically different local forms belonging to the same species may be brought about by genetic differentiation or environmental ecophenotypic effect or the combination of both. They may reflect habitat microenvironments as well as geographical environmental gradients. Observations on mounted specimens cannot discriminate among all these factors. On the other hand, feeding-site variation and seasonal variation may be found and analysed when sufficiently large samples are available. A sample (Table 1c, *A. yabunikkei*, Sample 28) shows statistically significant differences between the foliicolous and ramicolous subsamples in the means of the numbers of 'Total dorsal macroducts', 'Total perivulvar disc pores', 'Anterior spiracular disc pores', and 'Posterior spiracular disc pores'. In a sample examined for seasonal variation (Table 1c, *A. neolitseae*, Sample 6), the differences are significant between the full-grown and the teneral specimens in the means of the numbers of 'Total perivulvar disc pores' and 'Lateral macroducts on abd II' and scarcely significant in 'Total dorsal macroducts', 'Lateral macroducts on abd III', 'Lateral gland spines on abd II', and 'Lateral gland spines on abd III'.

Supplementary notes 4. Kawai (1980) mentioned the occurrence of *Aulacaspis alisiana* on *Neolitsea sericea* in Japan with a brief comment on diagnostic characters and a drawing of the pygidial margin. This species was originally described from Ali-Shan, Taiwan, as occurring on *Neolitsea acuminatissima* (Takagi, 1970; a redescription with a newly prepared figure in Takagi, 2010). In the present study, I have failed to find it in Japan, the samples from *N. sericea* falling under *A. neolitseae* or *A. sirodamo*. Kawai's *A. alisiana* apparently does not agree with *A. sirodamo* and probably corresponds to *A. neolitseae* (though his comment and drawing do not exactly point to *A. neolitseae*). A drawing of the median trullae of *A. alisiana* is given for comparison in the chart Fig. 10: *A. alisiana* (Fig. 10S) differs from *A. neolitseae* and the other species of the *yabunikkei* complex in the median trullae much smaller and from *A. neolitseae* and *A. sirodamo* in the side macroducts extending far anteriorly beyond the bases of the median trullae. (In addition, *A. alisiana* has robust prosomatic tubercles, and thereby it was referred to the *tubercularis* species group in Takagi, 2010.) Figures of *Aulacaspis actinodaphnes*, another species described from Taiwan (Takagi, 1970), are also given for comparison (Fig. 9, 10T). *A. actinodaphnes* may be supposed to be similar to *A. sirodamo* in the median trullae and in the relative height of these trullae to the side macroducts, but it has the median trullae much larger and the prosoma less remarkably swollen.

Furthermore, *Aulacaspis cupulifera* and *Aulacaspis cylicophora*, *Neolitsea*-associated species

recently described from southern Japan (Takagi, 2012b), are similar to the *yabunikkei* complex in the pygidial margin and the arrangement of the dorsal macroducts, but they are peculiar in having a pair of large sclerotic discoids (which are assumed to be suckers) on the ventral surface of the mesothorax.

3. Three Species of the Yabunikkei Complex

In Section 2, three distinct species are recognized in the material of the *yabunikkei* complex collected in Japan, one of them being identified with *A. yabunikkei* and the other two, *A. neolitseae* and *A. sirodamo*, remaining to be formally named. In the following lines the three species are described on the basis of the material from Japan, with notes on a few samples collected in Taiwan and Hong Kong and referred to *A. yabunikkei* and *A. sirodamo*.

3.1. *Aulacaspis yabunikkei*
(Table 1a–c, 2a, b; Fig.1, 2, 4, 10)

3.1.1. Material examined

In the original description of *Aulacaspis yabunikkei*, Kuwana (1926) did not specify any collection localities and stated that the species was 'Common in all parts of Japan proper.' However, no record has been made from the Tôhoku District and Hokkaidô, northern Japan. The samples referred to *A. yabunikkei* in the present study were collected in western and southern Japan: on the Pacific coast of Honsyû [Honshû] (Sample 1–14), in Kyûsyû [Kyûshû] including Tusima [Tsushima] (islands north of the mainland of Kyûsyû) (Sample 15–21), and on the Ryûkyû Islands (Sample 22–30; specimens from Sample 25 and 28 are figured in Takagi, 2012b). This species is associated with *Cinnamomum japonicum* and, in southern Japan, occasionally also with other species of *Cinnamomum*. The samples given below were collected from *C. japonicum* unless otherwise stated.

Sample 1–3. Bôsô Peninsula. Sample 1, Kisaradu [Kisarazu], 9.VII.1980; Sample 2, Kiyosumi-yama, 10.X.1980; Sample 3, Kamogawa, 12.X.1980.

Sample 4 and 5. Miura Peninsula. Sample 4, Takatori-yama, 2.VIII.1982; Sample 5, Aburatubo [Aburatsubo], 28.III.1995.

Sample 6–8. Idu [Izu] Peninsula. Sample 6, Itô, 29.III.1984; Sample 7 and 8, Simoda [Shimoda], 4.X.1967 (Sample 7), 25.III.1984 (Sample 8).

Sample 9–14. Kii Peninsula: Sample 9, Hi-no-Misaki, 1.XI.1971; Sample 10, Ryûzin-mura [Ryûjin-mura], 4.XI.1971; Sample 11, Gobô, 1.VIII.1986; Sample 12, Koza, 5.XI.1971; Sample 13, Arahune-Kaigan [Arafune-Kaigan], 5.XI.1971; Sample 14, Sio-no-Misaki [Shio-no-Misaki], 9.I.1962.

Sample 15–18. Tusima (islands north of the mainland of Kyûsyû). Sample 15, Sasuna, 14.V.1969; Sample 16, Mitake, 13.V.1969; Sample 17, Iduhara [Izuhara], 4.V.1969; Sample 18, Utiyama [Uchiyama], 10.V.1969.

Sample 19–21. Southern Kyûsyû. Sample 19, Nitinan-Kaigan [Nichinan-Kaigan], 25.V.1957; Sample 20, Kagosima [Kagoshima], 12.V.1957, on *Cinnamomum camphora*; Sample 21, Sata-Misaki, 26.IV.1963, on *Cinnamomum daphnoides*.

Sample 22–24. Amami-Ôsima [Amami-Ôshima]. Sample 22, Nase, 17.XI.1989; Sample 23, Nase, 13.XI.1989, on *Cinnamomum deoderleinii*; Sample 24, Koniya, 17.V.1975.

Sample 25–27. Tokuno-Sima [Tokuno-Shima]. Sample 25, Amagi-dake, 11.XI.1989; Sample

26, San, 10.XI.1989; Sample 27, Kametu [Kametsu], 9.XI.1989.

Sample 28–30. Okinawa. Sample 28 and 29, Nakizin [Nakijin], 21.III.1989 (Sample 28), 26.III.1989 (Sample 29); Sample 30, Nago, 24.III.1989.

In addition, two specimens are available from Peitou, Taiwan, and from *Cinnamomum* sp. They were recorded (Takagi, 1970) under the name *A. yabunikkei*, and this record has proved correct in view of the revised concept of the species. These specimens, being few and not good in condition, are excluded from the present study.

3.1.2. Recognition characters

Body of fully grown adult female attaining about, or somewhat more than, 1000μm in length; of the-*rosae* type in shape; prosoma moderately swollen, about 0.5 times as wide as body length, roundish along free margin, or rather quadrate with lateral margins behind prosomatic tubercles straight; prosomatic tubercles slightly produced or merged into general outline of prosoma; prepygidial postsoma with lateral sides subparallel; abd II somewhat produced laterally; pygidium usually about 210–255μm long and about 1.2–1.4 times as wide as long, obconical, with pore prominences and rugged processes little produced on abd IV and V. Peribuccal scleroses completely formed or rudimentary or often indiscernible. Submedian macroducts on abd III–V and usually also on VI, divided into segmental and infrasegmental series on III and IV, 1 or a few, rarely none, in each of the series and in segmental series on V, 0–2, usually 1, on VI; submarginal macroducts on abd III–V, 1 to several on each segment; total submarginal macroducts about twice as numerous as total submedian macroducts. Abd II with lateral macroducts as many as those on abd III; with lateral gland spines much fewer than on III. Marginal gland spines 1–4 (mode=2) on abd IV. Median trullae sunken into apex of pygidium almost entirely, divergent, united basally by a small zygotic sclerite, which is usually a little produced anteriorly; each trulla elongate, slightly curved laterally, of the same width throughout, rounded apically, minutely serrate on mesal margin. Marginal macroducts of abd VII extending anteriorly beyond bases of median trullae. Second and third trullae with lobules well developed and a little dilated.

3.1.3. Remarks

The revised concept of *Aulacaspis yabunikkei* is based on the primary diagnostic characters (Section 2.3) and supported by statistical comparisons with the newly recognized species *Aulacaspis neolitseae* and *Aulacaspis sirodamo* in the numbers of the main wax-secreting organs (Section 2.4). The examined samples substantially agree with the figure presented by Kuwana (1926, Plate IX, H–N) especially in the relative height of the median trullae to the marginal macroducts of the seventh abdominal segment. In the present state of my study, *A. yabunikkei* occurs only in Japan and Taiwan. It is not knowable whether the records of *A. yabunikkei* from other areas of Asia included forms corresponding to the revised concept of the species.

3.2. *Aulacaspis neolitseae*, n.sp.
(Table 1c, 2b; Fig. 1, 2, 5, 10)

3.2.1. Material examined

Collected on the Pacific coast of western Honsyû [Honshû] (Sample 1–6) and in Sikoku [Shikoku] (Sample 7) and northern Kyûsyû [Kyûshû] (Sample 8); associated with *Neolitsea*

sericea except for Sample 6, which was obtained from *Cinnamomum japonicum*.

Sample 1 and 2. Bôsô Peninsula. Sample 1, Amatu [Amatsu], 10.X.1980; Sample 2, Kominato, 12.X.1980.

Sample 3. Takatori-yama, Miura Peninsula, 2.VIII.1982.

Sample 4. Miyanosita [Miyanoshita], Hakone, 16.X.1974.

Sample 5. Warabo, Idu [Izu] Peninsusla, 28.V.1955.

Sample 6. Kozagawa, Kii Peninsula, 21.IX.1974 (on *Cinnamomum japonicum* in the grounds of the Hokkaidô University Wakayama Experimental Forest; the identification of the host plant was confirmed by re-examining leaves in the envelope of the dry material).

Sample 7. Senbon-yama [Sembon-yama], Sikoku Mountains, 14.XI.1964.

Sample 8. Inunaki-yama, 2.V.1962.

Described from a total of about 220 specimens, the holotype from Sample 3.

3.2.2. Recognition characters

Fully grown adult female very similar to that of *A. yabunikkei* in body shape and other features. Submedian macroducts usually 1 or 2, occasionally 3 or 4, and sometimes none in each of segmental and infrasegmental series on abd III and IV, 1 or sometimes 2, rarely none, on V, usually none, sometimes 1, on VI; submarginal macroducts 1 or 2, sometimes 3 or 4, on each of abd III–V. Lateral gland spines on abd II tending to be fewer than those on III. Marginal gland spines 2–5 (mode=3) on abd IV. Median trullae slightly attenuating subapically; marginal macroducts of abd VII scarcely or only a little extending anteriorly beyond bases of median trullae.

3.2.3. Remarks

The description given above may be too brief to present a new species. In reality, the stable or relatively stable diagnostic characters adoptable in distinguishing *A. neolitseae* from *A. yabunikkei* are very few. The differences in the shape of the median trullae and the relative height of the trullae to the side macroducts are so slight (Section 2.3) that they may require careful observations. The differences in the occurrence of submedian macroducts on the sixth abdominal segment and in the number of the marginal gland spines on the fourth segment are useful but, usually, only when sufficiently large samples are available (Section 2.4.3). However, the samples of *A. neolitseae* and *A. yabunikkei* compared in Section 2.4.1 (which were collected at the same spot, on the same day, and on the leaves of the host plants) show statistically significant differences in the mean numbers of some wax-secreting organs. In Section 2.4.4, the examined samples of these species form different clusters in the correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores.

The view is adopted that *A. neolitseae* is a distinct species in spite of its close similarity to *A. yabunikkei* in the adopted diagnostic characters. In the present state of my study, it is known only from Japan.

3.3. *Aulacaspis sirodamo*, n.sp.
(Table 1d, 2b, c; Fig. 2, 6–8, 10)

3.3.1. Material examined

Collected in the San'in District on the coast of the Sea of Japan, western Honsyû [Honshû] (Sample 1–4), and in northern Kyûsyû [Kyûshû] (Sample 5), all on the leaves of *Neolitsea sericea*

(called Siro-damo in Japan).

Sample 1–3. Northern Hyôgo Prefecture. Sample 1, Kasumi, 5.X.1977; Sample 2, Hata, near Kasumi, 4.X.1977; Sample 3, Mikawa-yama, 4.X.1977.

Sample 4. Omote-Hikimi-Kyô, Simane [Shimane] Prefecture, 9.X.1977.

Sample 5. Hiko-San, 8.V.1957. (Recorded under the name *A. yabunikkei* previously.)

Some specimens collected at Mozi [Moji], northern Kyûsyû, 24.IX.1949, on *Neolitsea sericea*, deposited in the Takahashi collection, and labelled '*Aulacaspis yabunikkei* Kuwana' are also referable to *A. sirodamo*. They are not good in condition (probably having been collected after their death on the host plant), and are excluded from the present study.

The following two samples are referred to *A. sirodamo* tentatively.

Sample 6. Kenting, Taiwan, 4.IV.1965, on the leaves of an undetermined species of Lauraceae. (This form was described and figured under the name *A. yabunikkei* in Takagi, 1970.)

Sample 7. Hong Kong, 21.IV.1965 (partly collected on 23.IV.1965), on the leaves of *Actinodaphne hypoleucophylla* (determined by Dr S. Hatusima).

Described from a total of about 130 specimens mounted from the samples collected in Japan (Sample 1–5), the holotype from Sample 4. Notes are given for Sample 6 (32 specimens) and 7 (10 specimens).

3.3.2. Recognition characters: Sample 1–5 (from Japan)

Body of fully grown adult female appearing robust as compared with those of *A. yabunikkei* and *A. neolitseae*, with prosoma well swollen, attaining about 0.6 times as broad as body length, and metathorax and abd I and II well lobed laterally; prosomtic tubercles low and broad, or slightly produced, or not discernible; dorsal derm tending to be broadly sclerotized on meso- and metathorax. Peribuccal scleroses, when formed, slender and weakly sclerotized. Submedian macroducts 1–3, occasionally none, in each of segmental and infrasegmental series on abd III and IV, and in segmental series on V, 0 or 1, occasionally 2, on VI; submarginal macroducts usually 3 or 4 on each of abd III–V, occasionally as many as 8 or 9 on III and also on IV. Lateral gland spines usually very few on abd II, much more numerous on III. Marginal gland spines 3–6 (mode=4 or 5) on abd IV. Median trullae rather robust, divergent, each gradually attenuating towards apex and distinctly serrate on mesal margin; basal zygotic sclerite well developed, produced and narrowing anteriorly beyond bases of trullae; marginal macroducts of abd VII not extending anteriorly beyond bases of median trullae.

3.3.3. Notes on Sample 6 (from Taiwan) and 7 (from Hong Kong) (Table 1d, Table 2c; Fig. 2, 8, 10R)

These samples are similar to Sample 1–5 (from Japan) in the shape of the full-grown body, the shape of the median trullae, and the development of the basal zygotic sclerite of the median trullae (which is distinctly produced anteriorly beyond the bases of the trullae), but differ in having smaller median trullae; in particular, Sample 6 is characterized in the median trullae definitely small as compared with those in Sample 1–5, being slightly exceeded by the side macroducts in height, and in their basal zygotic sclerite usually robust with the anterior end more or less roundish.

Sample 6 greatly differs from the other samples in the mean numbers of the dorsal macroducts, the perivulvar disc pores, the disc pores associated with each anterior spiracle, and the lateral gland spines all much larger. In accordance with the abundant dorsal macroducts, usually two submedian macroducts occur on the sixth abdominal

segment. On the contrary, the marginal gland spines of the fourth segment are fewer than in Sample 1–5.

Sample 7 have the perivulvar disc pores and the lateral macroducts tending to be fewer, and the marginal gland spines on the fourth abdominal segment much fewer, than in the other samples.

Sample 6 and Sample 7 remarkably differ not only from Sample 1–5 but also from each other in the correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores. On the lower scatter diagram in Fig. 2, Sample 6 and 7 are plotted distant from Sample 1–5 and from each other and much deviated from the regression line applied to Sample 1–5 and the straight extension of the line. The view is tentatively adopted that all these samples, nevertheless, belong to the same species, being similar in the primary diagnostic characters. The question whether these samples really belong to the same species should be decided on the basis of abundant material from a broader region in eastern Asia.

Sample 6 probably corresponds to Kuwana's (1926) Formosan form of *A. yabunikkei* and also to the form collected in Taiwan by Ferris and identified by Scott (1952) with *A. yabunikkei*, both these forms having been recorded from *Cinnamomum*. Sample 7 may be comparable with *A. yabunikkei* recorded by Scott (1952) and described by Chen (1983) and Tang (1986) from continental China. The figures drawn by all these authors are, as a whole, broadly variable in the total number of the dorsal macroducts and that of the perivulvar disc pores. Furthermore, Chen mentioned two plants of the families Elaeagnaceae and Acanthaceae in addition to three genera of the Lauraceae as the host plants of his *A. yabunikkei*. In the present state of our knowledge, the *yabunikkei* complex is restricted to lauraceous plants at least usually. Chen's records and a few others of unusual host association necessarily arouse a question, which is beyond the present research.

Kwon et al. (2003) and Suh (2013) studied specimens collected in southern Korea on *Neolitsea* and identified them with *A. yabunikkei*. Suh, however, took a critical view about the identification of the Korean form with *A. yabunikkei*. So far as based on the figures they presented, the Korean form is also referable to *A. sirodamo* tentatively.

3.3.4. Remarks

In the *yabunikkei* complex occurring in Japan, *A. sirodamo* is well characterized in the body shape at full growth (Section 2.2) and in the median trullae (2.3); it may be distinguished from *A. yabunikkei* and *A. neolitseae* in the number of the marginal gland spines occurring on the fourth abdominal segment (2.4.3); it differs remarkably from *A. neolitseae* and does not conform exactly to *A. yabunikkei* in the correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores (2.4.4). I think that, in Japan, the problem of the *yabunikkei* complex has found a settlement in recognizing these three forms as distinct species. In a broader geographical scope, however, it has not yet been cleared up. Published records and the limited material available for the present study suggest that some forms referable or closely similar to *A. sirodamo* occur in eastern Asia outside Japan, and the problem is now to be focused on 'the *sirodamo* complex'.

4. Seven Species of Aulacaspis Occurring on Lauraceae

In the course of my study on the *yabunikkei* complex, I have examined the possibility of discovering further forms referable to the complex in tropical Asia, because 'SE Asia' and even 'Java' (Tao, 1999) were included in the distribution range of '*A. yabunikkei*'. I have, however, failed to find such forms in the available Lauraceae-associated material. In this paper, seven species from the material I have checked for that purpose are described. One of them is identified with a little-known species originally described from China, and the other six, all collected in the Malay Peninsula, are described as new.

The examined samples excluding Sample 1 of *A. ferrisi* are available from the collections made in the surveys carried out in Malaysia, Nepal, and India for the projects mentioned under *Contents*. Most of the host plants of the samples from these countries were identified by Mr K. M. Kochummen, Forest Research Institute of Malaysia, botanists of the Department of Medicinal Plants, Nepal, and botanists of the Botanical Survey of India.

4.1. *Aulacaspis ferrisi*
(Table 1d, e, 2c, d; Fig. 11–19)

4.1.1. Published records

This species was described by Scott (1952) on the basis of the material 'Found on undetermined tree at Yeung Kong, Kwangtung Province, China, … on undersurface of leaves'. Chen (1983) described under the name *A. ferrisi* a form collected in Hunan, China, on the leaves of an undetermined tree. (However, the figure drawn by him does not agree with the figure presented in the original description in having on the median trullae a distinct zygotic sclerite, which is produced anteriorly beyond the bases of the trullae.) Tao (1999) gave Yunnan as the distribution range of *A. ferrisi* (but obviously in error). Hua (2000) listed Guangdong ('Kwangtung' in Scott), Hunan (Chen's record), and Yunnan (apparently adopted from Tao) as the known distribution areas of *A. ferrisi*, and mentioned *Litsea pungens*, a deciduous tree of the family Lauraceae, as the host plant of the species (probably following Chou, 1982, who, however, provided no grounds for his host record).

4.1.2. Material examined

I tried to borrow specimens from the type series deposited in the Ferris collection, but none have been available for my study. I have, however, little doubt that the samples examined in the present study have correctly been referred to *A. ferrisi*. The host plants of these samples all belong to the Lauraceae.

Sample 1. Kowloon Peninsula, Hong Kong District, 21.IV.1965, on *Lindera megaphylla* (identified by Dr S. Hatusima).

Sample 2–6. Malay Peninsula. Sample 2 and 3, Cameron Highlands, on *Lindera reticulata*: Sample 2, Mt. Beremban, alt. ca. 1600m, 22.X.1986; Sample 3, Mt. Jasar, alt. ca. 1300m, 17.X.1986. Sample 4, Ulu Kali, Pahang, alt. ca. 1700m, 28.XI.1985, on *Lindera grandis*. Sample 5, Bukit Bauk, Terengganu, 10.VIII.1990, on *Actinodaphne pruinosa*. Sample 6, Desaru, Johor, 19.VIII.1990, on *Actinodaphne* sp.

Sample 7–12. Kathmandu Valley, Nepal Himalayas, alt. ca. 1300–1500m. Sample 7, Gokarna Forest, 16.VIII.1975, on a seedling (*Neolitsea cuipala*?). Sample 8, Bhandarkhal Forest,

11.X.1983, on *Neolitsea cuipala*. Sample 9–12, Nagarjun, on *Lindera nacusua* (determined as '*Lindera nacusa*'), 6.IX.1975 (Sample 9), 12.X.1983 (Sample10 and 11), 18.X.1983 (Sample 12).

Sample 13–19. South India. Sample13–15, Nilgiri Hills, Tamil Nadu: Sample 13, Kallar, alt. ca. 800m, 9.XII.1978, on an undetermined species of Lauraceae; Sample 14 and 15, Mettupalaiyam View, ca. 1000m, 30.XI.1978, on *Litsea ligustrina*. Sample 16 and 17, Anaimalai Hills, Tamil Nadu/Kerala, alt. ca. 800m, 4.XII.1978, on *Cinnamomum* sp. (Sample 16) and an undetermined species of Lauraceae (Sample 17). Sample 18 and19, Periyar Tiger Reserve, Kerala, alt. ca. 900m, 19.XII.1978, on an undetermined species of Lauraceae (Sample 18) and *Cinnamomum zeylanicum* (now *C. verum*) (Sample 19).

Most of the examined specimens are fully grown or nearly so; immature ones various in growing stage are also available. Some samples have specimens mounted from both leaves and branches or twigs. (In Sample 3, however, the foliicolous and ramicolous subsamples are not distinguished in this study for a certain reason.)

Samples collected in the following localities are referable to this species, but they are too small and excluded from the present study: Mt. Kinabalu, Sabah (northeastern Borneo), alt. ca. 1500m, on *Nothaphoebe* sp.; Coonoor, Nilgiri Hills, alt. ca. 1600m, on *Neolitsea* sp.; Periyar Tiger Reserve, on *Actinodaphne hookeri*.

4.1.3. Geographical forms and local variation

The samples were collected in four widely separated geographical regions and, therefore, they may represent four geographical forms. These forms are, however, similar to one another in their adult female features except for the numbers of some wax-secreting organs, which are broadly variable in the samples from the Malay Peninsula and in those from South India.

Sample 1. This sample was collected on the Kowloon Peninsula, about 300km east of the Yeung Kong district (in which the type material was collected), on the branches of the host plant. The specimens are very similar to the figure of *A. ferrisi* presented in the original description, so that they are referable to the species without great difficulty (see also Section 4.1.5). Above all, the agreement is noticeable in the median trullae, which are prominent and joined together through their thick bases with no distinct zygotic sclerite. The only substantial difference is found in the perivulvar disc pores, which are much more numerous in the specimens from the Kowloon Peninsula (provided the figure drawn by Scott is exact in showing these disc pores). This difference, if real, may involve feeding-site effect (as well as local variation), because the comparison is made between the ramicolous specimens from the Kowloon Peninsula and the figure of a foliicolous one from the type series.

Sample 2–6. These samples were collected on the Malay Peninsula, at five localities in four areas, which are widely distant from one another and apparently different in environmental conditions. The median trullae are not much different from those in Sample 1, but with their joined bases somewhat less thick; they are somewhat variable in the degree of divergence, and have the basal zygotic sclerite often discernible. The samples are greatly variable in the total number of the dorsal macroducts and also of the perivulvar disc pores and in the number of the lateral gland spines (especially on the third abdominal segment). Sample 4 has the mean values of the numbers of these organs largest not only among the samples from the Malay Peninsula but also among all the examined samples (Table 1d, e); it is characteristic also in the number of the submedian macroducts on the sixth abdominal segment and in that of the marginal gland spines on

the fourth segment (Table 2c, d); moreover, it has usually two marginal gland spines on the fifth segment (whereas the other samples have a single gland spine at this position). Sample 5 and 6 have the smallest mean values in the numbers of the dorsal macroducts and the perivulvar disc pores among all the examined specimens. If the five samples from the Malay Peninsula really belong all to the same species, the differences in the numbers of the wax organs probably reflect the environmental conditions of the habitats: Sample 2, 3, and 4 were collected on mountains and Sample 4 at the highest altitude among them, whereas Sample 5 on a low hillside and Sample 6 at a spot near the sea-shore, both on the eastern coast of the peninsula.

Sample 7–12. All these samples were collected in the Kathmandu Valley, and are considerably uniform in main features including the numbers of the wax-secreting organs. The median trullae are similar to those in the samples from the Malay Peninsula, but often rather abruptly bent outwards subapically, with the basal zygotic sclerite usually discernible, though often obscure.

Sample 13–19. These samples were collected on hilly areas in South India. The specimens are similar to those from the Kathmandu Valley, but have the median trullae tending to be less strongly bent outwards subapically. They are variable in the numbers of some wax-secreting organs, but not so broadly as the samples from the Malay Peninsula.

Correlation between the mean total numbers of the dorsal macroducts and those of the perivulvar disc pores. This correlation is shown in a scatter diagram (Fig. 3). On the field of the diagram, the examined samples except Sample 4, 5, and 6 are gathered together rather intensively and strewn roughly along a positive trend. Sample 4 has the mean values much larger than those of all the other samples and, in the diagram, is widely distant from the nearest ones of the other samples, thus being isolated in the upper right corner of the field; Sample 5 and 6 have the smallest mean values and are isolated in the lower left corner of the field. Actually, however, these three samples are so plotted as to contribute to pushing up the correlation coefficient to a relatively high value (r=+0.88). Unless this is a mere coincidence, there is no reason for discriminating the three samples from the other ones and excluding them from the cluster formed by the latter. The observed correlation pattern strongly supports the view that all the examined samples belong to the same species. They vary probably in adaptation to the environments of their habitats as suggested by the samples from the Malay Peninsula (see *Sample 2–6* above).

4.1.4. Recognition characters

Body of fully grown adult female robust, attaining over 1400μm in length at maximum, of the-*rosae* type in shape; prosoma broader than long, somewhat wider than metathorax, rounded along free margin; prosomatic tubercles at most suggested by slight prominences; postsoma gradually narrowing caudad; pygidium obconical, broadly variable in size and relative width, usually about 215–255μm long and 1.3–1.5 times as broad as long. No peribuccal scleroses formed. Dorsal macroducts broadly variable in number; submedian macroducts on abd III–V, often also on VI, divided into infrasegmental and segmental series on III and IV, 0–2, at times 3 or 4, on VI; submarginal macroducts on abd III–V. Lateral macroducts and lateral gland spines usually well represented on abd II and III. Marginal gland spines on abd IV variable in number, usually 2 or 3, at times 4 or more, as many as 11 at maximum. Median trullae almost wholly sunken into apex of pygidium, large and thick, elongate, divergent,

united together through thick bases, gently curved and serrate on mesal margins; basal zygotic sclerite clear or obscure, not or scarcely produced anteriorly even when clearly discernible; marginal macroducts of abd VII extending anteriorly beyond bases of median trullae. Second and third trullae well represented, with lobules a little dilated. Marginal processes on abd IV and V low.

4.1.5. Remarks

One of the concerns I have in identifying the material with *Aulacaspis ferrisi* is the body shape. I take the view that the specimen from which Scott (1952) prepared his figure was a considerably but not fully grown one. As usual in the genus, the adult female of this species changes the body shape greatly during her growth. A fully grown adult female (Fig. 11) and two growing ones (Fig. 12, 13), all from Sample 1, are shown for comparison. The thickness of the joined bases of the median trullae and the development of the basal zygotic sclerite of the trullae are somewhat variable in the material, and are also matters of concern. The examined specimens, however, are not divisible into distinct forms on the basis of these features.

In the body shape and the prominent median trullae, this species is similar to *Aulacaspis megaloba*, of which the original form (Scott, 1952) occurs in China on *Rubus* and differs from *A. ferrisi*, above all, in having submedian macroducts on the second abdominal segment. *A. ferrisi* may be related to *Aulacaspis obconica*, n.sp., more closely because of the host association (Section 4.2.3).

4.2. *Aulacaspis obconica*, n.sp.
(Table1f, 2d; Fig. 20)

4.2.1. Material examined

Tanah Rata, Cameron Highlands, Malay Peninsula, alt. ca. 1400m, 14.X.1986, on *Actinodaphne* sp.

Female and male tests occurring on the lower surface of the leaves; female test flat and very thin.

Described from 32 fully grown adult females, one the holotype.

4.2.2. Recognition characters

Body of fully grown adult female robust, attaining about 1000μm in length, of the *rosae*-type in shape; prosoma about 1.5 times as wide as long, rounded along free margin, with prosomatic tubercles suggested by slight prominences; body roughly obconical in outline, metathorax a little narrower than prosoma, then the segments successively narrower caudad; pygidium about 200–210μm long, about 1.2–1.5 times as wide as long. No peribuccal scleroses formed. Each spiracle with a small cluster of disc pores. Submedian macroducts usually (89.0%, n=64) absent from abdomen, occasionally 1 present on abd V. Submarginal macroducts usually (93.8%, n=64) absent, rarely 1 present, on abd III; 1 or 2 present on each of IV and V. Lateral macroducts and lateral gland spines on abd II and III not numerous. Marginal gland spines on abd IV usually 2 or 3, rarely 1. Median trullae deeply sunken into apex of pygidium, elongate, a little attenuating subapically, with mesal margins gently curved and minutely serrate; united basally through a sclerite, which is slightly or scarcely produced anteriorly. Marginal macroducts of abd VII not extending anteriorly beyond bases of median trullae. Second

and third trullae well represented, with lobules dilated, roundish apically. Marginal processes of abd IV and V low.

4.2.3. Remarks

This species is comparable with *Aulacaspis ferrisi* (Section 4.1) in the body robust and tapering posteriorly and in the median trullae large and deeply sunken into the apex of the pygidium. It differs from the latter remarkably in the arrangement of the dorsal macroducts, which are usually absent in the submedian areas and in the submarginal area of the third abdominal segment. It is distinguishable also in the median trullae, which are distinctly narrower than in *A. ferrisi*. It is known from the Cameron Highlands, on which *A. ferrisi* also occurs.

4.3. *Aulacaspis ulukaliana*, n.sp.
(Table 1f, 2d; Fig. 21)

4.3.1. Material examined

Sample 1 and 2. Ulu Kali, Pahang, Malay Peninsula, alt. ca. 1700m, on *Lindera concinna*, 5.X.1986 (Sample 1), 29.VI.1990 (Sample 2).

Female and male tests occurring on the lower surface of the leaves; female tests flat, very thin.

The description is based on 32 adult females from Sample 1 and another 32, one the holotype, from Sample 2, all fully grown.

4.3.2. Recognition characters

Body of fully grown adult female rather slender, of the *rosae*-type in shape, usually about 600–700μm, 790μm at maximum, in length; prosoma somewhat wider than long, the frontal margin broadly rounded, then curved onto perpendicular lateral margins, with prosomatic tubercles sometimes produced; metathorax a little but distinctly narrower than prosoma; abd I–III slightly narrower than metathorax; pygidium usually about 160–190μm long, narrow, about 1.0–1.3 times as wide as long. Peribuccal scleroses ill formed and not sclerotized, or indiscernible. Anterior spiracles each with a small cluster of disc pores; posterior spiracles each with a small number of disc pores. Submedian macroducts very few; 1 present or often none on abd III; often 1 present on IV; usually 1 present on V; often (57.8%, n=64, in Sample 1) or at times (25.0%, n=64, in Sample 2) 1 present on VI. Submarginal macroducts also very few; 1 present or none on abd III; usually 1 and at times 2 present, rarely none, on IV; usually 1 or 2 and at times 3 present, rarely none, on V. Lateral macroducts and lateral gland spines few especially on abd II, at times no gland spines on II. Marginal gland spines usually 2, rarely 1 or 3, on abd IV. Perivulvar disc pores not numerous. Median trullae sunken into apex of pygidium, moderately divergent, elongate, with mesal margins abruptly curved outwards at about apical third, serrate especially apically to the curve; basally united together by a pair of small sclerites, which are confluent with a pair of slender sclerotized lines on the ventral surface of the pygidium. Marginal macroducts of abd VII extending anteriorly beyond bases of median trullae. Second and third trullae with lobules dilated. Marginal processes of abd IV and V not much produced.

4.3.3. Remarks

This species is similar to *Aulacaspis tubercularis* (revised by Takagi, 2010) in the median trullae and the pygidial margin, but it is smaller than the latter in the size of the pygidium and also of the fully grown body, and differs in having the prosomatic tubercles at most suggested by angles on the prosomatic margin and in the wax-secreting organs generally very few. If it is really closely related to *A. tubercularis*, it may represent a diminished form derived from the latter.

4.4. *Aulacaspis medangena*, n.sp.
(Table 1f, 2d; Fig. 22–24)

4.4.1. Material examined

Three samples were collected in the Malay Peninsula and Penang Is. (an island off the western coast of the peninsula) on lauraceous plants (called medang in Malaysia).

Sample 1 and 2. Bukit Bendera, Plau Pinang [Penang Is.], 19.XI.1991, on *Litsea* sp. (Sample 1); 21.XI.1991, on *Cinnamomum porrectum* (Sample 2).

Sample 3. Bukit Nanas, Kuala Lumpur, 23.VIII.1990, on *Lindera lucida*.

Female and male tests occurring on the leaves, females on both surfaces and males on the lower surface; female tests thick, somewhat convex dorsally.

The description is based on 14 specimens from Sample 1, 8 from Sample 2, and 17, one the holotype, from Sample 3, all fully grown adult females. A few teneral adult females are also available from Sample 3, and one of them is figured (Fig. 24).

4.4.2. Recognition characters

Body of fully grown adult female robust, attaining about 1000μm in length, of the *rosae*-type in shape; prosoma about 1.5 times as wide as long, roundish, prosomatic tubercles suggested by slight prominences; body gradually tapering from prosoma to pygidium in rough outline, abd II at times produced laterally; pygidium about 200–230μm long, about 1.2–1.5 times as wide as long. Peribuccal scleroses rudimentary or indiscernible. Submedian macroducts usually on abd I–VI, sometimes lacking on I and VI; 0–6 on I, often divided into infrasegmental and segmental series; a few to several ones in each of infrasegmental and segmental series on II–IV; a few ones on V; 1 usually (64–86%) present on VI. Submarginal macroducts usually on abd II–V, rarely none on II, a few to several ones on each segment; rarely 1 present on I. Marginal gland spines 2–4, usually 2 or 3, on abd IV. Median trullae sunken into apex of pygidium, divergent, elongate, with mesal margins curved and serrate; basally appearing united together, with a pair of small sclerites confluent with a pair of sclerotized lines on the ventral surface of the pygidium. Marginal macroducts of abd VII not or scarcely extending anteriorly beyond bases of median trullae. Second and third trullae with lobules dilated. Pore prominences on abd IV and V often with a pointed process.

4.4.3. Remarks

This species is very similar to *Aulacaspis scaphocalycis* especially in the pygidial margin. The latter species was described as a member of the *tubercularis* species group on the basis of the material collected from *Scaphocalyx* and several other plants but not from Lauraceae (Takagi, 2010). *A. medangena* differs from *A. scaphocalycis* in the prosomatic tubercles little produced, in having, usually, submedian macroducts on the first abdominal segment and submarginal macroducts on the second, in lacking distinct

peribuccal scleroses, and in some other details. The differences in the arrangement of the dorsal macroducts are remarkable and may be adopted as diagnostic ones in distinguishing the two species. Such differences, however, may occur also within a single species geographically, locally, or individually and, in fact, each of the examined samples is not entirely stable in the occurrence of dorsal macroducts, especially in the basal region of the abdomen. The other differences between the two are much less remarkable or even rather trifling. It may be questioned, therefore, whether the two are really distinct from each other. In spite of all this, there is no definite reason for uniting them into one and the same species.

4.5. *Aulacaspis kedahana*, n.sp.
(Table 1f, 2d; Fig. 25)

4.5.1. Material examined

Mt. Jerai, Kedah, Malay Peninsula, alt. 930m, 5.XI.1991, on *Neolitsea kedahensis*,.

Female and male tests occurring on the lower surface of the leaves; female tests small and thin, inconspicuous in situ.

Described from 32 fully grown adult females, one the holotype.

4.5.2. Recognition characters

Body of fully grown adult female rather slender, of the *rosae*-type in shape, attaining 880μm in length at maximum; prosoma somewhat wider than long, roughly pentagonal in outline, prosomatic tubercles suggested by rounded prominences; postsoma rather slender, roughly parallel-sided on metathorax to abd III, abd II tending to be produced; pygidium about 170–200μm long, about 1.2–1.4 times as wide as long, little rounded marginally. Peribuccal scleroses ill formed or indiscernible. Anterior spiracles each with a small cluster of disc pores; posterior spiracles each with a few to several disc pores. Submedian macroducts very few, usually 1 present on each of abd III–V, at times none on one or two of these segments. Submarginal macroducts usually 1 or sometimes 2 on each of abd III–V, none at times on III and rarely on IV. Lateral macroducts and lateral gland spines few, at times none, on abd II, not numerous also on III. Marginal gland spines 2–4, usually 3, on abd IV. Median trullae sunken into apex of pygidium, large, elongate, moderately divergent, joined together through thick bases, each with mesal margin serrate, gently rounded, apically meeting lateral margin, with which it forms a narrow angle. Marginal macroducts of abd VII much shorter than median trullae. Lobules of second and third trullae, especially mesal lobule of the second, tending to be narrowed. Marginal processes of abd IV and V not prominent.

4.5.3. Remarks

This species is characteristic in having the prosoma roughly pentagonal in outline. Its possible relationships to *A. cinnamomorum* (Section 4.6) and *A. jeraiana* (4.7) are mentioned in Section 4.7.3.

4.6. *Aulacaspis cinnamomorum*, n.sp.
(Table 1f, 2d; Fig. 26, 27)

4.6.1. Material examined

Collected in the Malay Peninsula on two species of *Cinnamomum*.

Sample 1. Mt. Beremban, Cameron Highlands, alt. 1540m, 22.X.1986, on *Cinnamomum scortechinii*.

Sample 2. Bukit Fraser [Fraser's Hill], Pahang, alt. ca. 1300m, 25.X.1986, on *Cinnamomum scortechinii*.

Sample 3. Ulu Gombak, Selangor, alt. ca. 1000m, 20.VI.1990, on *Cinnamomum impressicostatum*.

Female and male tests occurring on the leaves, on the lower surface or on both surfaces; female tests small, flat, and thin.

The description is based on 24 specimens from Sample 1, 14 from Sample 2, and 30, one the holotype, from Sample 3, all fully grown adult females.

4.6.2. Recognition characters

Body of fully grown adult female rather slender, of the *rosae*-type in shape, attaining about 800μm in length at maximum; prosoma somewhat wider than long, rounded on free margin, with prosomatic tubercles indiscernible or suggested by slight prominences; postsoma roughly parallel-sided on metathorax to abd III; pygidium about 140–180μm long, broad, being about 1.3–1.7 times as wide as long, little roundish. Peribuccal scleroses ill formed or indiscernible. Anterior spiracles each with a very small cluster of disc pores; posterior spiracles each with a small number of disc pores. Submedian macroducts absent. Submarginal macroducts very few, at most 1 or 2 on each of abd III–V, often lacking on III and also on IV. Lateral macroducts and lateral gland spines lacking on abd II except for rare occurrence of 1 macroduct or 1 gland spine; not numerous on III. Marginal gland spines 1–3, usually 2, on abd IV. Median trullae sunken into apex of pygidium, large, moderately divergent, joined together basally, mesal margin serrate, gently rounded, apically meeting lateral margin, with which it forms a narrow angle. Marginal macroducts of abd VII much shorter than median trullae. Second and third trullae with lobules narrowed in various degrees. Marginal processes of abd IV and V not prominent. Marginal macroduct on abd III sometimes lacking.

4.6.3. Remarks

This species is characteristic in having narrow lateral trullae, which are, however, variable in breadth. Fig. 26F and 27F show opposite extremes in this variation. The possible relationships of the species to *A. kedahana* (Section 4.5) and *A. jeraiana* (4.7) are mentioned in Section 4.7.3.

4.7. *Aulacaspis jeraiana*, n.sp.
(Table 1f, 2d; Fig. 28)

4.7.1. Material examined

Mt. Jerai, Kedah, Malay Peninsula, alt. ca. 500m, 8.XI.1991, on *Litsea grandis*.

Female and male tests occurring on the lower surface of the leaves, female tests also on the upper surface; female tests small and thin; male tests tricarinate as usual in the genus, standing oblique to the leaf surface, with the ventral portion well formed (the second instar male having many small ducts on the ventral surface as well as on the dorsal.)

Described from 29 fully grown adult females, one the holotype.

4.7.2. Recognition characters

Body of fully grown adult female robust, of the *vitis*-type in shape, attaining nearly 1000μm in length at maximum; body broadest across mesothorax, then abruptly narrowing on head, gradually narrowing caudad on postsoma, abd II tending to be produced; pygidium about 160–200μm in length, broad, being about 1.3–1.6 times as wide as long. Interantennal tubercle or swellings and interantennal derm pockets often present, but variable in development. Peribuccal scleroses not formed. Anterior spiracles each with a small cluster of disc pores; posterior spiracles with no accompanying disc pores. Submedian macroducts usually (96.6%, n=58) absent, rarely 1 occurring on abd V. Submarginal macroducts on abd III–V, usually 2, rarely 1, on each of III and IV, 1 or 2 on V. Lateral macroducts usually few on abd II and III, at times lacking on II; lateral gland spines few on abd II, not numerous on III. Marginal gland spines 1–3, usually 2, on abd IV. Median trullae sunken into apex of pygidium, large, divergent, united basally by a distinct zygotic sclerite, which is produced anteriorly a little beyond the bases of the trullae; mesal margin serrate, broadly rounded, apically meeting lateral margin, with which it makes a sharp angle. Marginal macroducts of abd VII much shorter than median trullae. Second and third trullae with lobules (especially inner ones) somewhat narrowed. Marginal processes on abd IV and V not prominent.

4.7.3. Remarks

The last three species described in this paper, *Aulacaspis kedahana*, *A. cinnamomorum*, and *A. jeraiana*, are commonly characterized in the median trullae pointed at the apex, where the mesal margin meets the lateral to form an angle, in the lateral trullae with the lobules, especially inner ones, narrowed in various degrees (often much narrowed in *A. cinnamomorum*), and in the dorsal macroducts remarkably reduced in occurrence and number. In the genus in general, the pointed median trullae and the narrowed lobules of the lateral trullae are rare, and the drastic reduction of the dorsal macroducts is also unusual, and the common occurrence of these characters in the three species suggests that these species are closely related to one another. These species, however, are remarkably different in body shape: the first two belong to the *rosae*-type, whereas the third to the *vitis*-type; the first has a roughly pentagonal prosoma, whereas the second a rounded one.

The possibility that the similarity among these three species in the pygidial features and also in the occurrence of the dorsal macroducts is due to convergence is not to be ruled out, though there is no clue as to any particular factor that may be responsible for the possible convergence. The other possibility that these species compose a taxonomically significant group is not easily rejected, but it finds no firm grounds, either. The possible species group composed of these three species does not represent an isolated case of the combination of the *rosae*-type and the *vitis*-type. The *calcarata* species group of *Aulacaspis* was proposed for seven species, of which five belong to the *rosae*-type and the other two to the *vitis*-type (Takagi, 1999). (See Supplementary notes 5 for a general comment.)

It should be added that the features called interantennal tubercle or swellings and interantennal derm pockets are often found in the species of the *vitis*-type (Takagi, 1999, 2012). In general, however, these features are very variable in development even on the opposite sides of the head, and not infrequently they disappear, leaving no trace. It seems that they do not occur at all in some species of the *vitis*-type. In this regard, the presence

or absence of these features may present no serious difficulty in combining the *vitis*-type with the *rosae*-type in a species group (apart from their functions and evolutionary significance, which remain unclarified).

Supplementary notes 5

The adult females of the Coccoidea are interpreted to be neotenic, being similar to the nymphs of the preceding instar in general body structure. In other words, they are nymphs provided with organs, functions, and behaviours necessary for reproduction. On this view, it is not very surprising that nymphs, of the female or even of the male, were mistaken for adult females occasionally. In the family Diaspididae, at least three cases of the nymph-adult mistake are known, and the taxonomic interpretations given by the authors concerned are questionable or erroneous (Takagi, 2003). Recently, Wu (2011) proposed and described *Mammilla jinzhaiensis* as based on diaspidid adult females occurring on the bamboo *Indocalamus migoi* (‘*Indocamus migoi*’) in Anhui, China, but the figure in the description apparently shows an aclerdid nymph probably of the male. (*Mammilla* Wu, 2011, therefore, should be synonymous with *Aclerda* Signoret, 1874, or *Nipponaclerda* McConnell, 1954, family Aclerdidae; it is homonymous with the gastropod genus *Mammilla* Schumacher, 1817.)

With some exceptions the adult females continue to grow, increasing in size and changing in body shape. In the course of growth, the diaspidid adult females (except those of the pupillarial forms) increase greatly in the size of the prepygidial region and change, sometimes remarkably, in the outline of the region owing to different growth rates on different parts of the region, whereas they remain practically unchanged in the size and shape of the pygidium (see Takagi, 2013, for examples in some *Aulacaspis* species of the *rosae*-type). This fact leads to the reasonable assumption that, in the course of evolution, some prepygidial features including the growth-rate differentiation change easily as compared with pygidial ones, which tend to be conservative. If this assumption is correct, it affords a probable explanation for the occasional occurrence of remarkably different body shapes in the same species, species groups, genera, and so on.

References

Chen Fang-G., 1983. The Chionaspidini (Diaspididae, Coccoidea, Homoptera) from China. Chengtu, 175pp.

Chou, Io, 1982. Monographia Diaspididarum Sinensium I. Shaanxi-a Eldonejo de Scienco kaj Tekniko, 195pp.

Hua L.-z., 2000. List of Chinese Insects I. Zhongshan University Press, 448pp.

Kawai, S., 1980. Scale Insects of Japan in Colors. Zenkoku-Nôson-Kyôiku-Kyôkai, 455pp.

Kuwana, I., 1926. The diaspine Coccidae of Japan, IV. Department of Finance, Japan, Imperial Plant Quarantine Service, Technical Bulletin 4, 44pp, Pl. I–XII.

Kwon, G.-M., Han, M.-J., and Lee, Y.-H., 2003. The genus *Aulacaspis* Cockerell, 1893 (Sternorrhyncha, Diaspididae) in Korea. Korean Journal of Applied Entomology 42: 15–20.

Scott, C. L., 1952. The scale insect genus *Aulacaspis* in eastern Asia. Microentomology 17: 33–60.

Suh, S.-J., 2013. On the armored scales, genus *Aulacaspis* Cockerell (Hemiptera: Diaspididae), of Korea. Insecta Mundi 0295: 1–8.

Takagi, S., 1970. Diaspididae of Taiwan based on material collected in connection with the Japan-U.S. Co-operative Science Programme, 1965 (Homoptera: Coccoidea) Part

II. Insecta Matsumurana 33, 146pp.
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. Notes on two lepidosaphidine scale insects described from Japan (Homoptera: Coccoidea: Diaspididae). Japanese Journal of Systematic Entomology 9: 171–175.
Takagi, S., 2010. The *tubercularis* species group of *Aulacaspis* (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana New Series 66: 57–114.
Takagi, S., 2012. Atypical species of *Aulacaspis* (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana New Series 68: 17-115.
Takagi, S., 2012b. Two new species of *Aulacaspis* from Japan, with notes on a strange organ and seasonal variation (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana New Series 68: 117–132.
Takagi, S., 2013. Some species of *Aulacaspis* related to mangrove-associated Australian species (Sternorrhyncha: Coccoidea: Diaspididae). Insecta Matsumurana New Series 69: 41-95.
Tang Fang-teh, 1986. The Scale Insects of Horticulture and Forest of China III. Shanxi Agricultural University, 305pp.
Tao, C. C.-c., 1999. List of Coccoidea (Homoptera) of China. Taiwan Agricultural Research Institute, Special Publication 78, 176pp.
Wu Shi-jun, 2011. Description of a new genus and new species of Diaspididae (Hemiptera: Coccoidea) from Anhui Province, China. Entomotaxonomia 33: 241–244.

Table 1. Numbers of main wax-secreting organs.

Table 1a	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis yabunikkei								
Sample 1 f	27-36.5-44 n=13	71-82.2-93 n=13	9-13.2-16 n=26	4-5.2-7 n=26	3-5.4-8 n=26	4-5.7-7 n=25	0(4.0%)-2.4-4 n=25	3-7.5-10 n=25
Sample 2 f	31-37.9-45 n=32	67-81.3-92 n=32	10-16.6-23 n=61	3-6.6-11 n=63	4-5.7-8 n=62	5-6.0-8 n=63	2-2.9-5 n=62	6-7.9-10 n=63
Sample 2 r	35-44.6-54 n=16	76-88.0-97 n=16	12-21.4-31 n=26	6-8.5-16 n=31	4-6.2-9 n=32	4-6.3-8 n=30	2-4.3-6 n=30	5-8.9-12 n=30
Sample 3 f	22-37.0-48 n=25	64-80.7-101 n=27	7-13.8-20 n=53	4-5.5-11 n-52	4-5.7-8 n=52	5-6.1-9 n=51	1-2.8-5 n=51	6-8.0-10 n=51
Sample 4 f	26-42.3-50 n=30	68-82.8-97 n=30	10-15.5-26 n=60	4-6.3-12 n=60	4-5.5-9 n=58	4-6.0-8 n=57	1-2.9-5 n=58	6-7.9-10 n=56
Sample 5 f	34-43.1-49 n=15	71-84.5-97 n=15	10-13.9-19 n=30	3-4.9-8 n=30	5-5.8-7 n=29	5-5.9-7 n=29	2-2.9-4 n=29	3-8.0-10 n=29
Sample 6 f	27-42.3-51 n=32	66-81.5-95 n=32	7-14.2-28 n=64	4-6.7-10 n=64	4-5.7-8 n=63	4-5.9-7 n=63	1-3.1-5 n=64	6-8.1-9 n=63
Sample 7 f	28-34.4-44 n=32	67-79.0-96 n=32	8-13.0-18 n=63	1-4.9-8 n=64	4-5.7-8 n=63	4-6.0-8 n=63	1-2.5-5 n=63	6-7.7-9 n=63
Sample 8 f	25-33.7-48 n=32	67-77.9-97 n=32	8-13.0-19 n=64	3-5.4-11 n=64	4-5.9-7 n=64	4-5.8-7 n=64	1-2.4-5 n=64	5-7.4-9 n=64
Sample 9 f	22-32.3-41 n=32	62-77.4-93 n=32	7-13.2-19 n=64	4-5.6-12 n=64	4-5.1-7 n=63	3-5.5-8 n=63	1-2.0-3 n=58	5-7.1-9 n=58
Sample 9 r	25-28.8-33 n=4	63-72.8-78 n=5	12-16.5-21 n=10	4-6.4-8 n=9	5-5.1-6 n=10	4-5.2-7 n=10	1-2.5-4 n=10	6-7.1-8 n=10
Sample 10 f	28-35.0-47 n=31	65-76.2-89 n=31	9-14.6-25 n=61	4-6.3-10 n=62	3-5.6-8 n=60	3-6.0-8 n=61	1-2.5-4 n=61	6-7.8-10 n=62
Sample 11 f	13-22.3-34 n=27	48-63.3-78 n=27	6-13.1-20 n=51	3-5.6-9 n=53	2-4.2-6 n=47	3-4.8-6 n=48	1-1.9-3 n=47	4-6.3-8 n=48
Sample 12 r	27-36.9-48 n=14	59-77.7-96 n=13	13-17.3-23 n=28	4-7.4-13 n=28	3-5.3-7 n=27	3-5.6-7 n=28	1-2.7-6 n=27	5-7.6-10 n=28
Sample 13 r	15-33.0-46 n=26	54-75.5-99 n=26	10-15.8-24 n=49	3-6.6-11 n=52	3-5.0-7 n=51	3-5.4-8 n=52	1-2.6-4 n=51	2-7.1-10 n=52

f: follicolous specimens; r: ramicolous specimens
27-36.5-44: lowest, mean, and highest values
n: sample size

Table 1b	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis yabunikkei								
Sample 14 f	14-24.1-33 n=24	50-64.5-77 n=24	5-12.6-18 n=48	2-5.4-8 n=48	4-5.0-7 n=48	4-5.4-7 n=48	0(8.5%)-1.7-4 n=47	3-5.8-7 n=48
Sample 15 f	25-34.8-42 n=11	57-78.1-95 n=11	10-15.1-25 n=22	4-6.1-9 n=22	4-5.4-8 n=22	4-6.1-7 n=22	1-2.6-4 n=22	5-7.1-8 n=22
Sample 16 f	27-34.0-42 n=7	59-70.7-79 n=7	10-14.0-24 n=14	4-5.8-8 n=14	3-5.1-6 n=12	5-6.2-7 n=12	1-2.1-3 n=11	4-7.4-9 n=11
Sample 17 f	23-34.7-46 n=26	61-79.1-98 n=26	8-14.8-27 n=50	4-7.0-11 n=48	3-5.1-8 n=52	3-5.6-9 n=52	1-2.8-6 n=52	4-7.4-10 n=52
Sample 18 f	22-38.5-49 n=32	60-77.9-95 n=32	9-12.6-18 n=63	3-5.8-9 n=62	4-6.1-8 n=63	4-6.1-9 n=64	2-3.5-6 n=63	6-8.3-14 n=64
Sample 19 f	28-37.0-45 n=5	62-75.0-84 n=5	11-14.5-22 n=10	5-7.0-10 n=10	4-4.7-6 n=10	3-5.9-7 n=10	2-3.0-5 n=10	6-7.6-10 n=10
Sample 19 r	32-39.3-46 n=6	70-83.2-97 n=6	11-15.6-24 n=11	3-7.4-13 n=12	2-5.8-8 n=12	5-6.0-7 n=12	2-3.1-5 n=12	6-8.0-10 n=12
Sample 20 f	24-35.7-47 n=6	65-75.2-89 n=6	9-13.1-20 n=14	3-5.1-8 n=14	4-5.3-8 n=14	4-5.6-7 n=14	2-3.6-5 n=13	5-7.3-9 n=12
Sample 20 r	34-45.4-53 n=10	64-79.6-93 n=10	12-16.7-21 n=18	5-7.3-10 n=19	4-5.9-7 n=20	5-6.5-9 n=20	3-4.3-7 n=18	5-7.5-10 n=19
Sample 21 f	18-31.7-50 n=6	51-66.2-81 n=6	6-12.2-19 n=12	4-5.9-9 n=12	3-3.9-5 n=12	4-4.4-6 n=12	2-2.8-7 n=12	5-6.4-8 n=12
Sample 22 f	12-22.7-44 n=32	44-71.2-93 n=32	6-12.2-20 n=61	2-4.4-10 n=64	1-4.1-6 n=64	2-4.9-6 n=62	0(12.5%)-1.3-4 n=64	2-6.1-8 n=62
Sample 23 f	13-20.8-29 n=30	42-59.7-75 n=31	8-12.2-18 n=60	2-4.7-7 n=62	2-3.7-6 n=59	3-3.9-6 n=60	0(3.4%)-1.6-3 n=58	4-5.8-8 n=59
Sample 24 f	26-35.9-44 n=32	71-82.9-95 n=32	9-15.2-22 n=64	2-4.6-8 n=62	4-5.7-7 n=64	4-5.5-7 n=60	1-3.5-6 n=62	5-7.6-11 n=59
Sample 25 f	22-26.3-36 n=24	60-70.6-85 n=24	8-14.8-19 n=48	2-4.8-8 n=48	4-5.0-7 n=48	4-5.3-7 n=47	0(6.3%)-1.7-3 n=48	5-6.4-8 n=47
Sample 26 f	13-23.3-37 n=29	45-67.2-87 n=29	7-12.0-20 n=59	2-4.5-8 n=60	3-4.8-7 n=54	3-4.9-6 n=55	0(1.9%)-1.8-5 n=52	4-6.5-10 n=53
Sample 26 r	22-26.4-40 n=5	75-81.0-91 n=5	12-15.6-19 n=10	5-6.4-7 n=9	5-6.3-8 n=10	4-5.9-7 n=10	2-4.1-7 n=10	7-8.3-10 n=10

Table 1c	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis yabunikkei								
Sample 27 f	13-24.3-31 n=32	50-68.3-77 n=31	8-14.1-20 n=63	2-5.2-8 n=64	4-5.7-7 n=64	4-5.5-7 n=64	1-2.2-4 n=64	4-6.9-9 n=64
Sample 28 f	19-30.0-47 n=30	60-80.3-101 n=31	9-15.0-24 n=61	2-6.7-12 n=62	3-5.4-9 n=62	4-5.5-7 n=61	2-3.3-6 n=60	4-7.4-10 n=61
Sample 28 r	26-42.3-54 n=31	66-93.2-112 n=31	11-20.2-29 n=62	5-9.3-15 n=62	3-5.7-9 n=61	4-6.0-9 n=62	1-3.7-7 n=61	6-7.6-10 n=62
Sample 29 f	25-38.5-51 n=16	66-84.8-94 n=16	9-15.0-20 n=32	4-6.1-8 n=32	4-5.7-7 n=31	4-6.0-7 n=30	1-2.8-5 n=30	6-7.9-10 n=30
Sample 29 r	31-37.5-45 n=8	83-88.1-95 n=8	16-19.1-24 n=16	7-8.6-11 n=16	3-4.5-6 n=16	4-5.1-7 n=16	1-3.6-5 n=16	5-7.1-9 n=16
Sample 30 r	30-46.4-59 n=31	78-90.4-109 n=31	7-19.3-31 n=61	6-8.4-13 n=62	4-5.8-9 n=61	4-6.4-9 n=61	2-3.7-6 n=60	6-8.4-11 n=59
Aulacaspis neolitseae								
Sample 1 f	21-24.0-27 n=8	76-79.3-83 n=8	8-10.8-14 n=16	3-4.4-7 n=16	4-6.3-8 n=16	5-6.5-8 n=16	4-5.2-7 n=16	6-7.9-10 n=16
Sample 2 f	21-29.8-38 n=60	72-93.3-111 n=60	7-11.8-15 n=121	4-5.8-8 n=121	5-6.6-10 n=118	5-7.2-11 n=119	4-6.1-8 n=118	6-8.4-11 n=118
Sample 3 f	20-24.9-30 n=30	70-81.0-94 n=30	7-10.4-16 n=60	3-4.9-8 n=60	4-6.8-10 n=59	5-6.1-9 n=60	2-5.3-8 n=59	5-7.5-9 n=60
Sample 4 f	22-27.3-32 n=30	75-85.9-93 n=30	9-12.8-16 n=60	4-6.3-8 n=60	5-7.1-9 n=60	6-7.6-9 n=60	3-6.2-8 n=60	6-8.5-10 n=60
Sample 5 f	21-25.4-30 n=21	79-91.4-102 n=21	8-13.1-18 n=40	4-6.3-10 n=37	5-7.8-11 n=42	5-7.8-10 n=42	4-6.3-9 n=38	5-8.7-10 n=37
Sample 6 f	13-17.7-22 n=22	60-68.1-77 n=22	8-11.9-17 n=43	3-5.0-9 n=43	2-4.5-8 n=43	3-5.1-7 n=43	2-3.8-6 n=43	4-6.1-8 n=43
Sample 6 f (teneral)	17-21.7-27 n=32	72-80.2-89 n=32	6-12.5-17 n=64	4-5.6-8 n=64	3-5.5-8 n=61	4-5.9-9 n=61	3-5.0-7 n=60	5-7.5-9 n=61
Sample 7 f	17-21.1-25 n=9	62-78.9-88 n=10	7-11.6-17 n=19	4-5.4-8 n=18	2-5.6-8 n=16	5-5.8-7 n=17	2-5.0-7 n=16	5-7.1-9 n=17
Sample 8 f	16-19.8-24 n=5	62-73.8-78 n=5	8-9.5-12 n=10	4-5.0-8 n=10	4-5.1-6 n=10	5-6.1-8 n=10	3-3.7-5 n=10	6-6.9-8 n=10

Table 1d	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis sirodamo								
Sample 1 f	26-36.3-47 n=30	71-81.1-92 n=30	4-7.1-9 n=60	3-5.4-9 n=60	9-12.2-17 n=60	7-10.6-14 n=60	1-2.3-4 n=60	9-11.8-15 n=60
Sample 2 f	34-40.2-47 n=32	71-83.3-92 n=32	3-7.8-11 n=63	4-5.8-8 n=64	8-11.4-14 n=59	7-10.1-14 n=63	1-2.4-5 n=62	6-10.5-13 n=63
Sample 3 f	32-38.5-44 n=32	71-82.2-95 n=32	5-7.4-10 n=64	1-5.3-9 n=64	6-10.0-13 n=64	5-8.9-14 n=64	0(1.7%)-2.3-4 n=64	7-9.9-13 n=64
Sample 4 f	24-32.2-42 n=30	66-78.0-85 n=30	3-6.2-9 n=60	2-4.9-9 n=58	6-8.8-12 n=60	5-7.3-9 n=60	1-1.8-3 n=60	7-8.6-12 n=60
Sample 5 f	27-31.7-36 n=7	73-79.3-85 n=7	6-8.1-12 n=10	3-4.6-6 n=8	7-8.7-12 n=14	7-8.4-10 n=14	1-2.4-3 n=14	8-8.9-11 n=14
Sample 6 f	45-70.1-85 n=32	99-115.6-139 n=31	10-15.1-20 n=64	3-6.5-10 n=64	4-7.0-9 n=63	5-7.3-10 n=64	3-5.5-7 n=63	6-8.8-12 n=63
Sample 7 f	25-34.3-45 n=9	60-63.3-87 n=9	7-11.1-14 n=18	3-4.4-7 n=18	3-4.6-6 n=20	4-5.7-7 n=20	1-1.9-4 n=18	6-7.2-9 n=19
Aulacaspis ferrisi								
Sample 1 r	31-51.7-66 n=32	84-102.5-124 n=32	13-22.1-34 n=56	3-6.7-13 n=62	3-6.3-10 n=58	4-6.0-8 n=62	4-6.5-9 n=58	6-8.6-12 n=62
Sample 2 f	35-57.3-73 n=20	90-111.3-129 n=20	11-19.2-30 n=37	5-7.0-12 n=37	5-9.5-13 n=32	5-8.6-12 n=36	5-7.3-10 n=32	7-9.6-13 n=36
Sample 3 f+r	24-59.1-87 n=32	91-118.5-152 n=35	12-21.6-23 n=50	5-8.1-12 n=60	5-8.7-12 n=66	5-7.9-11 n=66	3-6.6-10 n=66	7-9.5-13 n=66
Sample 4 f	90-105.8-116 n=6	132-143.3-166 n=6	12-13.1-14 n=10	5-7.3-8 n=12	7-8.5-10 n=12	6-7.4-10 n=12	7-9.5-11 n=11	12-14.5-18 n=12
Sample 5 f	12-25.5-37 n=17	57-73.6-88 n=17	8-13.1-17 n=34	2-3.6-5 n=34	3-4.8-7 n=32	3-4.8-6 n=32	2-4.5-6 n=30	4-5.8-8 n=32
Sample 6 f	13-25.4-39 n=16	61-75.7-84 n=15	9-14.3-17 n=30	4-4.3-6 n=32	3-4.9-7 n=31	3-5.0-7 n=30	1-4.3-7 n=31	4-6.8-9 n=30
Sample 7 f	27-46.0-59 n=31	93-101.6-119 n=32	17-27.4-38 n=49	5-9.3-16 n=61	4-6.5-8 n=55	4-5.8-8 n=57	4-7.6-10 n=55	6-9.5-13 n=57
Sample 8 f	38-47.2-55 n=12	83-93.0-98 n=12	12-18.8-24 n=21	6-7.4-11 n=23	5-6.5-9 n=22	5-5.9-7 n=22	6-8.0-9 n=20	8-9.2-11 n=22

Table 1e	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis ferrisi								
Sample 9 f	33-41.2-48 n=16	73-94.3-133 n=16	11-19.3-29 n=23	6-7.9-13 n=31	4-5.8-8 n=30	4-5.5-8 n=31	4-7.1-13 n=30	5-8.7-13 n=31
Sample 10 f	23-32.6-44 n=7	78-88.9-102 n=7	13-17.7-22 n=14	5-7.3-9 n=14	4-4.8-5 n=12	4-4.3-5 n=13	5-5.4-6 n=12	5-6.9-10 n=13
Sample 11 r	28-33.4-41 n=9	84-97.9-115 n=9	9-19.7-26 n=17	4-7.5-12 n=17	1-4.1-6 n=15	1-3.4-5 n=17	4-5.6-7 n=15	5-6.4-9 n=17
Sample 12 f	31-44.7-62 n=14	83-95.6-122 n=15	12-17.9-25 n=25	1-6.6-12 n=27	2-5.1-8 n=23	1-4.4-7 n=26	3-6.0-8 n=22	4-7.9-12 n=25
Sample 13 f	17-62.1-85 n=28	66-98.2-112 n=28	14-22.0-38 n=42	3-7.1-10 n=55	1-4.7-8 n=58	3-5.1-8 n=55	2-6.1-11 n=54	3-7.9-11 n=52
Sample 13 r	55-65.7-81 n=6	104-109.0-119 n=6	16-22.8-32 n=10	5-7.1-9 n=12	3-4.9-7 n=10	4-4.7-6 n=10	5-5.8-8 n=10	5-7.6-9 n=10
Sample 14 f	39-64.0-79 n=20	89-107.6-138 n=20	14-21.0-34 n=34	4-7.6-9 n=38	3-6.0-8 n=40	3-5.8-7 n=40	5-7.9-11 n=40	8-10.1-14 n=40
Sample 15 f	63-73.1-83 n=9	88-109.6-129 n=9	18-21.2-28 n=12	6-7.4-9 n=18	4-5.9-8 n=15	4-5.8-7 n=13	5-7.0-9 n=10	7-9.6-12 n=12
Sample 15 r	54-77.4-95 n=22	104-119.8-138 n=22	15-21.7-36 n=34	4-7.5-11 n=42	3-6.4-10 n=43	3-6.1-10 n=43	4-7.4-10 n=43	6-9.8-14 n=43
Sample 16 f	17-29.6-38 n=17	90-96.9-108 n=17	17-23.4-34 n=24	4-6.8-9 n=31	3-6.8-9 n=31	4-6.1-8 n=33	5-7.3-11 n=31	5-8.6-12 n=33
Sample 16 r	18-41.3-49 n=8	94-110.9-119 n=8	14-24.4-35 n=13	5-7.7-10 n=16	5-6.6-10 n=13	4-6.7-8 n=12	4-6.2-8 n=13	6-8.6-11 n=13
Sample 17 f	44-50.9-59 n=7	104-106.9-109 n=7	16-22.8-29 n=11	6-7.0-8 n=14	5-6.1-7 n=14	4-4.9-6 n=14	6-6.5-7 n=14	7-8.6-11 n=14
Sample 17 r	24-49.7-64 n=7	81-103.0-119 n=7	21-29.8-37 n=9	6-8.2-11 n=13	3-5.9-8 n=14	4-5.5-7 n=13	6-8.4-12 n=14	7-9.5-14 n=13
Sample 18 f	25-47.8-60 n=11	87-107.2-132 n=11	18-22.7-33 n=13	4-7.1-8 n=19	5-7.1-10 n=21	4-6.2-8 n=21	6-8.1-13 n=21	8-9.5-14 n=21
Sample 19 f	16-29.5-41 n=11	77-89.9-99 n=12	17-21.2-36 n=19	5-7.2-9 n=22	1-4.3-6 n=24	3-4.1-6 n=24	2-4.1-8 n=24	4-5.3-9 n=24
Sample 19 r	33-44.6-54 n=16	89-98.8-115 n=16	16-23.9-32 n=24	4-7.4-10 n=28	3-5.0-6 n=29	2-4.6-6 n=29	4-6.2-11 n=30	4-8.0-11 n=30

Table 1f	Total dorsal macroducts	Total perivulvar disc pores	Anterior spiracular disc pores	Posterior spiracular disc pores	Lateral macroducts on abd II	Lateral macroducts on abd III	Lateral gland spines on abd II	Lateral gland spines on abd III
Aulacaspis obconica								
Sample f	4-6.7-10 n=32	67-79.4-93 n=32	4-9.2-16 n=60	3-5.2-10 n=62	2-3.5-6 n=63	2-4.0-7 n=62	1-3.3-5 n=63	2-5.4-7 n=62
Aulacaspis ulukaliana								
Sample 1 f	6-13.7-18 n=32	44-53.0-75 n=32	3-6.0-8 n=62	2-3.3-5 n=61	1-2.3-4 n=64	3-3.7-5 n=64	0(11.1%)-1.0-3 n=63	2-3.5-5 n=63
Sample 2 f	3-10.1-18 n=32	41-47.6-64 n=32	3-5.7-10 n=64	2-2.9-4 n=63	1-2.1-4 n=64	2-3.5-5 n=64	0(7.9%)-1.1-3 n=63	2-3.1-4 n=64
Aulacaspis medangena								
Sample 1 f	25-64.3-80 n=14	83-91.0-100 n=13	9-12.1-20 n=28	2-3.7-5 n=27	5-6.0-8 n=27	4-5.8-7 n=26	2-6.7-10 n=27	4-8.8-12 n=26
Sample 2 f	45-56.7-71 n=7	81-86.0-92 n=7	10-12.4-16 n=16	2-3.7-4 n=16	4-5.9-8 n=16	4-4.9-7 n=15	5-7.1-10 n=16	8-8.9-11 n=16
Sample 3 f	31-62.6-85 n=16	77-91.0-104 n=16	8-13.6-19 n=32	3-4.4-7 n=34	4-6.1-8 n=31	3-5.5-7 n=31	3-6.0-9 n=29	6-8.9-15 n=29
Aulacaspis kedahana								
Sample f	8-11.4-14 n=32	39-49.8-65 n=32	3-6.8-10 n=64	2-3.0-5 n=63	0(4.8%)-2.2-4 n=63	2-3.6-5 n=64	0(19.0%)-1.0-3 n=63	5-6.7-9 n=63
Aulacaspis cinnamomorum								
Sample 1 f	1-5.0-8 n=24	49-61.2-72 n=24	3-5.1-8 n=44	2-3.3-4 n=44	0 or 1(2.1%) n=48	1-3.0-5 n=48	0 n=48	2-3.3-5 n=48
Sample 2 f	4-6.4-10 n=14	45-57.1-62 n=14	3-4.9-7 n=27	3-3.7-4 n=27	0 or 1(3.6%) n=28	2-2.7-3 n=27	0 n=28	2-3.5-5 n=27
Sample 3 f	2-3.5-7 n=30	43-53.4-61 n=30	1-4.6-8 n=58	1-3.2-5 n=59	0 n=60	1-2.7-4 n=60	0 or 1(5.0%) n=60	2-3.6-5 n=59
Aulacaspis jeraiana								
Sample f	9-10.6-13 n=29	52-67.5-84 n=29	3-4.0-6 n=54	0 n=58	0(10.3%)-1.6-3 n=58	1-3.1-4 n=58	1-2.1-4 n=58	2-4.1-6 n=58

Table 2. Numbers of submedian macroducts on abd VI and marginal gland spines on IV: frequency in percentage.

Table 2a	Submedian macroducts on abd VI						Marginal gland spines on abd IV											
	0	1	2	3	4	n	1	2	3	4	5	6	7	8	9	10	11	n
Aulacaspis yabunikkei																		
Sample 1 f		100				26		100										26
Sample 2 f		98.4	1.6			64		98.4	1.6									64
Sample 2 r		100				32		93.8	6.2									32
Sample 3 f		100				54		96.2	3.8									53
Sample 4 f	3.3	95.0	1.7			60		96.7	3.3									60
Sample 5 f		100				30		96.7	3.3									30
Sample 6 f		98.4	1.6			64		100										64
Sample 7 f		100				64	2.0	98.0										64
Sample 8 f		100				64		96.9	3.1									64
Sample 9 f		100				64		100										64
Sample 9 r		100				9		100										10
Sample 10 f		98.4	1.6			62	1.6	98.4										62
Sample 11 f	27.8	72.2				54		100										54
Sample 12 r	3.6	96.4				28	3.6	92.8	3.6									28
Sample 13 r	7.7	88.5	3.8			52		94.2	5.8									52
Sample 14 f	50.0	50.0				48		100										48
Sample 15 f	13.6	86.4				22		100										22
Sample 16 f	7.1	92.9				14		92.9	7.1									14
Sample 17 f	5.8	94.2				52		92.3	7.7									52
Sample 18 f	1.6	98.4				64		90.6	9.4									64
Sample 19 f	20.0	80.0				10		80.0	20.0									10
Sample 19 r		100				12		100										12
Sample 20 f	8.3	91.7				12		71.4	28.6									14
Sample 20 r	10.0	85.0	5.0			20		50.0	45.0	5.0								20

f: folicolous specimens; r: ramicolous specimens
100: 100%; n: sample size

Table 2b	Submedian macroducts on abd VI						Marginal gland spines on abd IV											
	0	1	2	3	4	n	1	2	3	4	5	6	7	8	9	10	11	n
Aulacaspis yabunikkei																		
Sample 21 f	16.7	83.3				12		91.7	8.3									12
Sample 22 f	42.2	57.8				64	1.6	98.4										64
Sample 23 f	57.4	42.6				61		100										58
Sample 24 f		96.9	3.1			64		85.9	12.5	1.6								64
Sample 25 f	6.2	93.8				48		100										46
Sample 26 f	37.9	62.1				58		100										57
Sample 26 r		100				10		90.0	10.0									10
Sample 27 f	34.4	65.6				64	4.7	95.3										64
Sample 28 f	3.2	96.8				62		98.4	1.6									62
Sample 28 r	4.8	95.2				62		87.1	11.3	1.6								62
Sample 29 f	6.2	93.8				32		93.8	6.2									32
Sample 29 r	6.2	93.8				16		81.3	18.7									16
Sample 30 r	3.2	95.2	1.6			62	4.9	90.2	4.9									61
Aulacaspis neolitseae																		
Sample 1 f	93.8	6.2				16			81.3	18.7								16
Sample 2 f	60.8	39.2				120		2.5	76.5	21.0								119
Sample 3 f	85.0	15.0				60		5.0	75.0	20.0								60
Sample 4 f	96.7	3.3				60		1.7	70.0	28.3								60
Sample 5 f	92.9	7.1				42			56.1	39.0	4.9							41
Sample 6 f	95.5	4.5				44		2.3	90.9	6.8								44
Sample 6 f (teneral)	100					64		3.2	82.5	14.3								63
Sample 7 f	100					18			85.0	15.0								20
Sample 8 f	100					10			100									10
Aulacaspis sirodamo																		
Sample 1 f	56.7	43.3				60			6.7	50.0	36.6	6.7						60

Table 2c	Submedian macroducts on abd VI						Marginal gland spines on abd IV											
	0	1	2	3	4	n	1	2	3	4	5	6	7	8	9	10	11	n
Aulacaspis sirodamo																		
Sample 2 f	31.3	64.0	4.7			64			4.7	57.8	28.1	9.4						64
Sample 3 f	23.4	76.6				64			4.7	42.2	42.2	10.9						64
Sample 4 f	68.3	31.7				60			6.7	41.7	43.3	8.3						60
Sample 5 f	64.3	35.7				14			35.7	50.0	14.3							14
Sample 6 f	1.5	4.7	84.4	9.4		64		15.6	65.7	15.6	3.1							64
Sample 7 f	20.0	75.0	5.0			20	5.0	95.0										20
Aulacaspis ferrisi																		
Sample 1 r	70.3	26.6	3.1			64	1.5	17.2	68.8	12.5								64
Sample 2 f	2.5	90.0	7.5			40			27.5	42.5	15.0	15.0						40
Sample 3 f+r	15.9	69.6	14.5			69		1.5	25.0	48.5	19.1	5.9						68
Sample 4 f			16.7	25.0	58.3	12						33.4	25.0	16.7	8.3	8.3	8.3	12
Sample 5 f	70.6	29.4				34		61.8	35.3	2.9								34
Sample 6 f	84.4	15.6				32		59.4	40.6									32
Sample 7 f	3.1	79.7	17.2			64		3.0	76.6	18.8	1.6							64
Sample 8 f		66.7	33.3			24		4.3	95.7									23
Sample 9 f		96.9	3.1			32		6.2	84.4	9.4								32
Sample 10 f	7.1	92.9				14		35.7	50.0	14.3								14
Sample 11 r		94.4	5.6			18		16.7	83.3									18
Sample 12 f		70.0	30.0			30		23.1	69.2	7.7								26
Sample 13 f		55.4	42.9	1.7		56		7.0	36.8	43.9	8.8	3.5						57
Sample 13 r		50.0	50.0			12		8.3	50.0	41.7								12
Sample 14 f	5.0	45.0	47.5	2.5		40			55.0	35.0	7.5	2.5						40
Sample 15 f	5.5	16.7	77.8			18		5.6	22.2	61.1	11.1							18
Sample 15 r	4.6	15.9	56.8	22.7		44			56.8	36.4	6.8							44
Sample 16 f	61.8	38.2				34		20.6	58.8	20.6								34

Table 2d	Submedian macroducts on abd VI						Marginal gland spines on abd IV											
	0	1	2	3	4	n	1	2	3	4	5	6	7	8	9	10	11	n
Aulacaspis ferrisi																		
Sample 16 r	43.8	50.0	6.2			16		18.7	68.8	12.5								16
Sample 17 f	28.6	71.4				14			85.7	14.3								14
Sample 17 r	42.9	57.1				14		7.1	50.0	35.8	7.1							14
Sample 18 f	18.2	81.8				22			68.2	27.3	4.5							22
Sample 19 f	43.5	56.5				23		16.7	83.3									24
Sample 19 r	21.9	78.1				32			87.1	12.9								31
Aulacaspis obconica																		
Sample f	89.0	11.0				64	3.2	56.5	40.3									62
Aulacaspis ulukaliana																		
Sample 1 f	42.2	57.8				64		96.9	3.1									65
Sample 2 f	75.0	25.0				64	4.7	95.3										64
Aulacaspis medangena																		
Sample 1 f	35.7	64.3				28		63.0	33.3	3.7								27
Sample 2 f	14.3	85.7				14		93.8	6.2									16
Sample 3 f	17.6	82.4				34		20.6	67.6	11.8								34
Aulacaspis kedahana																		
Sample f	100					64		6.2	71.9	21.9								64
Aulacaspis cinnamomorum																		
Sample 1 f	100					48		100										48
Sample 2 f	100					28	3.6	96.4										28
Sample 3 f	100					60		95.0	5.0									60
Aulacaspis jeraiana																		
Sample f	100					58	1.7	96.6	1.7									57

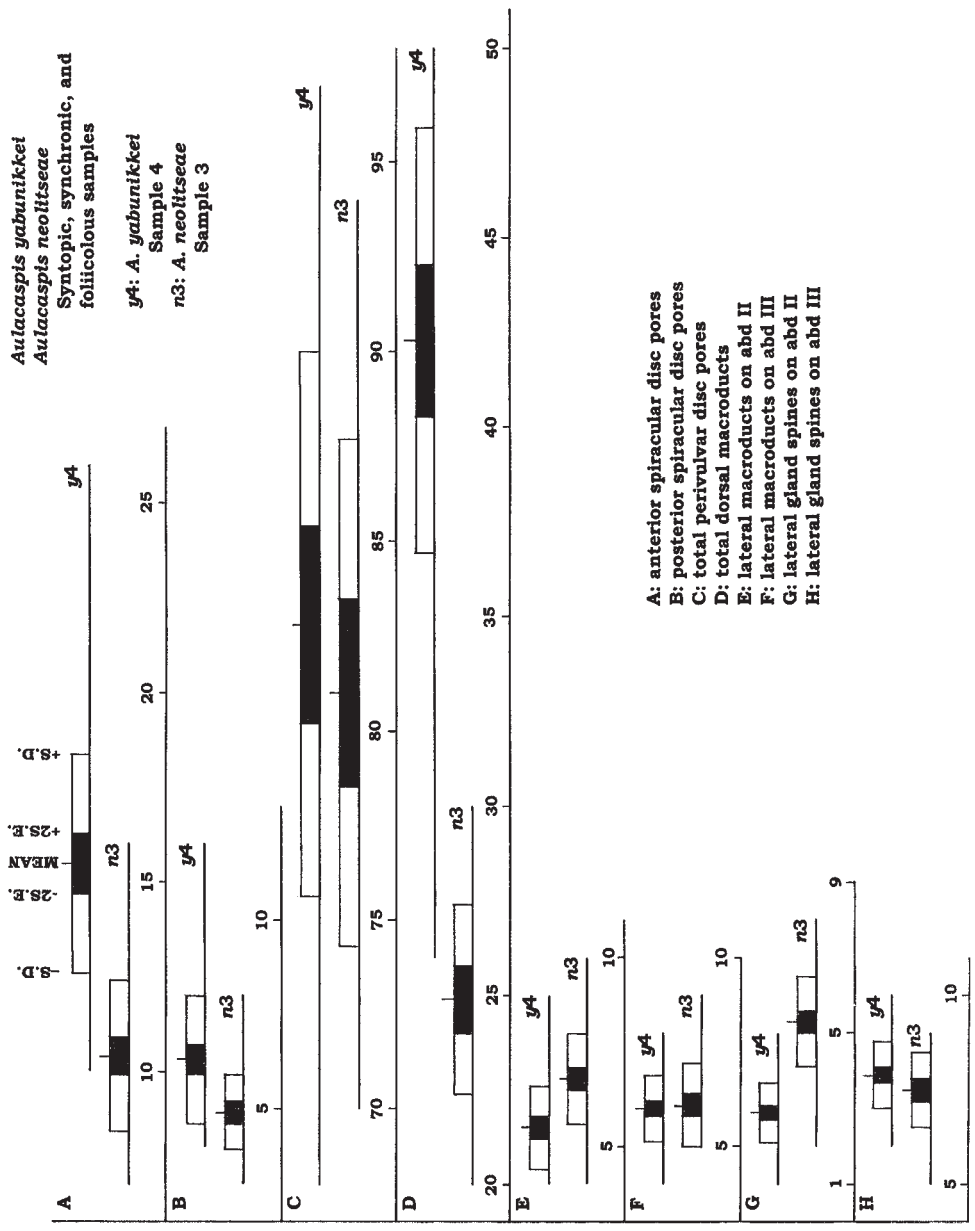

Fig. 1. *Aulacaspis yabunikkei*, Sample 4, and *A. neolitseae*, Sample 3, adult females. Dice-Leraas diagrams for the numbers of the main wax-secreting organs.

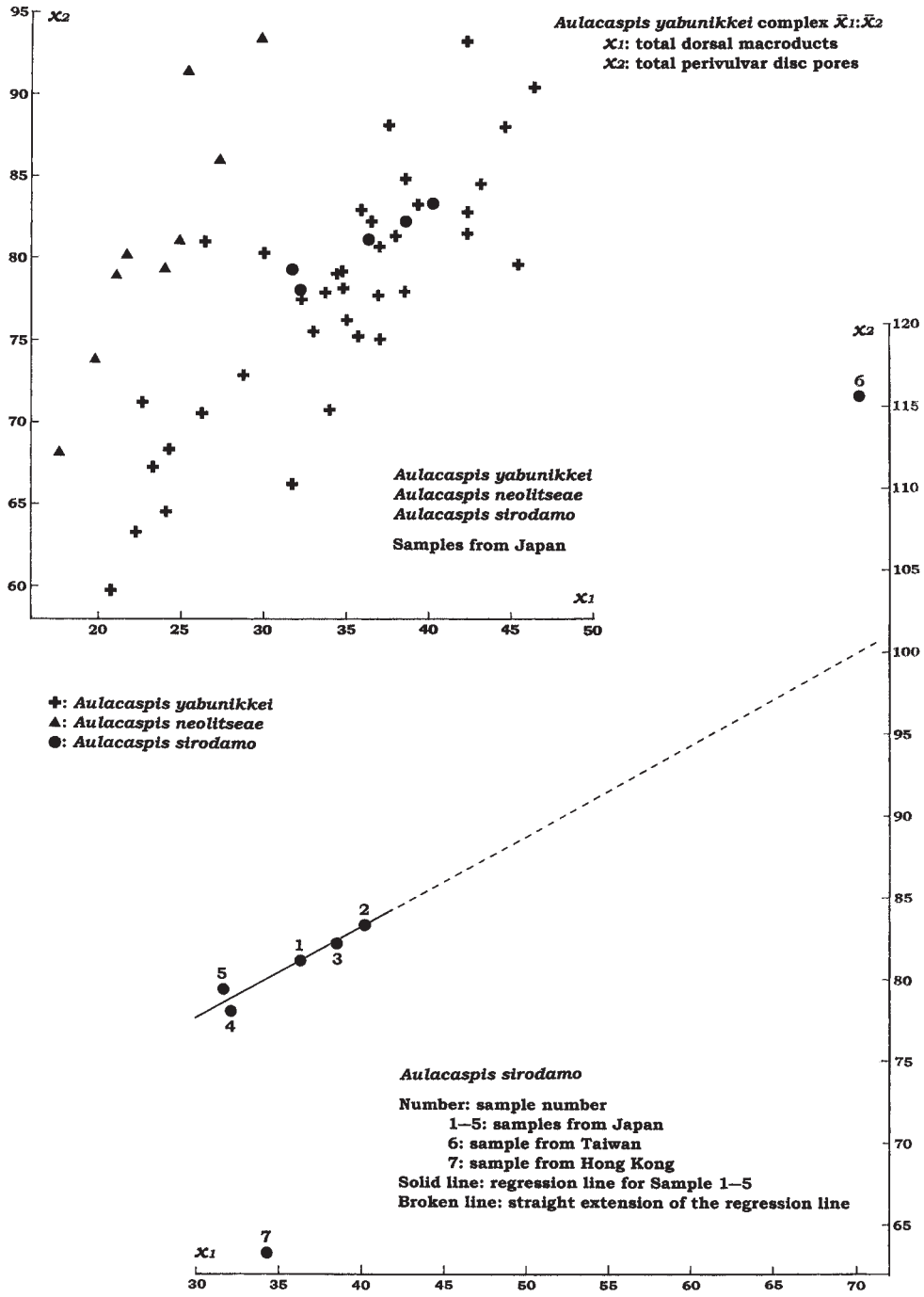

Fig. 2. The *yabunikkei* complex of *Aulacaspis*, adult females. Scatter diagrams for mean total numbers of perivulvar disc pores against mean total numbers of dorsal macroducts.

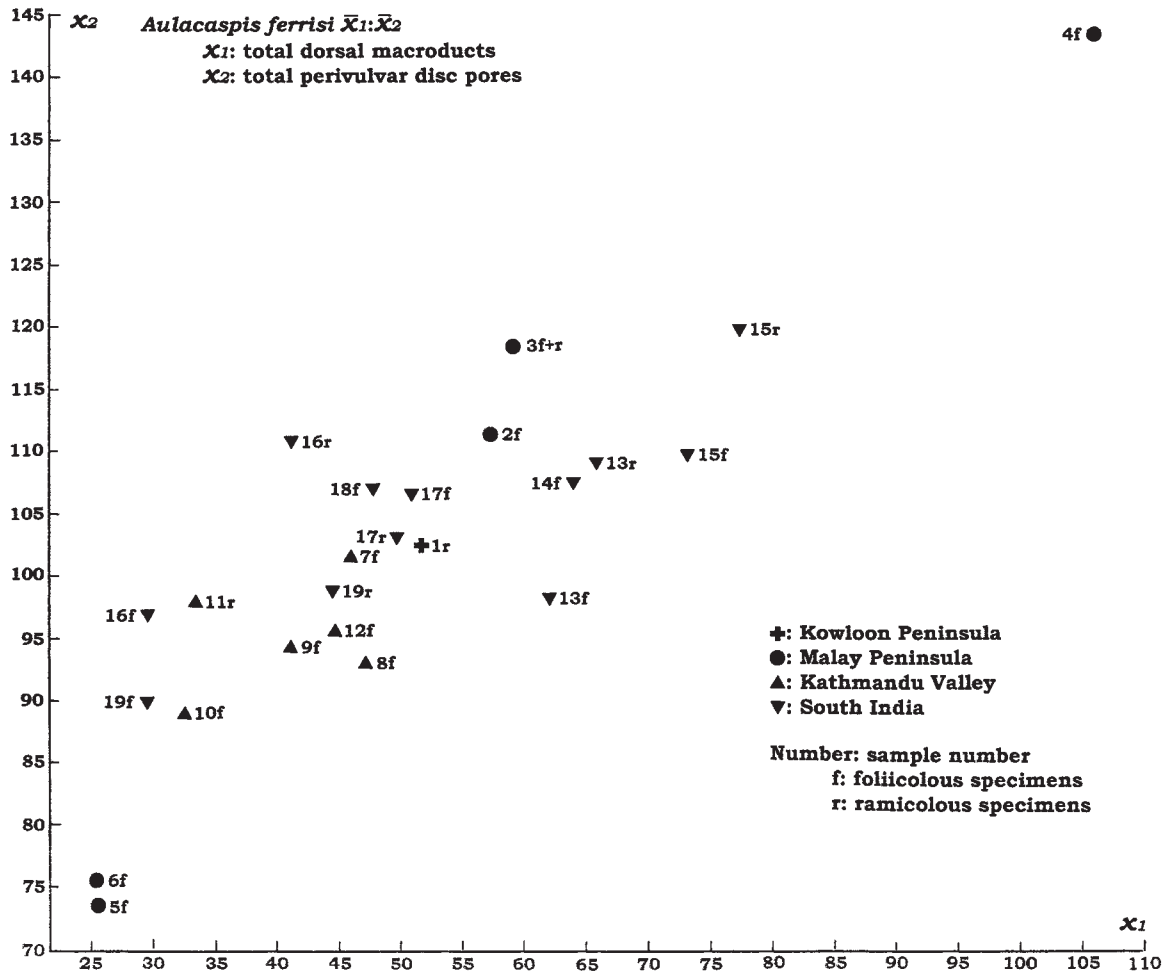

Fig. 3. *Aulacaspis ferrisi*, adult females. Scatter diagram for mean total numbers of perivulvar disc pores against mean total numbers of dorsal macroducts.

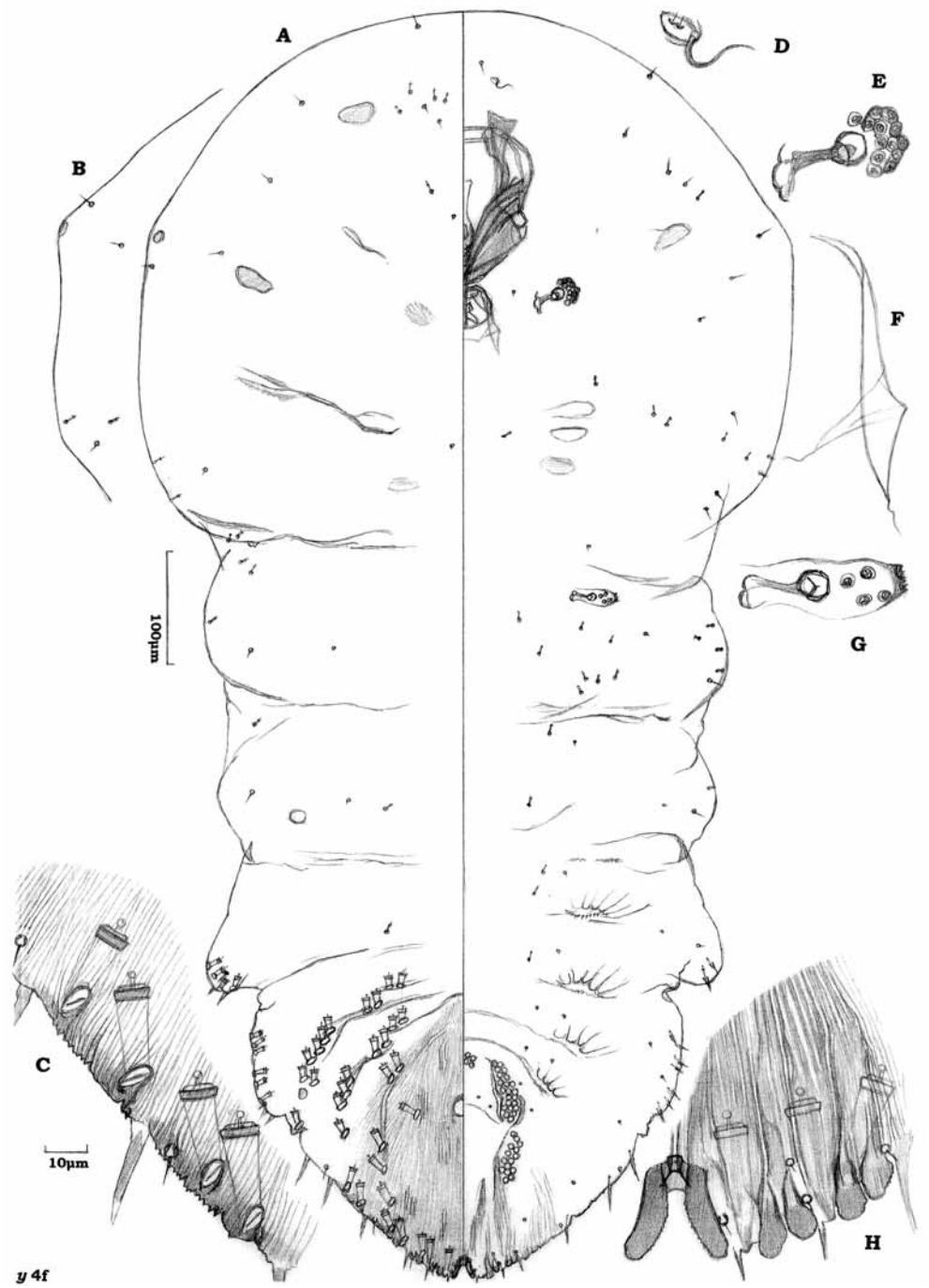

Fig. 4. *Aulacaspis yabunikkei*, Sample 4, fully grown foliicolous adult female. B, prosomatic margin, part, variation; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, peribuccal sclerosis; G, posterior spiracle; H, trullae. (Scale bar 100µm for A, B; 10µm for C–H.)

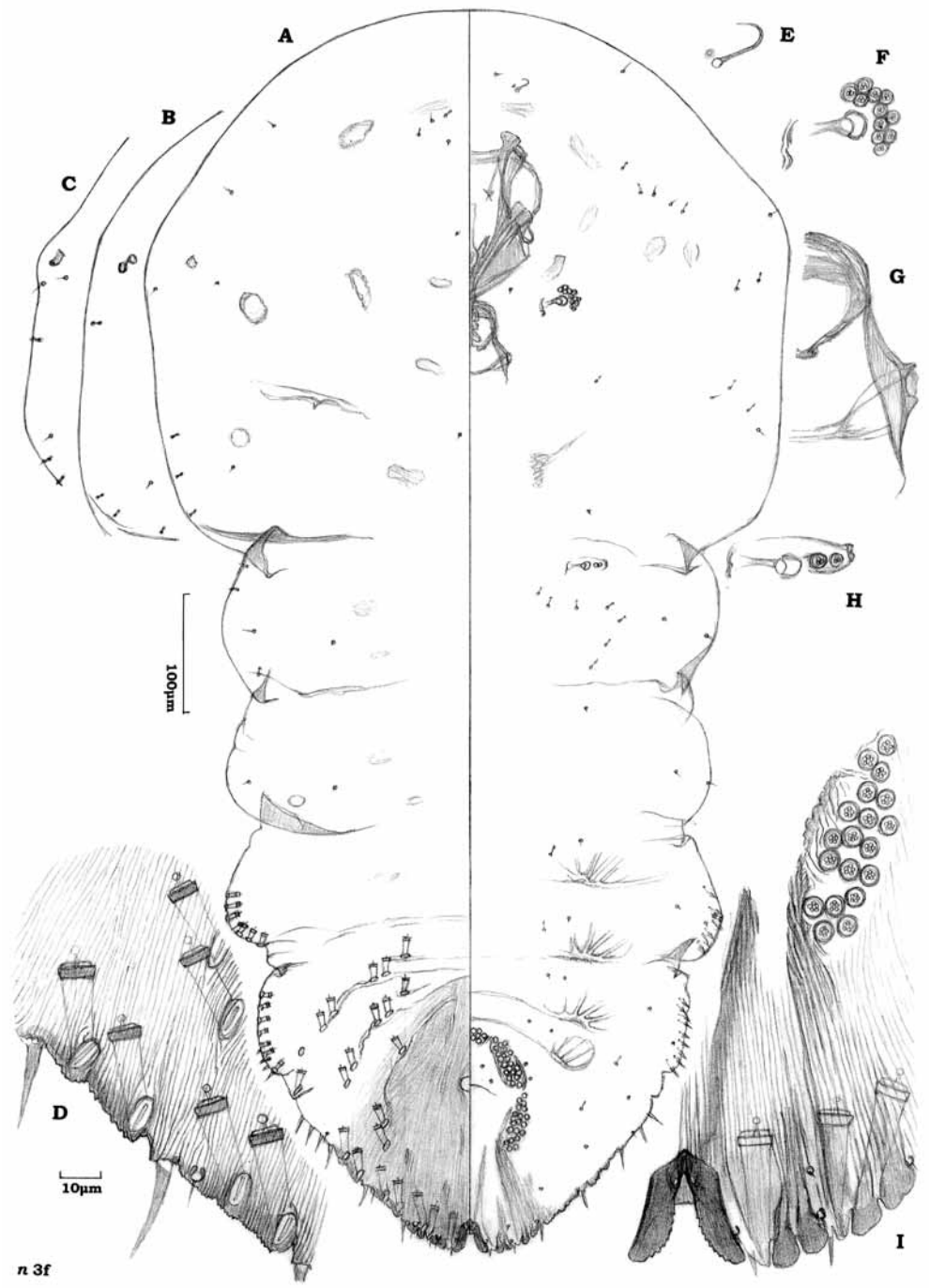

Fig. 5. *Aulacaspis neolitseae*, Sample 3, fully grown foliicolous adult female. B, C, prosomatic margin, part, variation; D, pygidial margin, part; E, antenna; F, anterior spiracle; G, peribuccal sclerosis; H, posterior spiracle; I, trullae. (Scale bar 100µm for A–C; 10µm for D–I.)

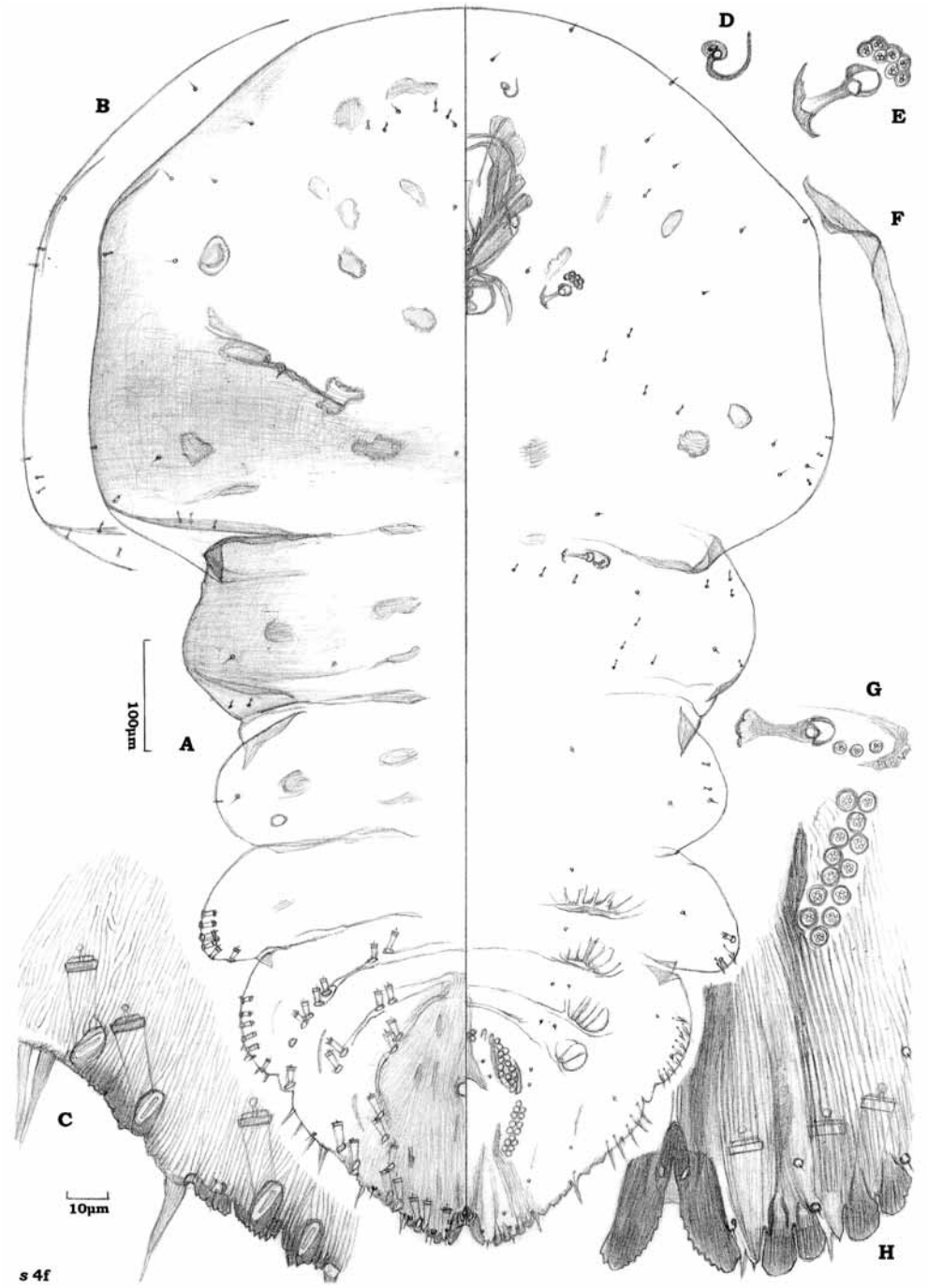

Fig. 6. *Aulacaspis sirodamo*, Sample 4, fully grown foliicolous adult female. B, prosomatic margin, part, variation; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, peribuccal sclerosis; G, posterior spiracle; H, trullae. (Scale bar 100µm for A, B; 10µm for C–H.)

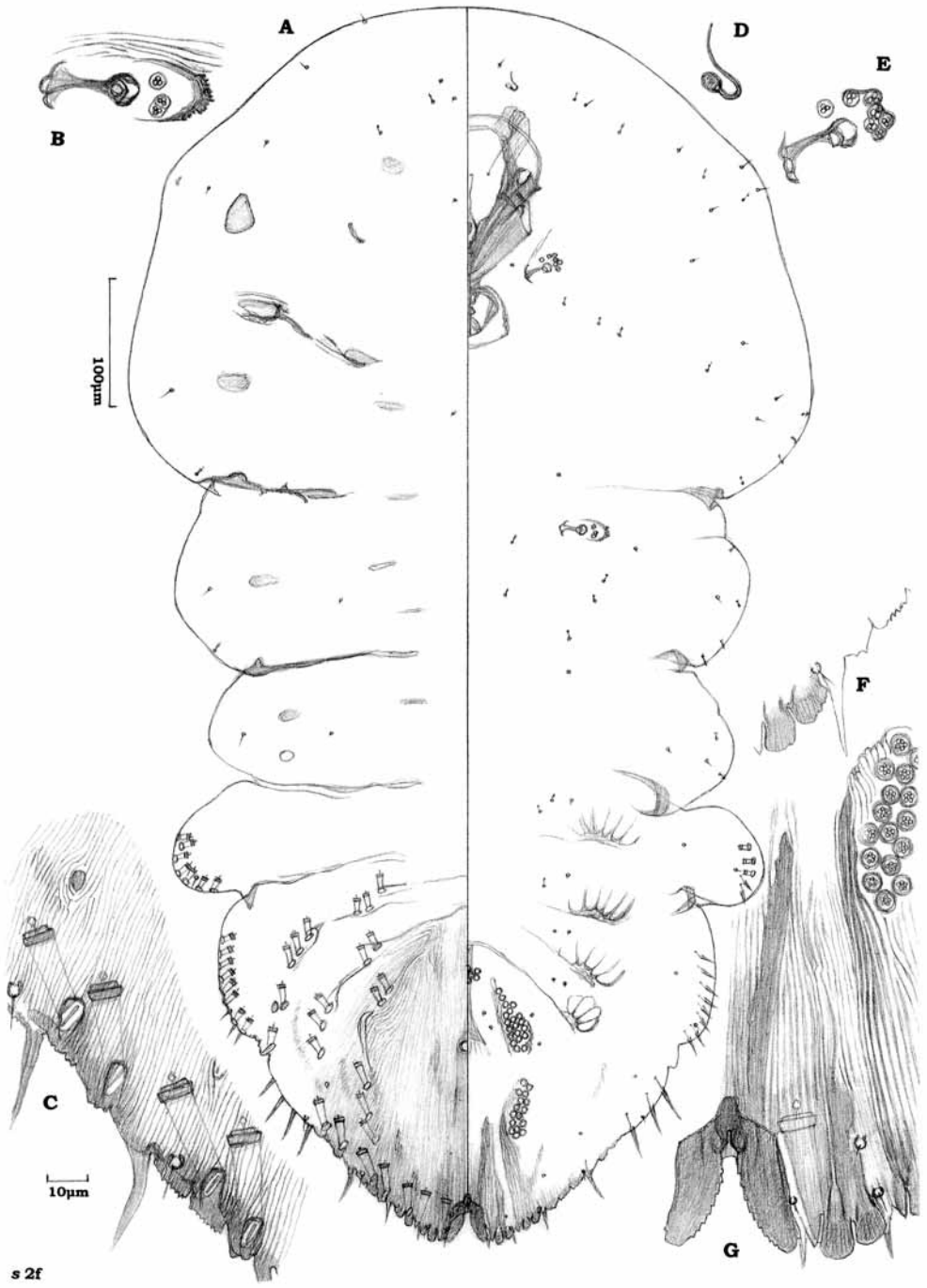

Fig. 7. *Aulacaspis sirodamo*, Sample 2, considerably but not fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

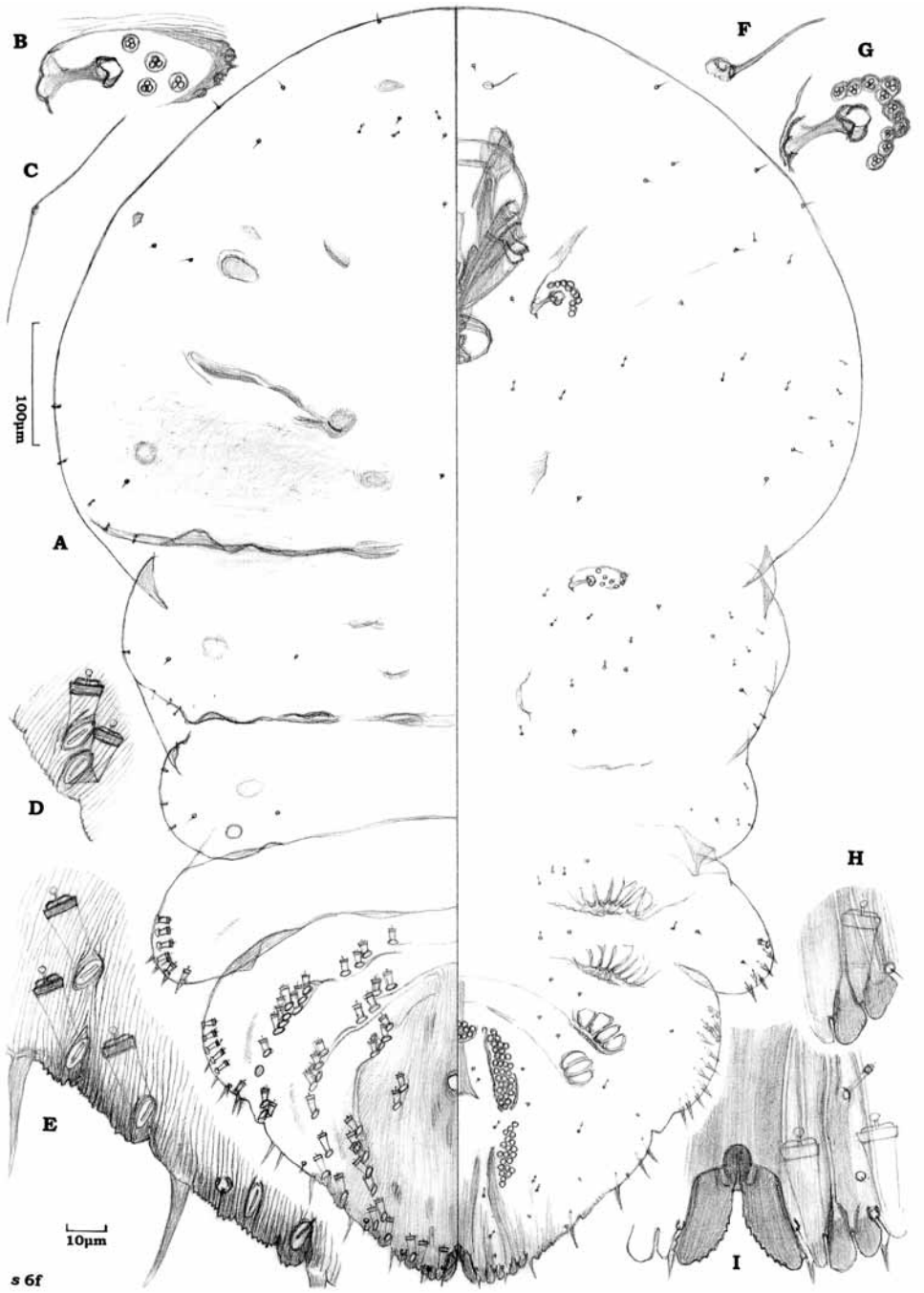

Fig. 8. *Aulacaspis sirodamo*, Sample 6, fully grown foliicolous adult female. B, posterior spiracle; C, prosomatic margin, part; D, posterolateral corner of abd III; E, pygidial margin, part; F, antenna; G, anterior spiracle; H, third trulla; I, median and second trullae. (Scale bar 100µm for A, C; 10µm for B, D–I.)

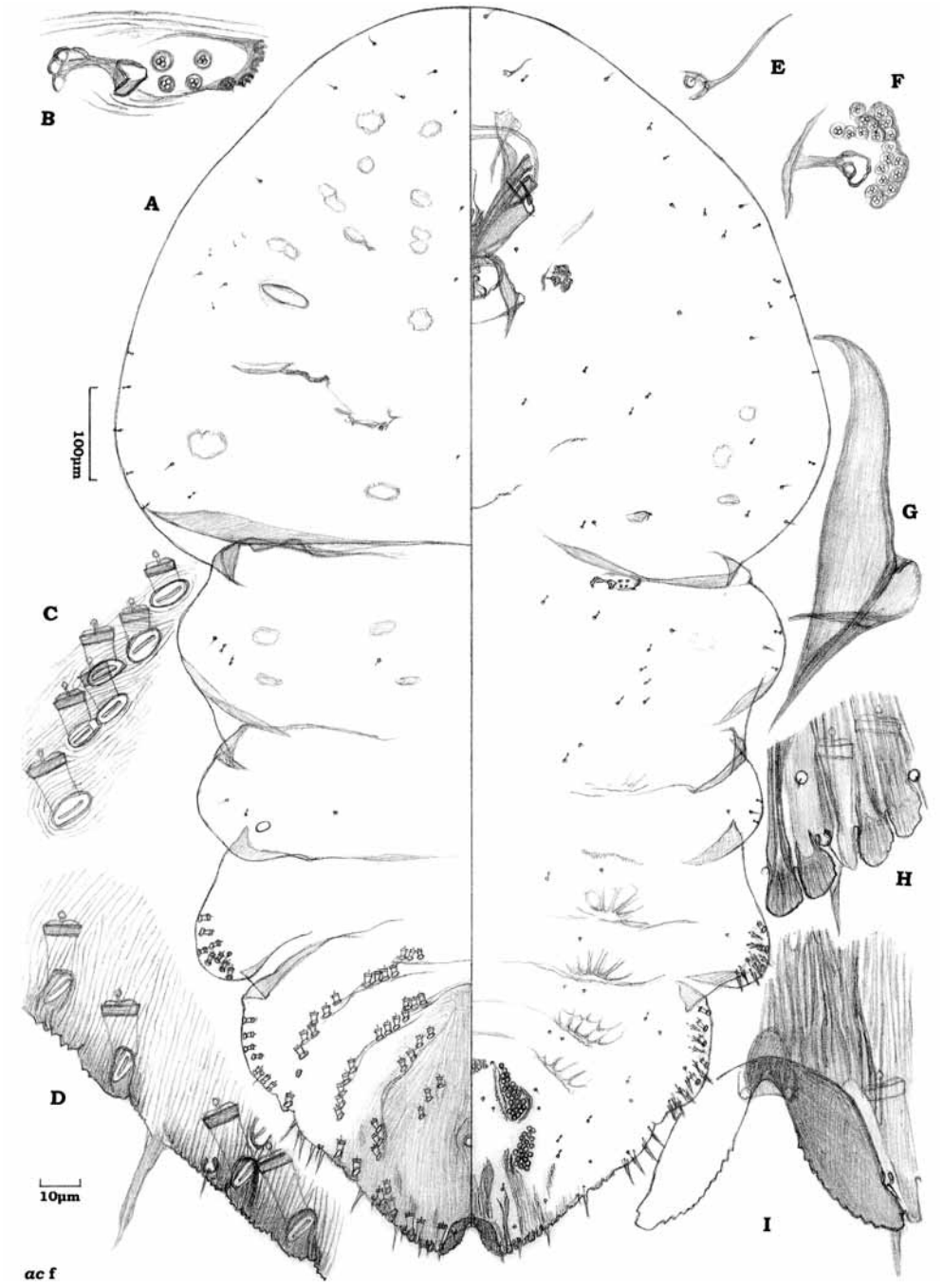

Fig. 9. *Aulacaspis actinodaphnes*, fully grown foliicolous adult female from type material. B, posterior spiracle; C, submarginal macroducts on abd III; D, pygidial margin, part; E, antenna; F, anterior spiracle; G, peribuccal sclerosis; H, second and third trullae; I, median trullae. (Scale bar 100µm for A; 10µm for B–I.)

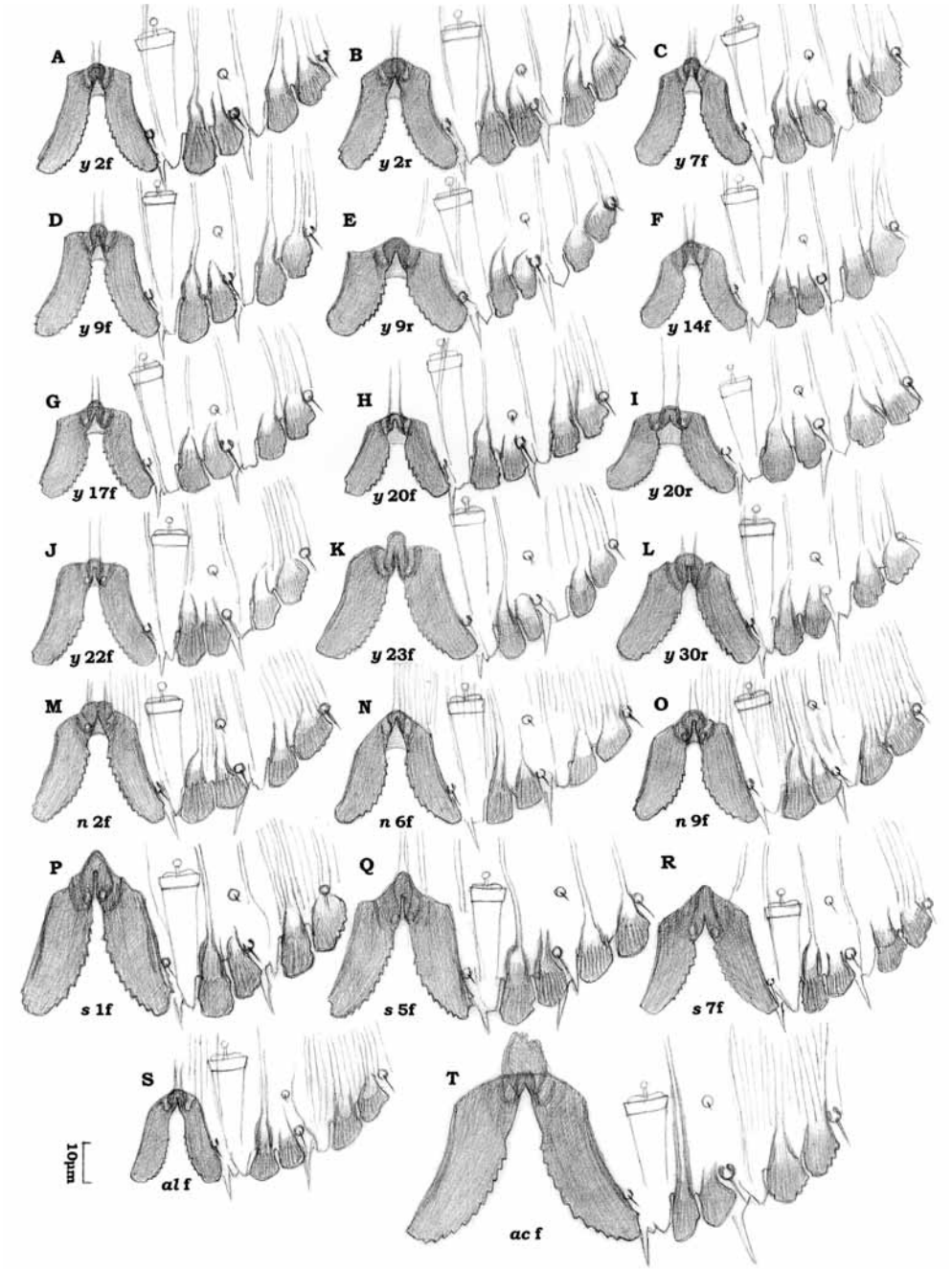

Fig. 10. *Aulacaspis yabunikkei*, *A. neolitseae*, *A. sirodamo*, *A. alisiana*, and *A. actinodaphnes*, adult females. Trullae, ventral view, with dorsal marginal macroduct (outline) on the seventh abdominal segment. A–L, *A. yabunikkei* (*y*); M–O, *A. neolitseae* (*n*); P–R, *A. sirodamo* (*s*); S, *A. alisiana* (*al*); T, *A. actiodaphnes* (*ac*). Number: sample number (*al*, *ac*: from type material); f: foliicolous specimen; r: ramicolous specimen. (Scale bar 10μm for A–T.)

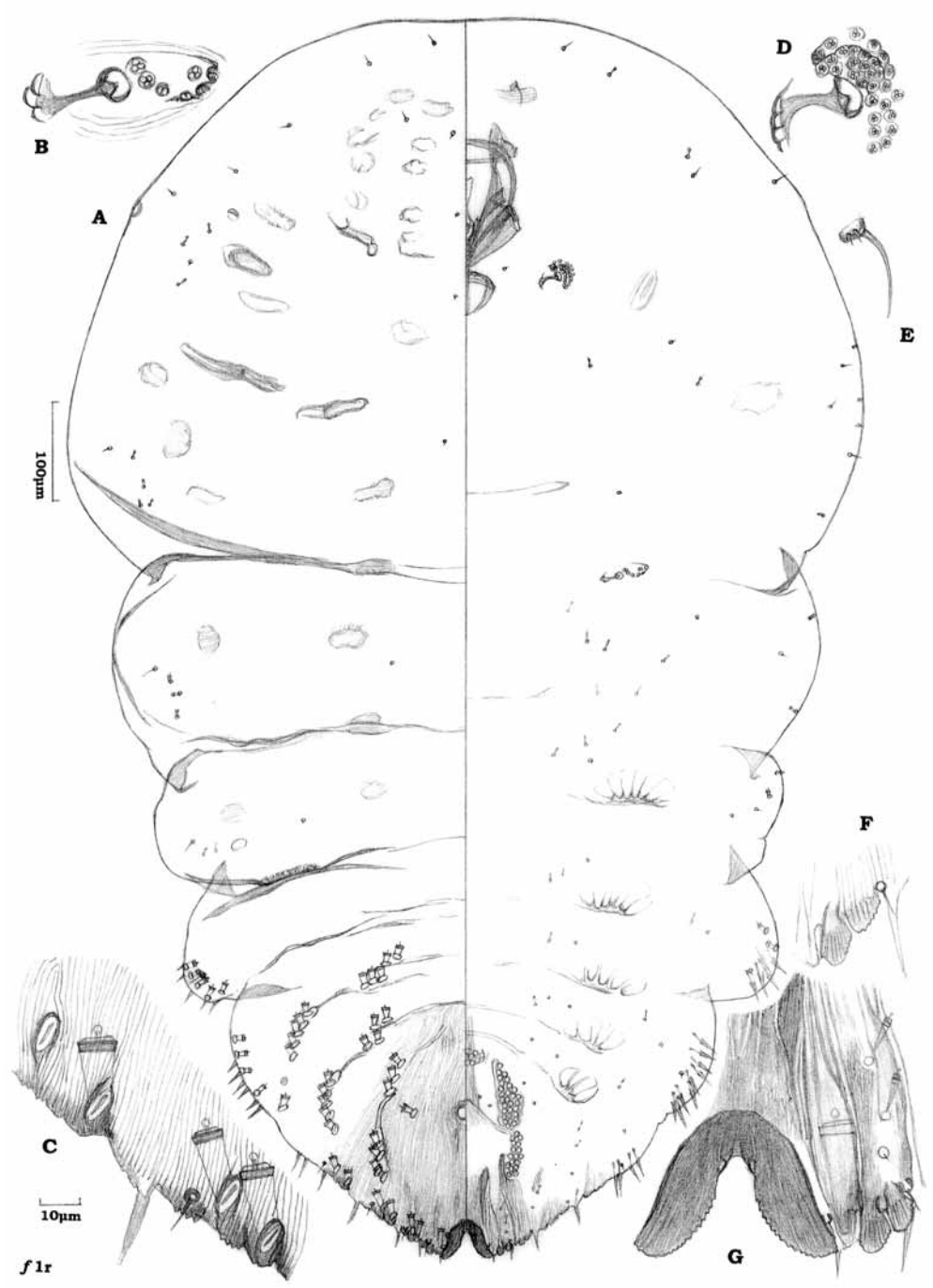

Fig. 11. *Aulacaspis ferrisi*, Sample 1, fully grown ramicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, anterior spiracle; E, antenna; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

Fig. 12. *Aulacaspis ferrisi*, Sample 1, considerably but not fully grown ramicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

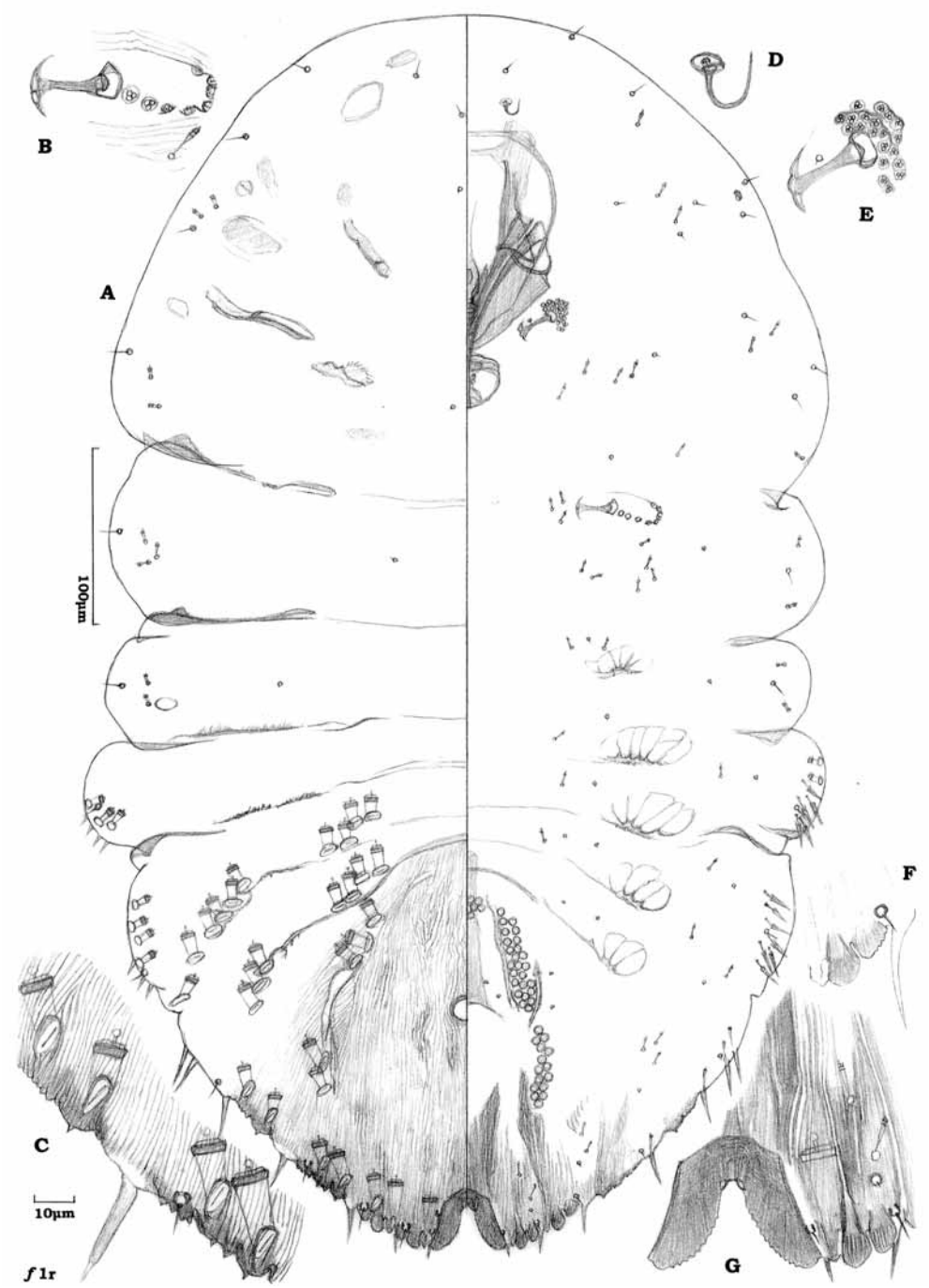

Fig. 13. *Aulacaspis ferrisi*, Sample 1, ramicolous adult female at an early stage of growth. B, posterior spiracle; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

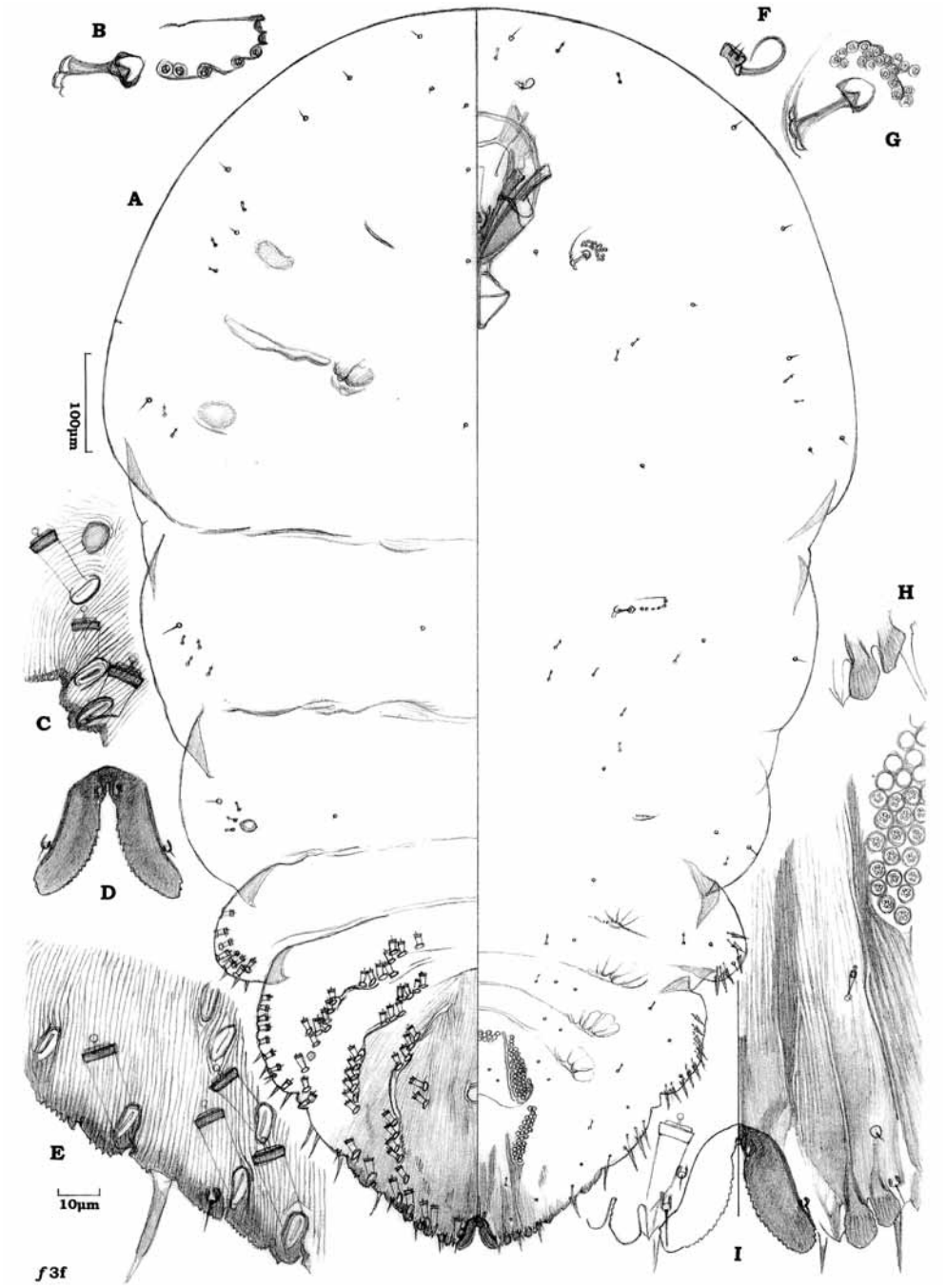

Fig. 14. *Aulacaspis ferrisi*, Sample 3, fully grown adult female. B, posterior spiracle; C, posterolateral corner of abd III; D, median trullae, variation; E, pygidial margin, part; F, antenna; G, anterior spiracle; H, third trulla; I, median and second trullae. (Scale bar 100µm for A; 10µm for B–I.)

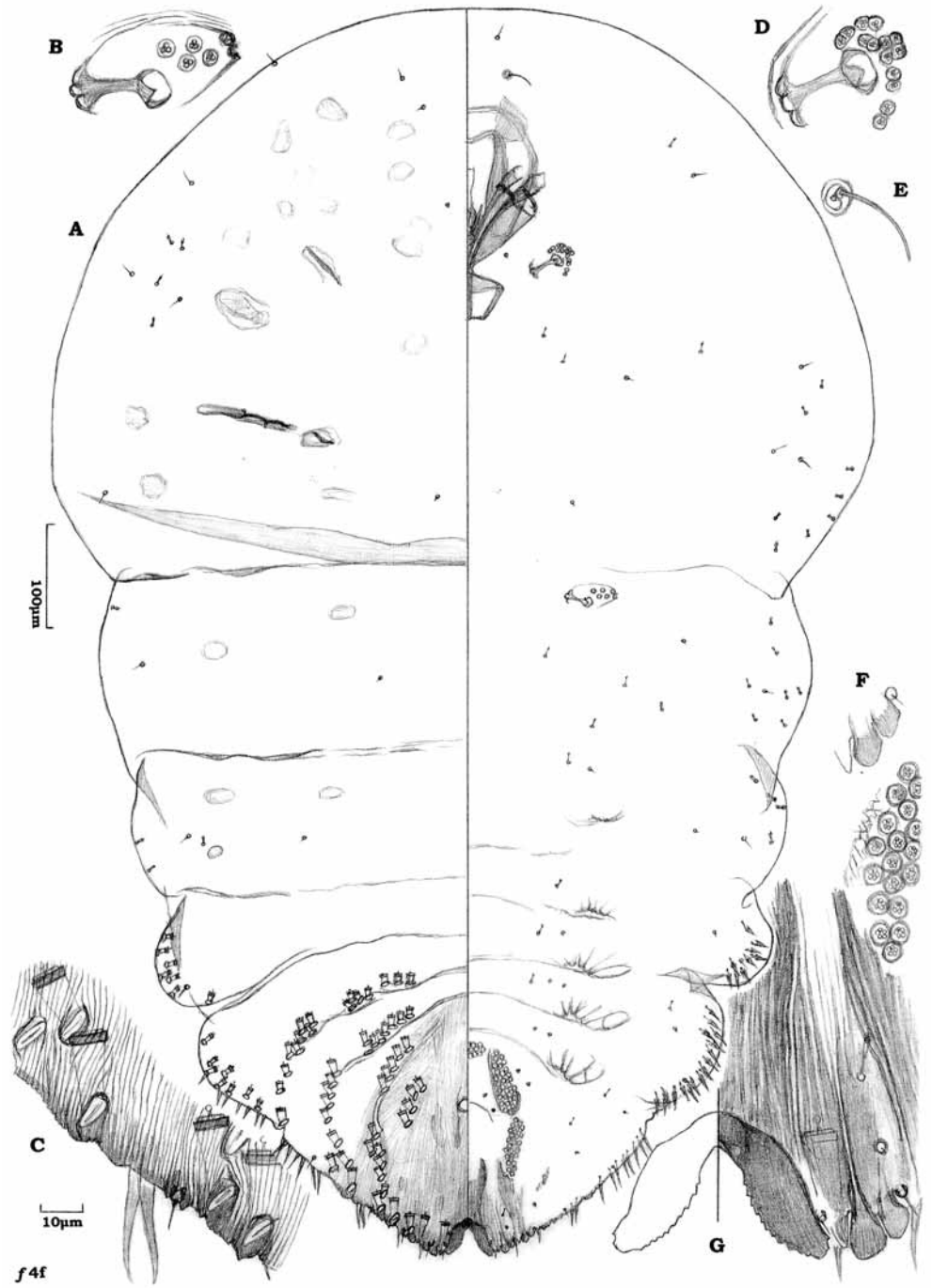

Fig. 15. *Aulacaspis ferrisi*, Sample 4, fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, anterior spiracle; E, antenna; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

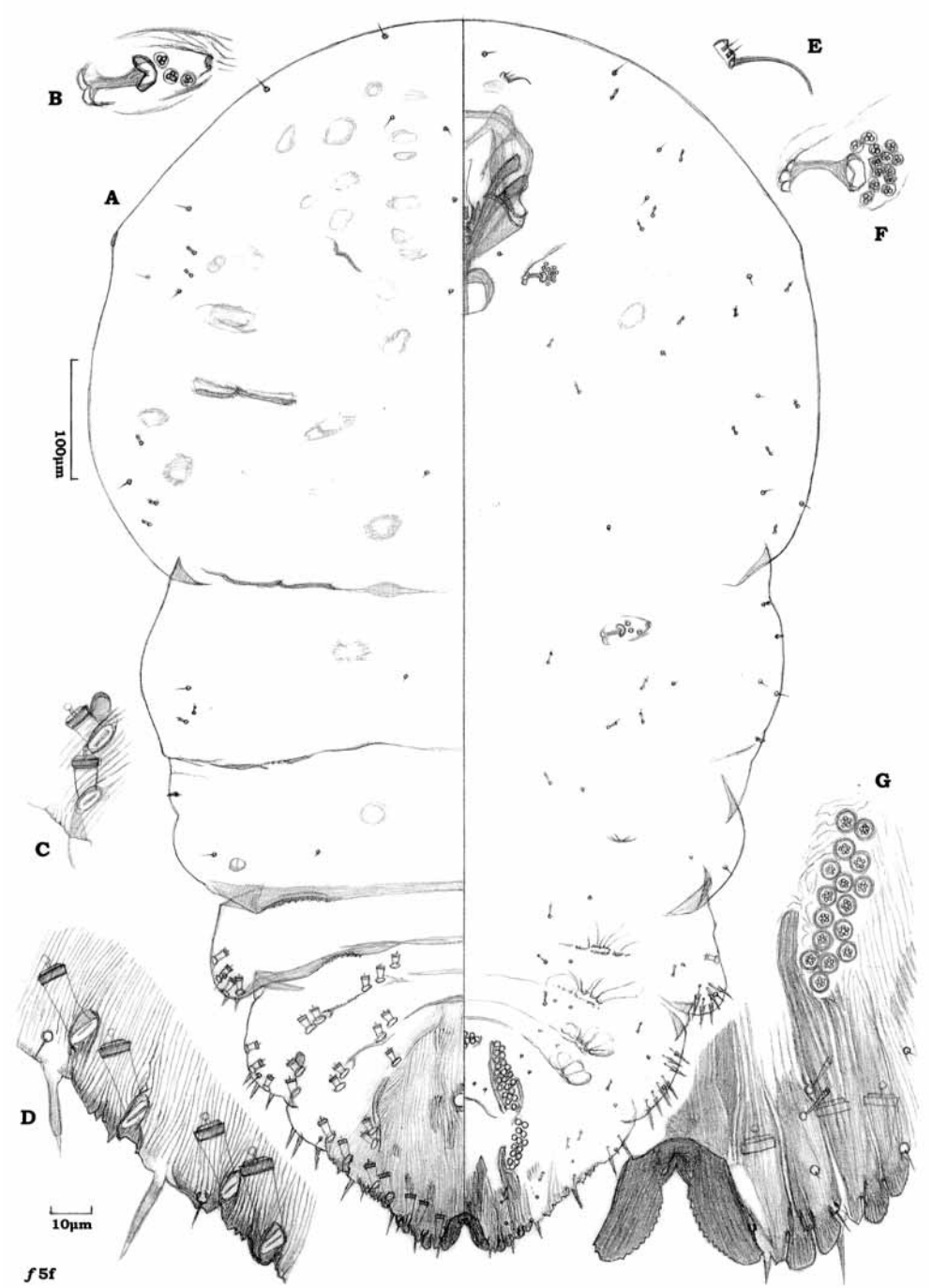

Fig. 16. *Aulacaspis ferrisi*, Sample 5, fully grown foliicolous adult female. B, posterior spiracle; C, posterolateral corner of abd III; D, pygidial margin, part; E, antenna; F, anterior spiracle; G, trullae. (Scale bar 100µm for A; 10µm for B–G.)

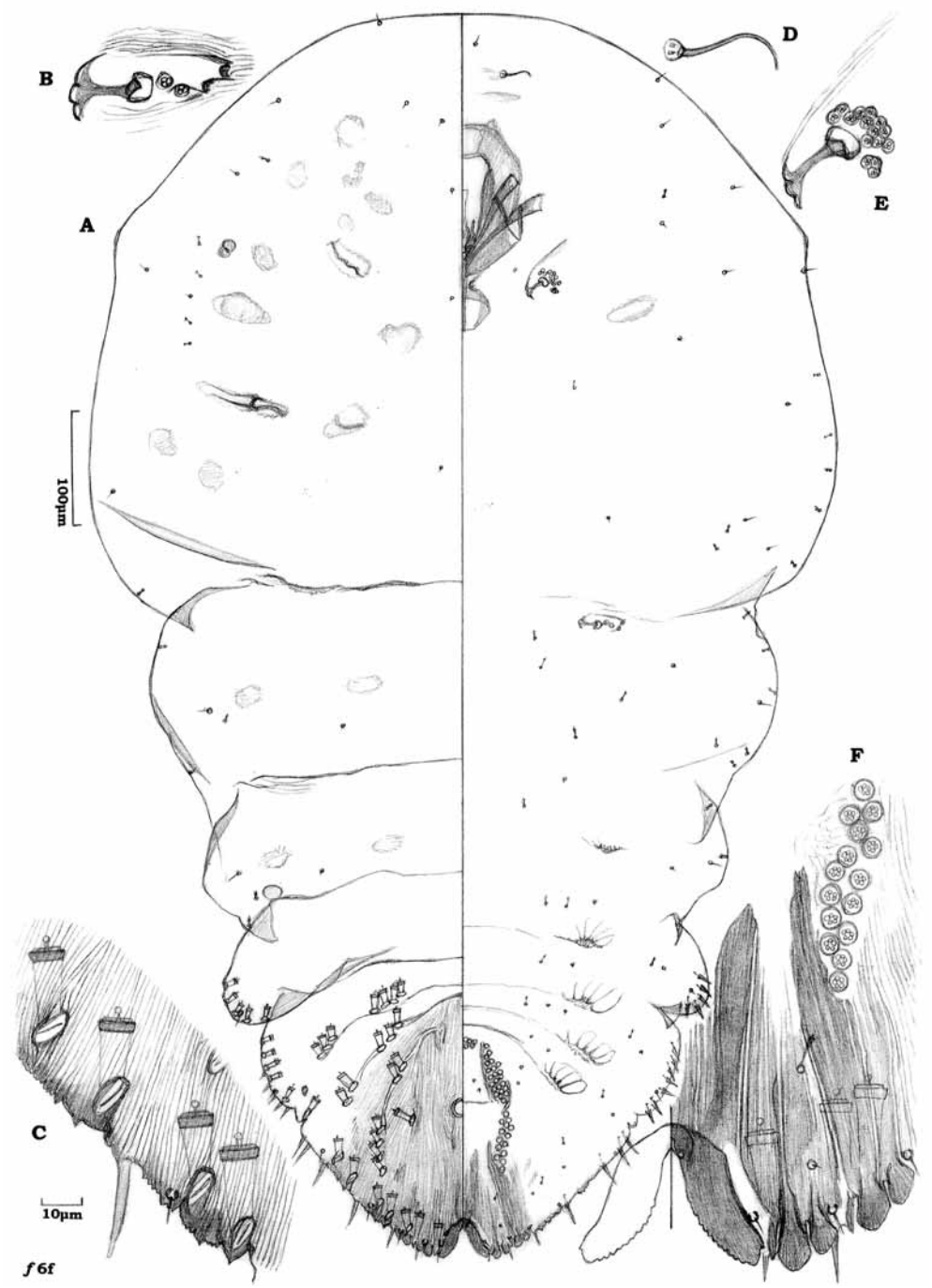

Fig. 17. *Aulacaspis ferrisi*, Sample 6, fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, antenna; E, anterior spiracle; F, trullae. (Scale bar 100µm for A; 10µm for B–F.)

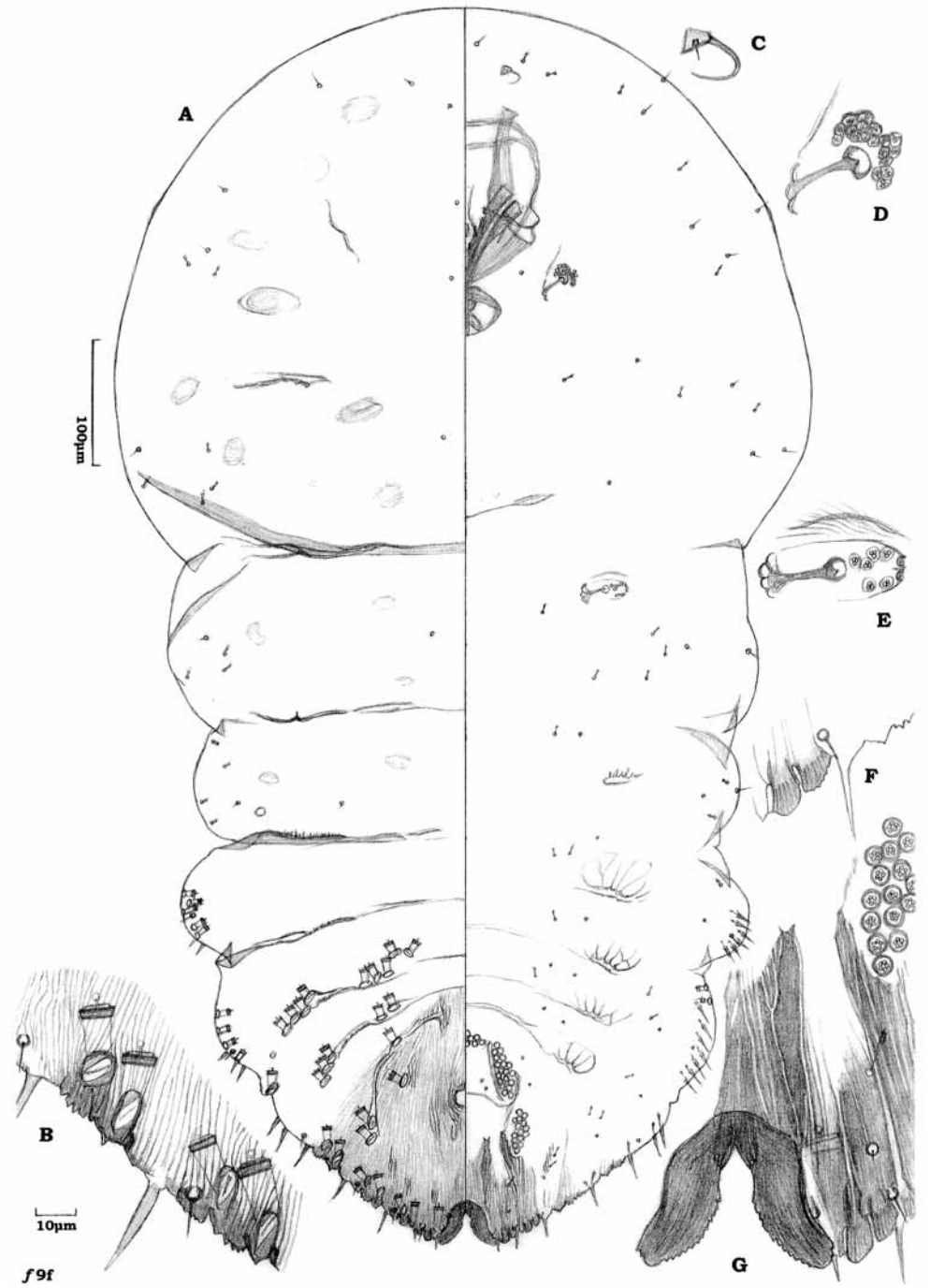

Fig. 18. *Aulacaspis ferrisi*, Sample 9, fully grown foliicolous adult female. B, pygidial margin, part; C, antenna; D, anterior spiracle; E, posterior spiracle; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

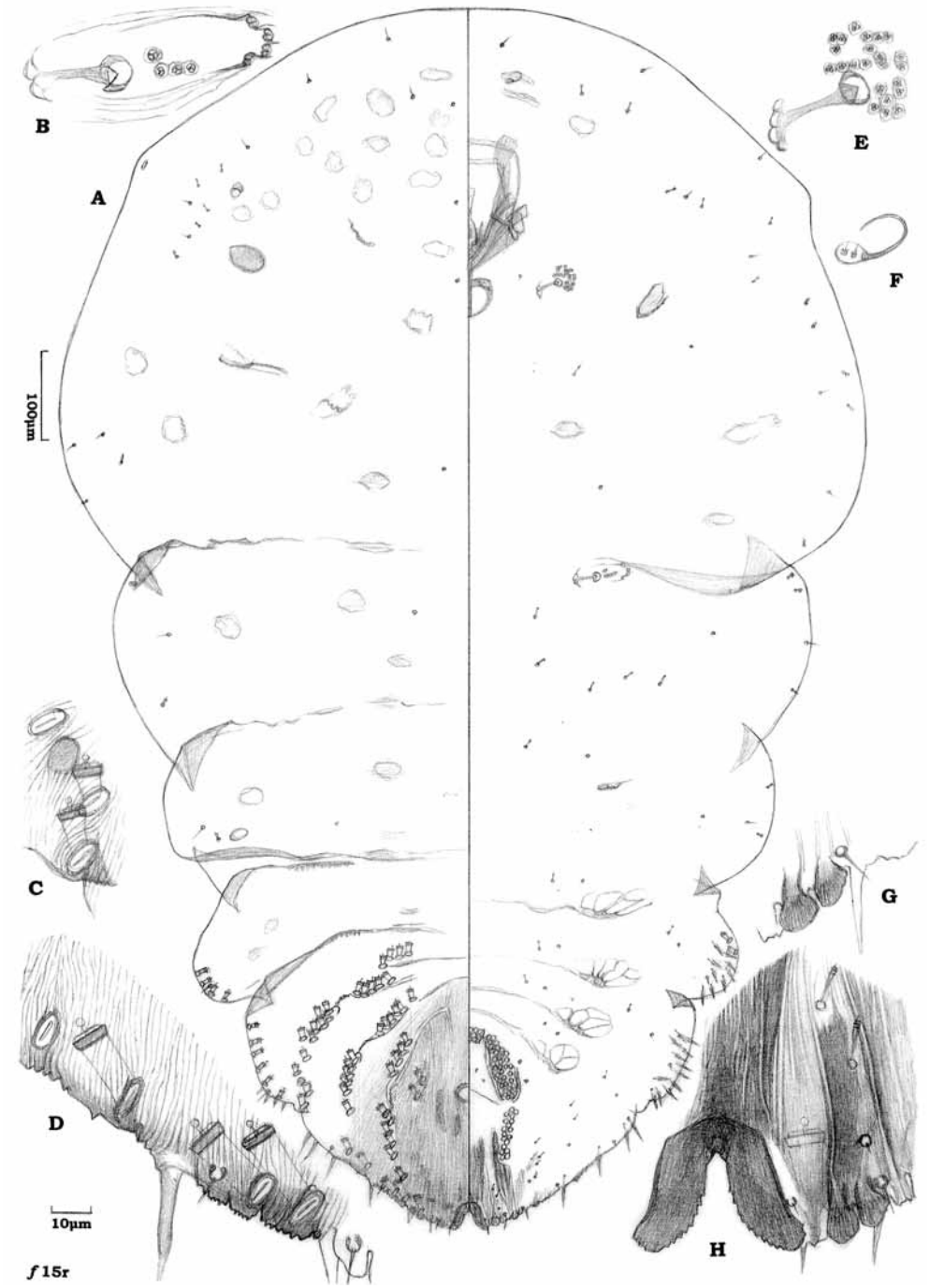

Fig. 19. *Aulacaspis ferrisi*, Sample 15, fully grown ramicolous adult female. B, posterior spiracle; C, posterolateral corner of abd III; D, pygidial margin, part; E, anterior spiracle; F, antenna; G, third trulla; H, median and second trullae. (Scale bar 100µm for A; 10µm for B–H.)

Fig. 20. *Aulacaspis obconica*, fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, anterior spiracle; E, antenna; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

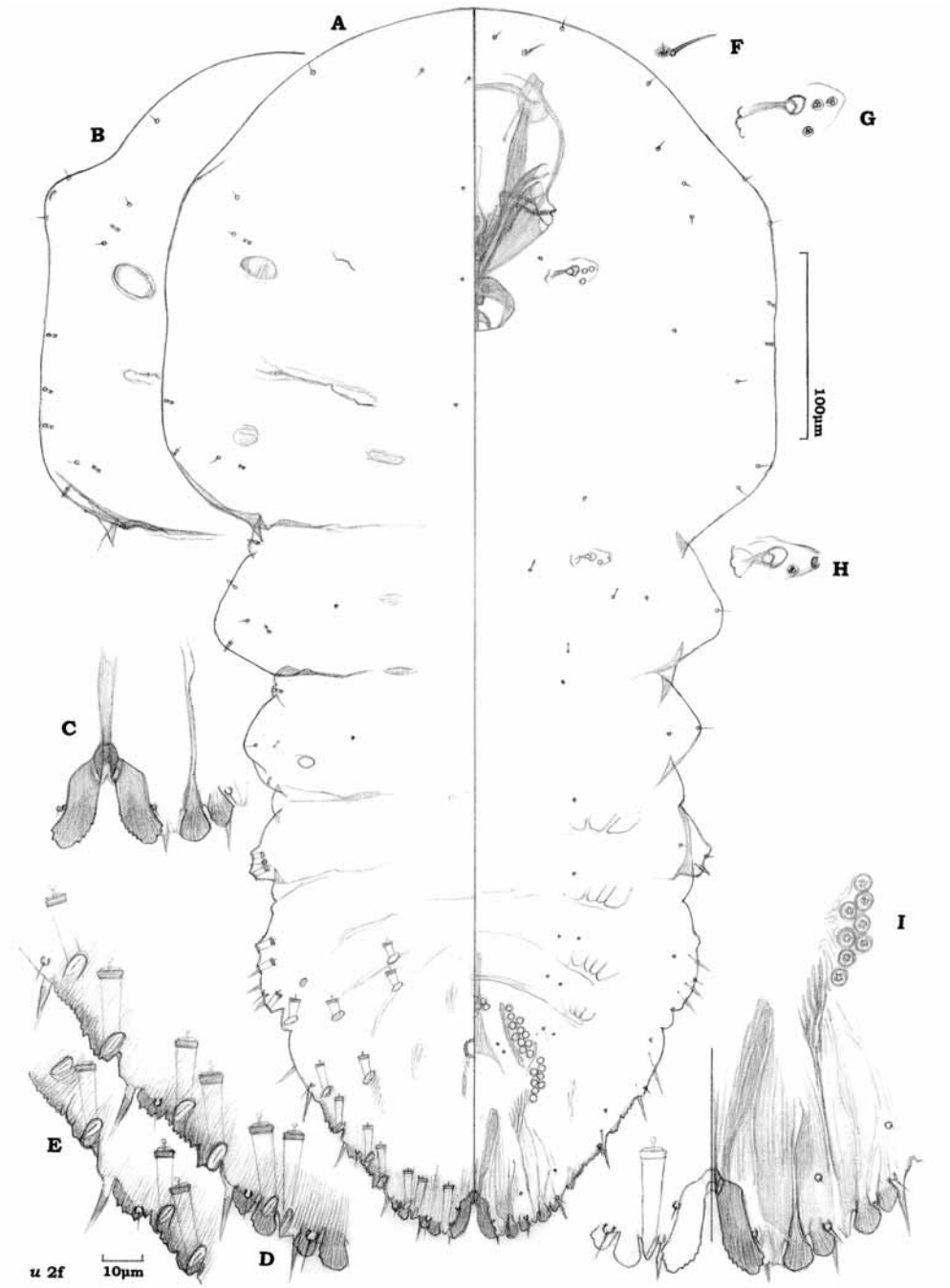

Fig. 21. *Aulacaspis ulukaliana*, Sample 2, fully grown foliicolous adult female. B, prosomtic margin, part, variation; C, median and second trullae, variation; D, E, pygidial margin, part; F, antenna; G, anterior spiracle; H, posterior spiracle; I, trullae. (Scale bar 100µm for A, B; 10µm for C–I.)

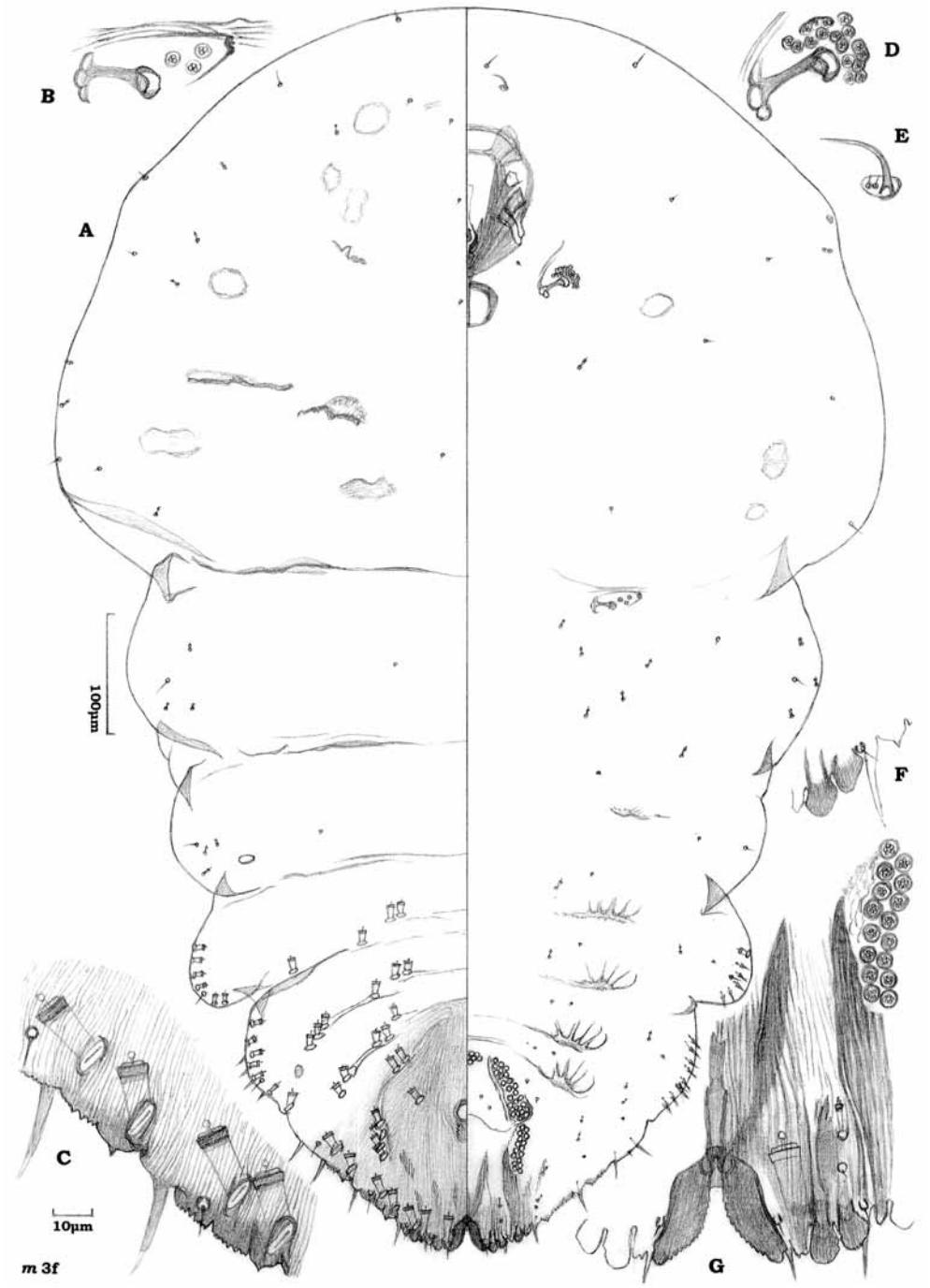

Fig. 22. *Aulacaspis medangena*, Sample 3, fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, anterior spiracle; E, antenna; F, third trulla; G, median and second trullae. (Scale bar 100µm for A; 10µm for B–G.)

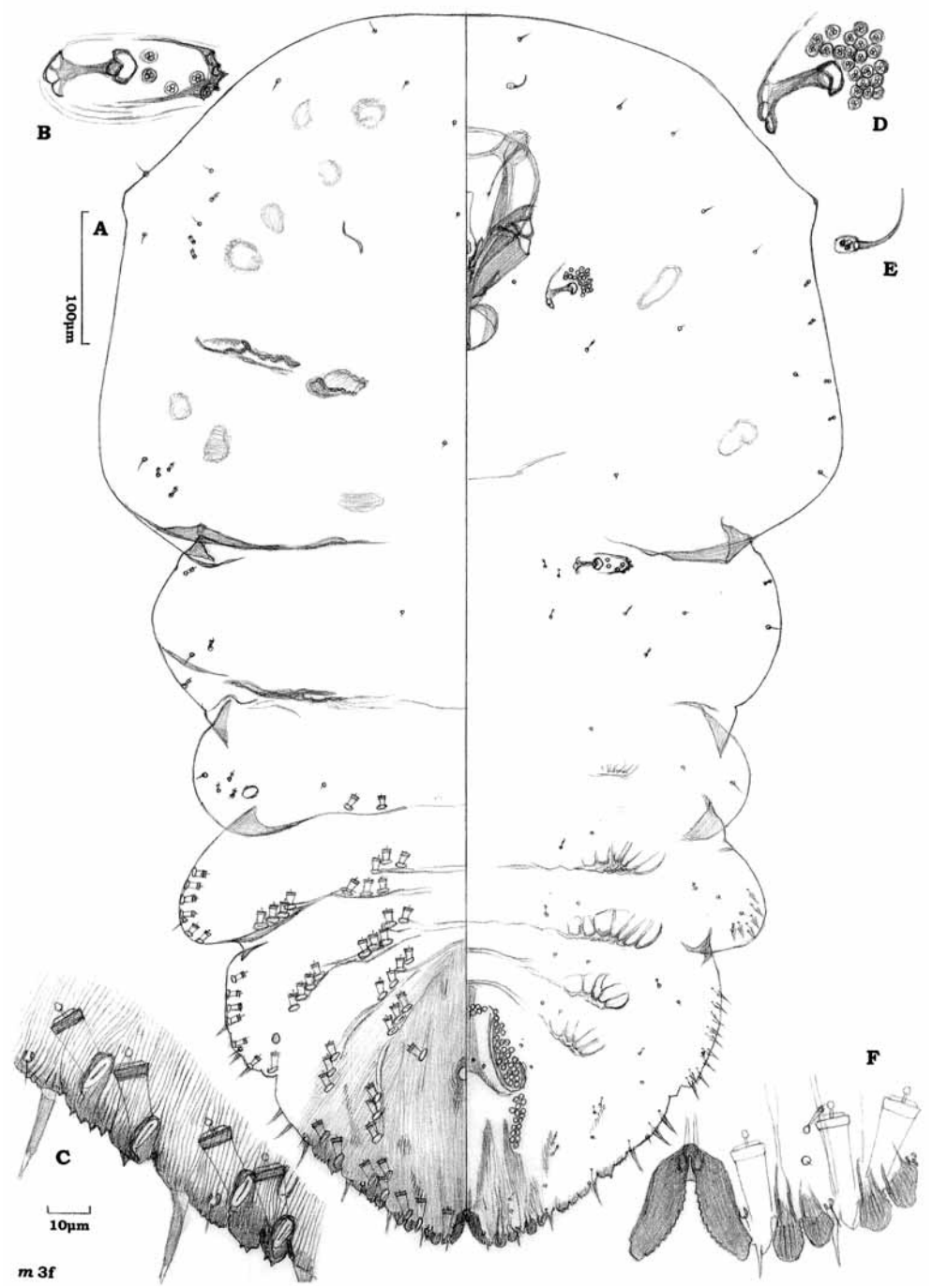

Fig 23. *Aulacaspis medangena*, Sample 3, considerably but not fully grown foliicolous adult female. B, posterior spiracle; C, pygidial margin, part; D, anterior spiracle; E, antenna; F, trullae. (Scale bar 100µm for A; 10µm for B–F.)

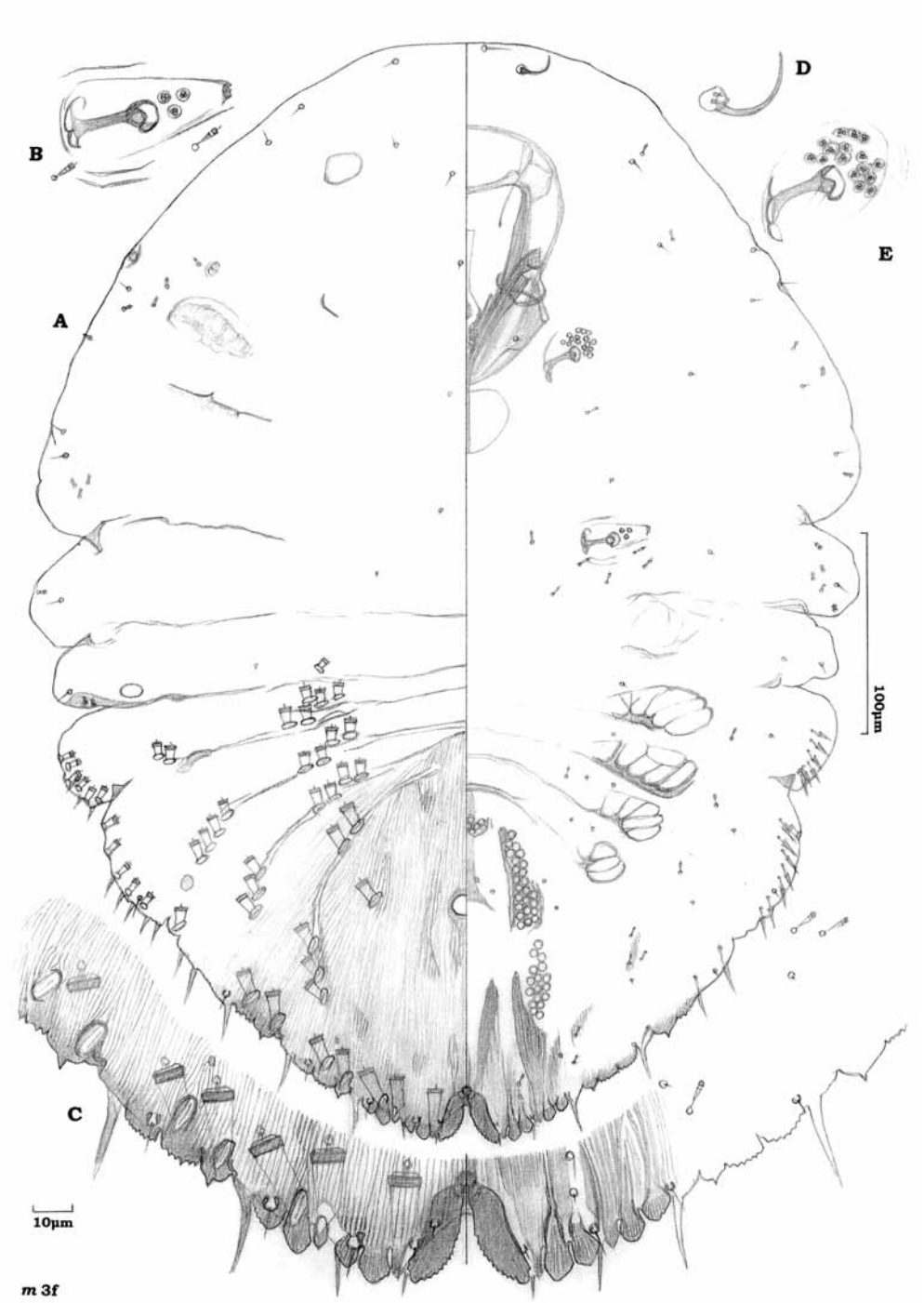

Fig. 24. *Aulacaspis medangena*, Sample 3, teneral foliicolous adult female. B, posterior spiracle; C, pygidial margin; D, antenna; E, anterior spiracle. (Scale bar 100µm for A; 10µm for B–E.)

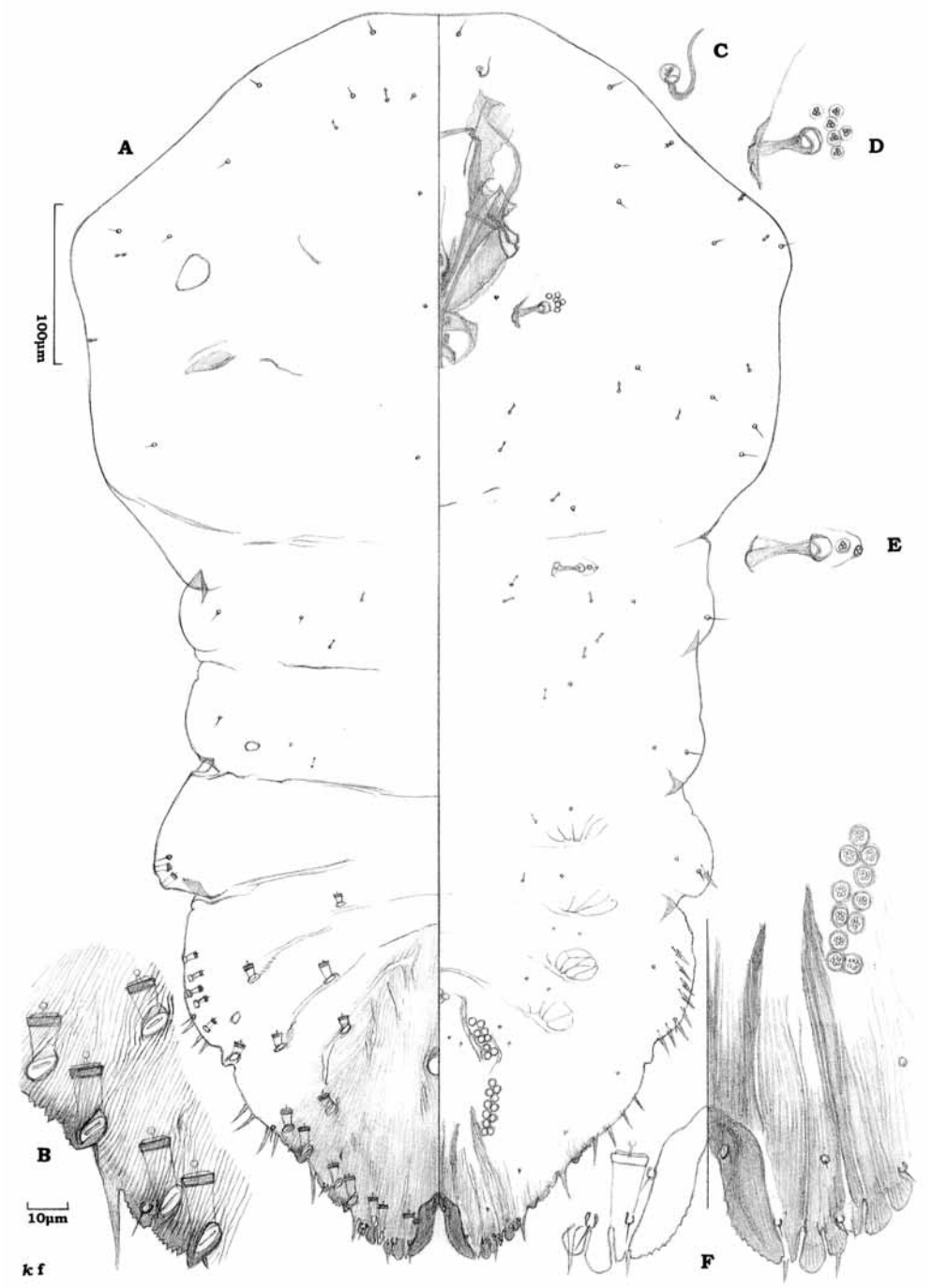

Fig. 25. *Aulacaspis kedahana*, fully grown foliicolous adult female. B, pygidial margin, part; C, antenna; D, anterior spiracle; E, posterior spiracle; F, trullae. (Scale bar 100µm for A; 10µm for B–F.)

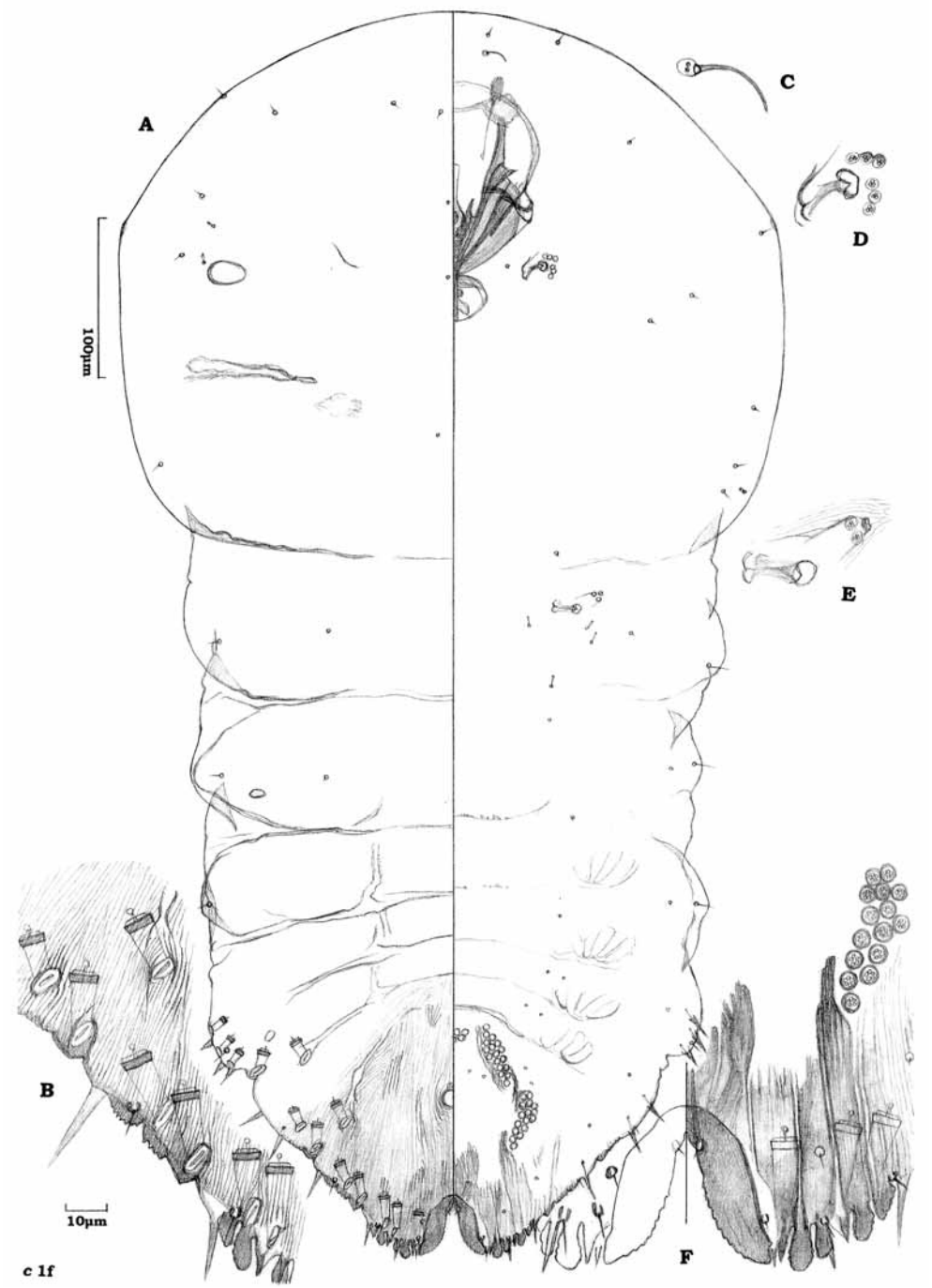

Fig. 26. *Aulacaspis cinnamomorum*, Sample 1, fully grown foliicolous adult female. B, pygidial margin, part; C, antenna; D, anterior spiracle; E, posterior spiracle; F, trullae. (Scale bar 100µm for A; 10µm for B–F.)

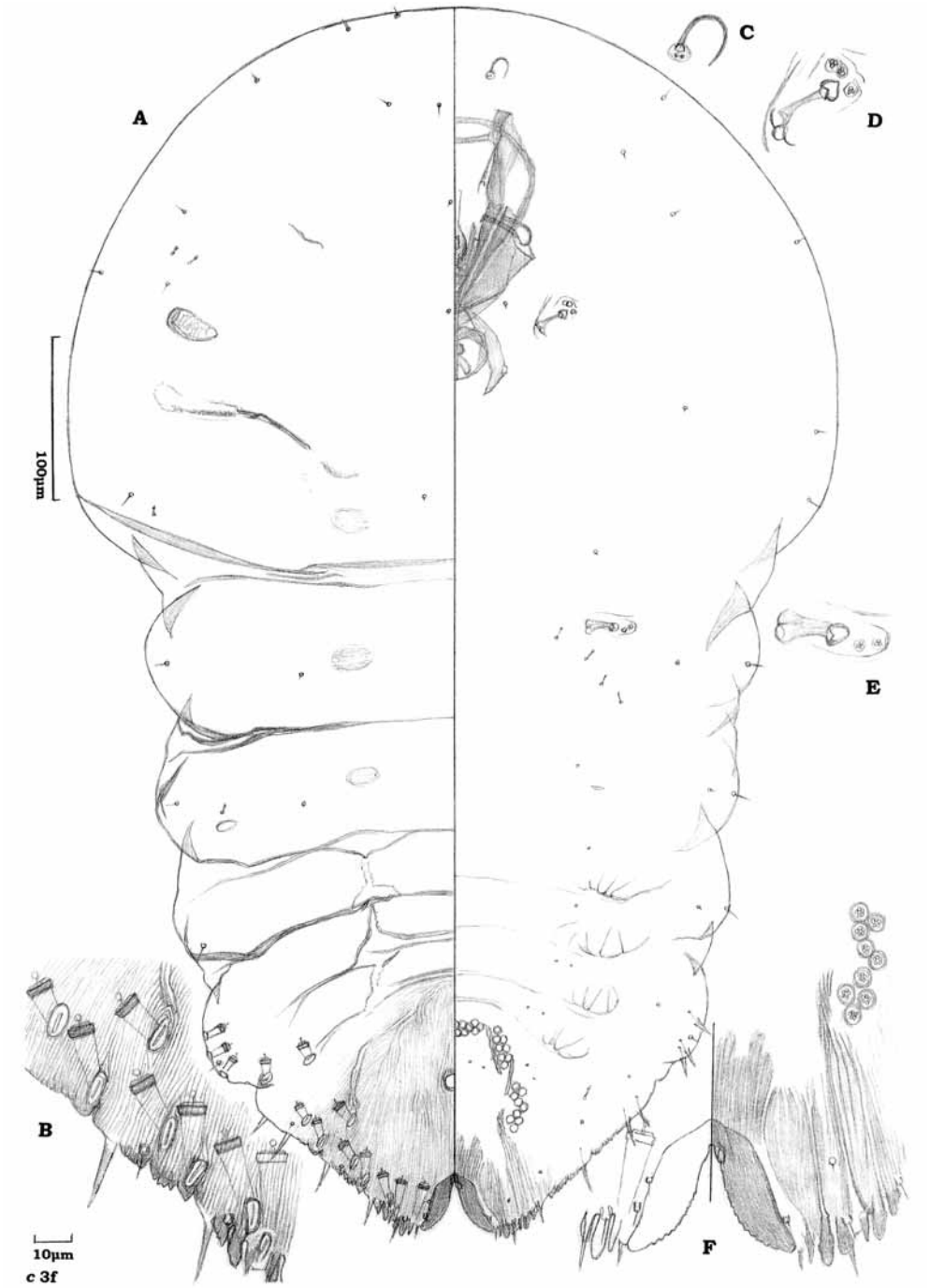

Fig. 27. *Aulacaspis cinnamomorum*, Sample 3, fully grown foliicolous adult female. B, pygidial margin, part; C, antenna; D, anterior spiracle; E, posterior spiracle; F, trullae. (Scale bar 100µm for A; 10µm for B–F.)

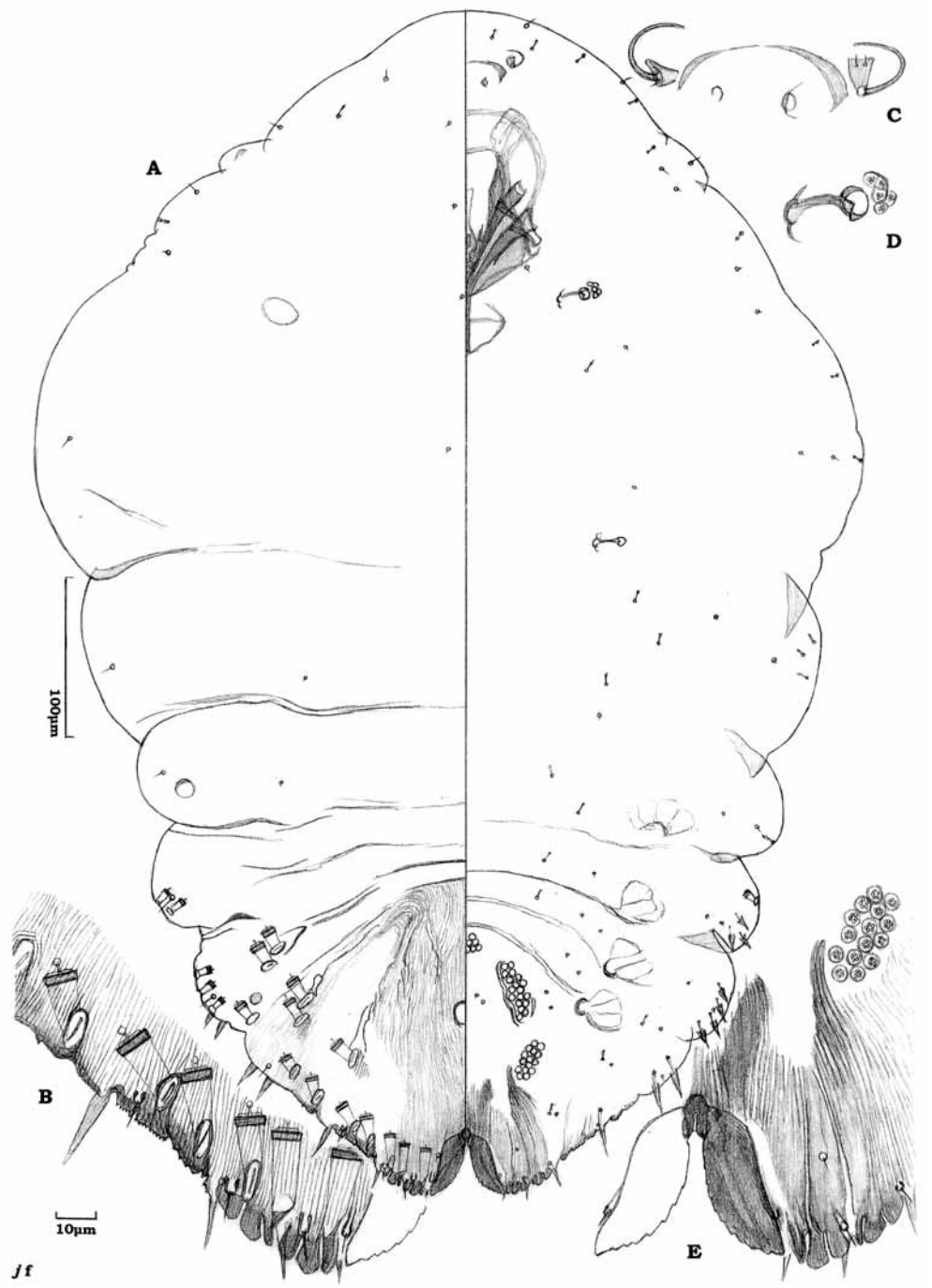

Fig. 28. *Aulacaspis jeraiana*, fully grown foliicolous adult female. B, pygidial margin, part; C, antenna, with interantennal swellings and derm pockets; D, anterior spiracle; E, trullae. (Scale bar 100µm for A; 10µm for B–E.)