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Title	A new scale insect genus from Hong Kong : another clue to the Rugaspidiotini-problem (Sternorrhyncha : Coccoidea : Diaspididae)
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Citation	Insecta matsumurana. New series : journal of the Faculty of Agriculture Hokkaido University, series entomology., 66, 37-55
Issue Date	2010-10
Doc URL	https://hdl.handle.net/2115/44626
Type	departmental bulletin paper
File Information	03.pdf



**A NEW SCALE INSECT GENUS FROM HONG KONG:
ANOTHER CLUE TO THE RUGASPIDIOTINI-PROBLEM
(STERNORRHYNCHA: COCCOIDEA: DIASPIDIDAE)**

By SADAO TAKAGI and JON H. MARTIN

Abstract

TAKAGI, S. and MARTIN, J. H., 2010. A new scale insect genus from Hong Kong: Another clue to the Rugaspidiotini-problem (Sternorrhyncha: Coccoidea: Diaspididae). *Ins. matsum. n. s.* 66: 37–55, 6 figs.

Nanhaiaspis chiulungensis, n. gen. and n. sp., is described on the basis of material collected on an undetermined bamboo in the Chiulung [Kowloon] Peninsula, opposite Hong Kong Island. *Rugaspidiotus communis* Hu, 1987, which occurs on reed in Hainan Island, is transferred to the new genus (*Nanhaiaspis communis*, n. comb.) on the supposition that it should be characterized nearly the same as *N. chiulungensis*, in contradiction to the original description. Referable to the Diaspidini but not to the Rugaspidiotini, *Nanhaiaspis* can be an incipient rugaspidiotine in having much reduced pygidial appendages and amphisomatic pygidial macroducts, and thus affords another clue to the Rugaspidiotini-problem, which has not been completely settled.

In an appendix, *Aulacaspis acronychiae*, n. sp., is described on the basis of a single specimen collected in Hong Kong on *Acronychia pedunculata*. It is close to *A. guangdongensis* described from Guangdong, China, and occurring on *Aglaia odorata*.

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Contents. Introduction — *Nanhaiaspis*, n. gen. — *Nanhaiaspis chiulungensis*, n. sp. — *Nanhaiaspis communis*, n. comb. (= *Rugaspidiotus communis* Hu, 1987) — Taxonomic significance of *Nanhaiaspis* — References — Appendix: A new species of *Aulacaspis* from Hong Kong — References — Figures.

INTRODUCTION

The genus proposed in this paper is based on a scale insect collected on an undetermined bamboo in the Chiulung [Kowloon] Peninsula, opposite Hong Kong Island. We adopt the view that this scale insect is very close to and possibly conspecific with *Rugaspidiotus communis* occurring on reed in Hainan Island, about 450km distant from the Chiulung Peninsula. The fact is that the adult female of the Chiulung form greatly disagrees with the description of *R. communis* given by Hu (1987) in having pygidial macroducts not only on the dorsal surface but also on the ventral surface, on which they are nearly the same as those on the dorsal surface in abundance and arrangement — a character unusual in adult female diaspidids. The Chiulung form disagrees with the description of *R. communis* also in having distinct, though flat, median trullae and in the positions of the dorsal bosses on the abdomen. However, we do not think that the two forms are really different in these characters. We therefore tried to borrow specimens of *R. communis* in order to confirm our view, but no specimen of that species has been available for our examination.

In this paper the Chiulung form is described as a new species only tentatively, but a new genus is erected for it, and *R. communis* is transferred to the new genus on the supposition that this Hainan form has characters very similar to those of the Chiulung form, in contradiction to the original description. The new genus is referable to the Diaspidini and apparently does not belong to the Rugaspidiotini, but can be an incipient rugaspidiotine and thus affords another clue to the Rugaspidiotini-problem, which is still far from completely settled (as to the problem, see Takagi, 1995, and Takagi et al., 1997). In this regard, the genus is worthy of particular attention and also of a detailed study based on further material.

The classification of the Diaspididae as well as of the other Coccoidea is mainly based on the stage of the adult female, which, as compared with the other stages, is persistent and easily obtainable for study. Except for the pupillarial genera, the long-living adult female remarkably increases in body size, laboriously constructs a shelter (called a scale or test), and deposits eggs (or, when ovoviviparous, gives birth to nymphs) under the shelter, and thus plays a leading role in adaptation to the sedentary juice-sucking diaspidid life on the host plant. The classification based on the stage of the adult female alone, therefore, should reflect adaptive aspects in this stage to a great degree. The other stages are expected to be relatively free from the adaptation in the adult female, having their own roles in the life history and, therefore, to present other aspects in evolution. However, the second-instar females and the 'homomorphic' second-instar males are, in general, considerably 'attracted' to the conspecific adult females in manifesting their phenotypic characters especially in the marginal features of the pygidium. 'Phenotypic attraction' (Takagi, 2008) is sometimes apparent in the first-instar nymphs that have the apical processes of the abdomen characteristically shaped and similar to the median trullae in the adult females.

Nanhaiaspis, n. gen.

Etymology. Nanhai (南海) in Chinese, literally meaning south sea, is applied to the South China Sea.

Type species. *Nanhaiaspis chiulungensis*, n. sp.

Adult female. Body elongate ovoid, broadest across base of abdomen, head narrowly and pygidium broadly rounded. Pygidium composed of abd V and succeeding segments, broader than long, rounded nearly evenly along margin; marginal gland spines present on abd V–VIII but very small; median trullae [median pygidial lobes] and other marginal prominences reduced into low undulations; no distinct lateral trullae; marginal setae on both surfaces small, no setae between median trullae; anus situated anteriorly to centre of pygidium; a pair of well-developed sclerotized dermal folds present anterolaterally to anus on supposed border between abd V and VI. Macroducts of the two-barred type, occurring on dorsal and ventral surfaces of pygidium, each with orifice elliptical and surrounded by a sclerotic rim; dorsally arranged in an oblique row arising marginally and succeeded by a longitudinal row on each of abd V and VI, also a single macroduct occurring marginally on VII, all situated on supposed posterior borders of these segments (so that the rows are termed ‘segmental’); ventrally in an oblique row arising marginally on each of abd V–VII, all situated within supposed posterior borders of these segments (‘infrasegmental’). Macroducts occurring also on prepygidial segments laterally. Perivulvar disc pores in 7 small groups (median group and 3 pairs of groups, which may be termed submedian, anterolateral, and posterolateral groups). Antennae separated from each other by a space narrower than frame of mouth-parts, each with a robust tubercle and 1 or 2 short setae. Anterior and posterior spiracles accompanied with trilocular disc pores. Abd I and III each with a dorsal boss submarginally on each side.

Second-instar female (exuvial cast). Similar to adult female in pygidial margin. Macroducts occurring on dorsal and ventral surfaces of pygidium mostly on margin. Exuvial cast bivalvate, the dorsal and ventral portions being attached to each other by a hinge-like anterior portion.

First-instar nymph (female and male exuvial casts). Antennae 5-segmented; segment II–IV deeply constricted halfway; segment V a little longer than IV, annulate towards apex. A pair of enlarged dorsal ducts present on head. No ducts near anus. Nine short spinous processes occurring on each side of body on margin of abdomen and meta- and mesothorax, cleft once or more to form sharp points; each process accompanied with a microduct posteriorly. No heavily sclerotized processes at posterior end of body. Legs with tibia much shortened, distinctly articulated with tarsus; tarsus with a campaniform sensillum dorsally on base (not only in the male but also in the female). Exuvial cast bivalvate. (The antennal characters are based on one female antenna. The other antennae on the female and male exuvial casts are badly damaged or wholly lost.)

Remarks. This genus is referable to the Diaspidinae and to the Diaspidini and possibly to the Fioriniina or the Kuwanaspina as will be discussed, but it is not easy to find its relationships to other genera of the Diaspidini. In the adult female, the marginal appendages of the pygidium are too much reduced to show the affinities of the genus. *Nanhaiaspis* is characteristic in having seven groups of perivulvar disc pores instead of the usual five groups. If the presence of supernumerary groups is due to ‘secondary division of the groups’ (Ferris, 1942), the possibility that it occurs in unrelated forms is not excluded, however rare it may be. (*Natalaspis simplex* has seven and *Nt. formosana* has five groups of perivulvar disc pores as will be mentioned. In this case, the presence or absence of supernumerary groups has no generic value.) The ‘amphisomatic’ occurrence (occurrence on both surfaces) of good macroducts on the pygidium is also a remarkable character of the genus and unusual in the family, but is known in a few other forms, which are not particularly closely related to each other. The patterns of arrangement of

the pygidial macroducts on the dorsal and ventral surfaces are characteristic of the genus, but they are apparently derivable from a usual arrangement of dorsal pygidial macroducts in the Diaspidini.

The first-instar female and male are characteristic in having spinous marginal processes around the abdomen and meta- and mesothorax. Similar processes, however, are known to occur sporadically in unrelated forms.

The second-instar male of *N. chiulungensis* has a unique character pattern, of which the taxonomic significance is not fully explainable with the present state of our knowledge. In the Diaspidini and a few other groups of the family, the second-instar males of congeneric species are sometimes far from uniform, so that the second-instar male of *N. chiulungensis* is described not under the genus but under the species.

For further discussion on the genus, see the section Taxonomic significance of *Nanhaiaspis*.

Nanhaiaspis chiulungensis, n. sp.
(Figs 2–5)

Material examined. Chiulung [Kowloon] Peninsula, opposite Hong Kong Island: arboretum area in Shin Mun Country Park, 15 Dec. 2001, J. H. Martin, JHM 7593. Associated with an undetermined species of bamboo, occurring within a bundle of developing leaves still rolled together, at the leaf bases. Four adult females, two second-instar males, and their exuvial casts have been available for study. Two of the adult female specimens are not stained (so that they were observed by phase-contrast microscopy): one of them is badly distorted and not all its features are clearly observable. One of the second-instar males is teneral and shrunk, so that this stage has been studied mainly on the basis of the other specimen. Holotype (adult female) and all the other specimens are deposited in the collection of the Natural History Museum, London.

Female and male tests white; female test bivalvate (with the ventral portion formed the same as the dorsal and separated from the latter along the posterior margin), ovoid in outline; male test elongate, cylindrical.

Adult female. Pygidium shallowly recessed apically, the recess with a pair of flat, irregularly incised, sclerotic processes, which apparently represent the median trullae. Pygidial margin on abd V–VII with low roundish prominences. Dorsal macroducts of pygidium on each side: 1 on abd VII just on margin, 7–9 on VI (4–6 in oblique and 2 or 3 in longitudinal row), 8 or 9 on V (3 or 4 in oblique and 2–4 in longitudinal row, plus 1 or 2 anteriorly to longitudinal row); total on each side 17 or 18, on both sides 35. Ventral macroducts of pygidium on each side: 3 on abd VII; 4–10 on VI; 4 or 5 on V; total on each side 11–18, on both sides 25–33. Total of pygidial macroducts 60–68. Abd IV with 4–6 macroducts in each posterolateral corner; anterior segments with macroducts laterally on each side as follows: III with 2–4, II with 4 or 5, I with 4–6, metathorax with 3–6, and mesothorax with 1 or none; total of these macroducts on each side 18–26, on both sides 37–48. Microducts sparsely scattered on both surfaces. Gland spines occurring on each side as follows (not all gland spines are distinctly observable): 1 on each of abd III and VI–VIII, 2 on each of IV and V. Perivulvar disc pores: 4 or 5 in median, 2–4 in submedian, 7–12 in anterolateral, and 7 or 8 in posterolateral group, total 38–48. Anterior spiracles each with a transverse row of 4–10 disc pores; posterior spiracles each with (3? or) 4–9.

Second-instar female. Similar to the adult female especially in pygidial margin, but much simplified especially in the occurrence of macroducts. Macroducts on each side of pygidium: 4 marginals on abd IV–VII and 1 submarginal on VI on dorsal surface; 3 marginals on V–VII and 2 submarginals on VI and VII on ventral surface, the submarginal macroduct on VII being set close to the marginal macroduct.

Second-instar male. Heteromorphic, being utterly different from the second-instar female, and also from the adult female, in character pattern. Body oblong, with posterior end broadly truncate; abd III partly and succeeding segments wholly becoming heavily sclerotic. There is a pouch-like invaginated structure (‘dermal pouch’) on each posterolateral angle of the body. The details of the dermal pouch are not clearly observable, but it seems that it has a bundle of macro- and microducts on the bottom and some small ducts on the walls. The bundle of ducts should arise from a communal pore (glanduliferous crater), which probably opens on the bottom of the pouch and, therefore, is not clearly visible. The truncated posterior end of the body is provided with a pair of short spinous processes (‘apical processes’), which are separated from each other by a wide space and irregularly cleft to form sharp points. Many sclerotic conical processes, smaller than the apical processes, occurring in a nearly continuous row on each side of the abdomen. This row starts at the posterolateral angle of the second segment and extends posteriorly on the lateral margins of the third to fifth segments. (In one of the examined specimens, the conical processes count 20 on one side and 21 on the other; in the other specimen, which is teneral and shrunk, the processes are not exactly countable.) Macroducts occurring on meso- and metathorax and basal 2 abdominal segments laterally and on both dorsal and ventral surfaces on posterior segments, where they occur at submarginal, intermediate, and submedian spots. Antennae set close, each represented by a short seta accompanied with 2 minute setae. Anterior spiracles each with 4–6 disc pores; posterior spiracles with none.

Nanhaiaspis communis (Hu), n. comb.

(Fig. 1)

Rugaspidiotus communis Hu, 1987: 220 [Adult female; Hainan Is., Guangdong, China, under the leaf-sheath of *Phragmites communis*].

In the original description of this species, all the macroducts of the pygidium are described and figured as occurring on the dorsal surface — as is usual with adult female diaspidids. But the arrangement of the pygidial macroducts shown in Hu’s figure (which is reproduced here: Fig. 1, upper) gives a rather strange impression. A modification of the figure, therefore, has been attempted by rearranging these macroducts onto the dorsal and ventral surfaces on the model of *N. chiulungensis*. In the modified figure (Fig. 1, lower), while the segmental macroducts are retained on the dorsal surface, the infrasegmental macroducts are removed onto the right half of the figure, the ventral surface, on which they are reversed to make their mirror images but otherwise intact. When thus modified, *R. communis* agrees with *R. chiulungensis* in the rows of pygidial macroducts arranged characteristically on the dorsal and ventral surfaces, respectively. Hu’s figure, therefore, should be accurate in drawing these rows apart from the fact that all of them are shown on the same surface.

Probably most scale insect taxonomists have had the experience of being confused

about which body surface bears a feature under observation in light microscopy. Setae, microducts, and other subtle features may easily be mistaken as to the surface they occur upon. This is especially true when mounted specimens (which are flattened dorsoventrally) are minute and have the derm not sclerotized and not stained well. Actually, even remarkable features were sometimes misunderstood. In *Conchaspis* (Conchaspidae), for example, the wax-secreting ducts, which are fairly large, were long supposed to open on the dorsal surface of the insect body, but in reality they open on the ventral surface (so that the insect should curve up the abdomen when applying secreted wax filaments onto the ceiling of the test, which is dome-shaped over the insect body) (Khoo, 1978; Takagi, 1992, 1997). This confusion was caused not only by the structure of the ducts (which is surely misleading) but probably also by the reasonable (but erroneous) preconception that these wax-secreting ducts, being responsible for forming the dorsal test, should open on the dorsal surface of the insect body. It is natural to suppose, by the same reason, that in diaspidids the pygidial macroducts should be restricted to the dorsal surface. However, a few exceptional cases have already been known, and *Nanhaiaspis* adduces another case.

In the original description of *R. communis* it is stated and shown in the figure that submarginal dorsal bosses occur on the second and third abdominal segments. However, these bosses occur on the first and third segments in *N. chiulungensis*. Moreover, the occurrence of this feature on the first segment is a usual character in diaspidids, having been observed broadly in the family. It is very probable, therefore, that *R. communis* and *N. chiulungensis* do not differ in the positions of these bosses.

According to the original description, *R. communis* has no trullae [pygidial lobes]. *N. chiulungensis* is provided with a pair of flat processes, apparently rudimentary median trullae, in the apical recess of the pygidium. It is possible that such processes occur also in *R. communis* and were interpreted as mere marginal undulations. If *R. communis* really has no trace of median trullae, the two forms should be distinct species.

Because no specimen of the Hainan form has been available for the present study, we leave to future study a critical comparison between *R. communis* and *N. chiulungensis* and their exact taxonomic relationship. However, we have no doubt that *R. communis* is congeneric with *N. chiulungensis*, and it is transferred to the new genus herewith.

Rugaspidotus communis, now *Nanhaiaspis communis*, as described and figured by Hu and *N. chiulungensis* as represented by the examined specimens differ in the numbers of wax-secreting organs (especially the macroducts and the spiracular and perivulvar disc pores), which are apparently fewer in the latter. The populations inhabiting Hainan Island and the Chiulung Peninsula, therefore, probably differ from each other in the numbers of these organs. *N. communis* and *N. chiulungensis* may be local forms of the same species; otherwise they should represent good species, which may have differentiated in host association, occurring on reed and bamboo, respectively. In the present state of our knowledge we may correctly assume that *Nanhaiaspis* is represented by at least several forms (conspecific local forms or different species) distributed in eastern Asia, especially along the coast of the South China Sea, and associated with Poaceae.

TAXONOMIC SIGNIFICANCE OF NANHAIASPIS

An incipient rugaspidotine?

Diaspis arizonica Cockerell is the type species of *Rugaspidotus* MacGillivray,

the type genus of the tribe Rugaspidiotini (or the subtribe Rugaspidiotina under the Odonaspidini or the Diaspidini). The pygidium in the adult female of *Rugaspidiotus arizonicus* is described as follows: 'Pygidium strongly sclerotic dorsally and in a marginal zone ventrally, marked with numerous irregular furrows and with numerous quite small ducts both dorsally and ventrally. The ducts are of a very obscurely two-barred character, short and slender. Margins of the pygidium irregularly lobed and indented, none of these irregularities being definitely identifiable as the usual paired lobes' (Ferris, 1938). Forms more or less similar to *R. arizonicus* in these pygidial features but not necessarily so in other features, and even some forms not so similar in the pygidium, were referred to the tribe Rugaspidiotini, probably because it was difficult to find their positions in other groups. Recently some forms once placed in the tribe have proved to have no close relationship to *R. arizonicus* and to each other so far as based on their nymphal characters, and it has been supposed that this tribe as composed by authors is largely an assemblage of unrelated forms. The Rugaspidiotini-problem, therefore, is primarily concerned with convergence in the stage of the adult female.

In spite of Hu's assignment of the Hainan form to *Rugaspidiotus*, *Nanhaiaspis* has no close resemblance to *R. arizonicus* (especially in having good macroducts, which are arranged in definite rows), and there is no good reason for regarding it as the same as *Rugaspidiotus* or (if *R. arizonicus* represents a distinct tribe) for referring it to the Rugaspidiotini. Nevertheless, it is plausible and possible that it represents an early stage in the evolution of the rugaspidiotine character pattern, having the pygidial appendages much reduced and the pygidial ducts on the ventral surface developed nearly the same as those on the dorsal surface; in other words, it can be an incipient rugaspidiotine. Hu's assignment of the Hainan form to *Rugaspidiotus*, therefore, is not entirely disharmonious with this interpretation.

A fioriniine or kuwanaspidine genus?

Nanhaiaspis apparently has arisen from a form possessing well-developed pygidial appendages. The median trullae are still present in *N. chiulungensis*. The obscure roundish processes on the pygidial margin should be rudimentary marginal appendages. The marginal gland spines are also much reduced in size but occur in a complete set on the pygidium. The macroducts are of the two-barred type; on the pygidium, they show no trace of reduction in size and are arranged in distinct segmental and infrasegmental rows. In all these respects, *Nanhaiaspis* is referable to the Diaspidinae, and there is no evidence that it belongs to the Lepidosaphidini. The view is adopted that it is a modified form of the Diaspidini.

The second-instar male of *N. chiulungensis* has a bundle of ducts on each side of the abdomen, and it is assumed on the basis of many other forms that these ducts open in a communal pore (glanduliferous crater) (which is not clearly visible in the examined specimens). Many species of the subtribes Fioriniina and Kuwanaspidina, tribe Diaspidini, have communal pores of ducts in the second-instar males. These subtribes, however, bear no particular resemblance to each other in the adult females.

The adult females of the Fioriniina have, at least typically, a pair of well-developed setae at the mesal bases of the median trullae. In the adult female of *N. chiulungensis* there is no trace of setae between the median trullae, and this suggests that *Nanhaiaspis* has no relationship to the subtribe. However, it may also be possible that the absence of the setae is due to a loss in association with the reduction of the trullae.

The Kuwanaspidina concentrate in eastern Asia, and most of the species occur on bamboos. In this regard the possibility that *Nanhaiaspis* has some relationship to this subtribe may not be excluded. However, there is no good morphological basis to support this view.

Ancestral to Natalaspis?

Natalaspis MacGillivray or *Poliaspoides* MacGillivray is one of the genera referred by authors to the Rugaspidiotini. It has at least two named species, *Natalaspis simplex* (Green) and *Nt. formosana* (Takahashi). These species are native to tropical Asia and associated with bamboos, occurring under the leaf-sheath. *Nt. simplex* has seven groups of perivulvar disc pores, agreeing in this character with *Nanhaiaspis*, but *Nt. formosana* has five groups. *Natalaspis* and *Nanhaiaspis* may have some relationship as will be discussed, but the morphological gap between them in the adult females is too great to connect them.

Nt. formosana was studied by Takagi (1995) and assumed to have originated from a usual form of the Diaspidini. In the first instar, it is similar to *Nanhaiaspis chiulungensis* in having apically cleft spinous processes around the abdomen and metathorax. The second-instar male is characterized, above all, by having at the posterior end of the body a pair of slender processes, which are dilated and sometimes frayed apically. These processes, though unusually elongated, probably represent the median trullae. The apical processes in the second-instar male of *N. chiulungensis* may also be the median trullae. They are not elongated as the processes of *Nt. formosana* but cleft apically, and thus appear to correspond to the latter in shape, too.

The common occurrence of a particular feature in one stage alone does not necessarily indicate a close relationship between taxa. When the processes occurring on the body margin in the first-instar nymph and the processes at the pygidial apex in the second-instar male are combined, their common occurrence in *Nanhaiaspis* and *Natalaspis* may indicate the possibility, rather strongly, that these genera have some relationship to each other. In the adult females, *Nanhaiaspis* as compared with *Natalaspis* is apparently primitive. If they are really related to each other, *Nanhaiaspis* should represent or approach an evolutionary stage ancestral to *Natalaspis*.

In the other features of the second-instar males *N. chiulungensis* and *Nt. formosana* do not seem to be particularly closely related. *Nt. formosana* has no communal pores in the second-instar male, but this does not necessarily mean that it has no relationship to the Fioriniina or the Kuwanaspidina. Not all species of these subtribes possess communal pores. In the fioriniine genus *Sinistraspis* MacGillivray, for example, two types of the second-instar males were found, one type with a pair of communal pores and the other without them. Moreover, the nymphs of both these types were referred to the same species, *S. unilateralis* (Newstead), because the adult females were variable but not divisible into distinct forms corresponding with the two types of the second-instar males (Takagi, 2000). The second-instar male of *Nt. formosana* has small groups of short ducts marginally on the second to seventh abdominal segments. In their positions, these ducts are reminiscent of the modified ducts occurring in the second-instar males of some Chionaspidina. However, it is also possible that they correspond to the small ducts occurring within the dermal pouches in the second-instar male of *N. chiulungensis*.

The second-instar male of *N. chiulungensis* is heteromorphic, being remarkably different from the adult and second-instar females in character pattern. In the Diaspidini,

Odonaspidini, and Smilacicolini, the heteromorphic second-instar males are, in general, interpretable to be of atavistic nature. This is especially true in the Odonaspidini, in which the heteromorphic second-instar males of some species clearly exhibit the character pattern of the distinct tribe Parlatoriini (Aono, 2009). The second-instar male of *N. chiulungensis*, with its truncated body end, apical processes, dermal pouches, abundant macroducts on both surfaces of the body, and abdomen beaded with conical processes on the lateral margins, appears very strange, because there has been known no other diaspidid form that has such a character pattern.

As stated above, *Nanhaiaspis chiulungensis* has communal pores in common with Fioriniina and Kuwanaspidina. However, the typical heteromorphic second-instar males of the subtribe Fioriniina as represented by those of *Fiorinia* and *Pseudaulacaspis* are not particularly closely similar to the second-instar male of *N. chiulungensis* in other features.

Published figures of the second-instar males of seven species belonging to five genera referred to the subtribe Kuwanaspidina are available for comparisons in this stage. One of these species, *Nikkoaspis berincangensis* (occurring at a high altitude of the Malay Peninsula; Takagi, 1999: Fig. 12) may roughly be compared with *N. chiulungensis* on the assumption that the pectinate processes occurring around the abdomen correspond to the spinous and conical marginal processes in the latter. It is characterized in common with the latter in having abundant dorsal and ventral macroducts, and is similar also in the arrangements of these macroducts on both surfaces. It is rather similar to the latter in having an obtuse body end. However, it has no structure corresponding to the dermal pouches.

The comparison made above between *N. chiulungensis* and *Nk. berincangensis* in the second-instar male is not fully convincing but not wholly negative in showing a possible relationship between these genera. *Nikkoaspis* probably has unknown species concentrating in southern China to northern Indochina (Takagi, 1999). The possibility that some of them are more similar to *Nanhaiaspis* in the second-instar male may not be excluded.

Amphisomatic occurrence of macroducts

Nanhaiaspis is noteworthy, above all, in having good macroducts arranged in definite rows on both surfaces of the pygidium in the adult female. The amphisomatic occurrence of macroducts is known also in *Amphisoma* and *Galeomytilus*. These genera, erected monobasically, were studied especially with reference to the formation of their bivalvate tests (Takagi, 1995). They are similar to *Nanhaiaspis* also in the trullae and marginal pore prominences much reduced or obsolete. They, therefore, also can be incipient rugaspidiotines, and suggest the emergence of the rugaspidiotine character pattern from different taxonomic groups. *Amphisoma* belongs to the Diaspidini, and is referable to the Chionaspidina. It has the pygidial macroducts clearly differentiated into marginal, submarginal, and submedian ones as in many other Diaspidini (in which, needless to say, the pygidial macroducts are restricted to the dorsal surface). *Galeomytilus* is apparently referable to the Lepidosaphidini, having megaducts.

The type species of *Amphisoma* and *Galeomytilus*, *A. erectum* and *G. obesus*, live among the dense erect hairs of the host plant (*Colona serratifolia*, Tiliaceae). Their amphisomatic macroducts and reduced pygidial appendages are interpreted to be adaptive in forming their tests in the narrow and confined space on the plant. Their

completed female tests are different in shape, standing (in *A. erectum*) or lying (in *G. obesus*) among the erect hairs of the plant, and suggest different movements of the insect bodies in test construction. These cases suggest that the convergence towards the rugaspidiotine character pattern makes a start on such particular feeding sites on the host plants as to restrict the body movements of the adult females in test construction.

The female of *Neparla katus* (belonging to the Parlatoriini) presents another case of the amphisomatic occurrence of pygidial macroducts combined with the formation of a bivalvate test on a hidden plant part (under the stipule), but it has the marginal appendages of the pygidium represented fairly well except that the pectinae occurring laterally to the third trullae are reduced into small simple processes (Takagi, 1987).

The female of *Nanhaiaspis chiulungensis* also constructs a bivalvate test. Such a test is not securely fixed to the plant body by its ventral portion, which is formed the same as the dorsal portion. The specimens were found enclosed within rolled young leaves, which will grow, open, and then make the tests exposed to the risk of dropping off. On the other hand, *N. communis* was collected from under the leaf-sheath, which tightly covers the tests. The question arises, therefore, whether *N. chiulungensis* always and normally occurs within growing rolled leaves. (It should be added here that three other diaspidid species, belonging to *Kuwanaspis*, *Formosaspis*, and *Odonaspis*, were found on the same plant material and within the rolled leaves, which should have attracted crawlers of these species as well as of *N. chiulungensis*.) It is necessary to ascertain the exact feeding site that has promoted the appearance of amphisomatic pygidial macroducts and reduced pygidial appendages combined with the formation of a bivalvate test in *Nanhaiaspis*.

The second-instar females of *Nanhaiaspis chiulungensis*, *Amphisoma erectum*, and *Galeomytilus obesus* also have macroducts on both surfaces of the pygidium probably as a result of phenotypic attraction to their adult females, and the construction of bivalvate female tests apparently starts in the second instar.

The second-instar males of *N. chiulungensis* and *A. erectum* are known, and they have abundant macroducts on both surfaces of the body. Because they are heteromorphic, the amphisomatic occurrence of macroducts in them should be attributed to a reason other than phenotypic attraction to the adult females.

Concluding remarks

The Rugaspidiotini-problem is ultimately to determine the positions of all the rugaspidiotine-patterned forms in higher taxa (subfamilies, tribes, and so on). They have been referred to monobasic or small genera, which thus appear to be more or less isolated even in the stage of the adult female. Some if not all of these genera may be worthy of erection of their own higher taxa especially when they are characteristic also in one or more of the other stages (Takagi, 1995).

The tribe Odonaspidini, which was once connected with the Rugaspidiotini, should have evolved from the Parlatoriini under the conditions exactly or nearly similar to those that promoted the emergence of *Natalaspis*. The tribe has been recognized as a good taxon, because it is discrete from the Parlatoriini in the character pattern of the adult female and is characterized also in the first instar, and probably because it comprises a good number of species.

However, in recognizing a higher taxon, the size (the number of contained lower taxa) may not be an essential factor. According to Willmer (1990), the overall effect of evolutionary modes in the invertebrates is comparable to 'an old-fashioned meadow, where

a few hardy perennial designs flourish and branch amongst the grasses'. Given that this is a general tendency in the emergence and evolution of higher taxa, the rugaspidiotine-patterned forms should correspond to grasses in Willmer's meadow, representing individual trials in adaptation to living at some particular feeding sites on the host plants. Whether they remain to be grasses (and, thus, are liable to be lost eventually) or develop to hardy perennial designs may depend upon whether they can exploit and broaden their adaptive zones (niche-organism systems) successfully.

The present study has not clarified the taxonomic relationships of *Nanhaiaspis* to other groups satisfactorily, and the significance of the genus in the Rugaspidiotini-problem remains not fully appreciable. However, it has brought the hope that there would be discovered further forms that are helpful in proceeding not only with the taxonomic position of *Nanhaiaspis* but also with that of a rugaspidiotine-patterned genus, *Natalaspis*.

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APPENDIX

A NEW SPECIES OF AULACASPIS FROM HONG KONG

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In the scale insect collection made by J. H. Martin in Hong Kong one specimen of *Aulacaspis* was found. Although it has been difficult to place the specimen specifically, it is in good condition and seems to represent a new species, which is described below.

Aulacaspis acronychiae, n. sp.

(Fig. 6)

Material examined. A single specimen of the adult female collected in the New Territories, opposite Hong Kong Island: Ma On Shan Country Park, mountain trail, on *Acronychia pedunculata* (Rutaceae), 9.XII.2003, S. K. Lau and J. H. Martin, JHM 7923. Deposited in the collection of the Natural History Museum, London.

The slide has no specific note about the feeding site, but the specimen was probably mounted from a leaf surface because of the absence of note for stem- or petiole-feeding (which is usually written down). It was found amongst whiteflies, for which the material JHM 7923 was primarily collected.

Adult female (holotype). The specimen has the prosoma weakly sclerotic in broad marginal areas on both surfaces, with rudimentary peribuccal scleroses, so that it should not be fully matured. It seems, however, that the body has attained its full size. Body robust, cuneiform; prosoma rounded, with a pair of slight prominences representing prosomatic tubercles; postsoma as a whole gradually narrowing posteriorly, abd II and III subequal in width, pygidium nearly triangular. Antennae separated from each other by a space narrower than frame of mouth-parts, each represented by a slender seta accompanied with a minute seta, both arising immediately from derm. Median trullae [pygidial lobes] sunken in a small apical recess of pygidium except for their apices, robust, united by a large rounded sclerosis basally, separated from each other by a narrow but distinct space, then divergent, dentate (each with 4 distinct teeth) on the slanting mesal margins, and rounded apically. Second and third trullae with each lobule robust and roundish, inner lobule of the second with a pair of slender basal scleroses. Pore prominences low; prominence associated with mesal marginal macroduct of abd IV flat, with a small triangular process medially. Anterior spiracles each with a compact group of nearly 30 disc pores (not exactly counted); posterior spiracles each with 11 or 15 disc pores. Perivulvar disc pores rather numerous, 18/35–28/21–27, total 129. Dorsal macroducts numerous; submedian macroducts occurring on abd II–VI, distinctly separated into segmental and infrasegmental series on II–IV; submarginal macroducts on abd II(or III)–V. Submedian macroducts: 12 in segmental and 5 in infrasegmental series on II, 8 or 9 and 4 or 6 on III, 6 or 7 and 3 on IV, 6 or 7 on V, and 2 or 3 on VI; submarginal macroducts: 0 or 2 on II, 8 or 12 (excluding one situated at the outer end of the row and representing the marginal macroduct of the segment) on III, 11 or 12 on IV, and 7 or 10 on V; total of submedian and submarginal macroducts 160. Lateral macroducts: 11 or 15 on abd II, and 9 on III. Lateral gland spines: 7 or 8 on abd II, 9 or

11 on III. Marginal gland spines: 7 or 8 on IV, 1 on V, 2 (overlapping) on VI, 1 on VII, and 1 on VIII.

Remarks. This species closely agrees with *Aulacaspis guangdongensis*, which was described by Chen et al. (1980) from Zhanjiang, Guangdong Province, China, not very far from Hong Kong, as occurring on the leaves of *Aglaia odorata* (Meliaceae), and redescribed by Chen (1983) apparently on the basis of the same material. It differs from the description of that species as follows: 1) Antennae without tubercle. [In *A. guangdongensis*, each antenna has a robust tubercle (Chen, 1983, Fig. 31).] 2) Median trullae separated basally by a narrow but obvious space and dentate (each having four distinct teeth in the holotype) on the oblique mesal margin. [Median trullae separated basally by 'a seam', 'extending straight' on the oblique mesal margin, which is thus not dentate nor serrate.] 3) Submedian and submarginal dorsal macroducts about twice as many as those in *A. guangdongensis*. [The figure in Chen et al., 1980 (and also in Chen, 1983) shows 42 dorsal macroducts on the left (dorsal) half of the abdomen, so that the specimen should have a combined total of about 84 dorsal macroducts.]

The specimens of *A. guangdongensis* were collected on the leaves of the host plant and the specimen of *A. acronychiae* should also have been mounted from the leaf (see under Material examined), so that the differences between them mentioned above should not be due to a difference in feeding site. *A. guangdongensis* and *A. acronychiae*, which are undoubtedly very closely related to each other, should therefore represent distinct species or local or host-associated forms belonging to the same species.

In this genus, the antennae are of simple structure, but their characters are fairly stable in a species. The difference between *A. acronychiae* and *A. guangdongensis* in the structure of the antennae suggests that they are different species. The median trullae are sometimes remarkably variable in a species, and may vary in size, in width, in the degree of serration, in the development of the basal zygotis (of which the presence and absence sometimes occur even within a species as site-caused variations), and so on. As stated above, *A. acronychiae* and *A. guangdongensis* clearly differ in the median trullae. With the single available specimen of *A. acronychiae* and the single record of *A. guangdongensis* it is not easy to evaluate the difference properly but, on comparison with some known cases, it may be questioned if it falls in the category of infraspecific variation. The number of the dorsal macroducts may be adopted in distinguishing the two forms, but only tentatively, because the dorsal macroducts are broadly variable in number in some species of the genus studied on the basis of abundant material.

After all, *A. acronychiae* is probably a distinct species closely related to *A. guangdongensis*. This view may be challenged by a study based on further material.

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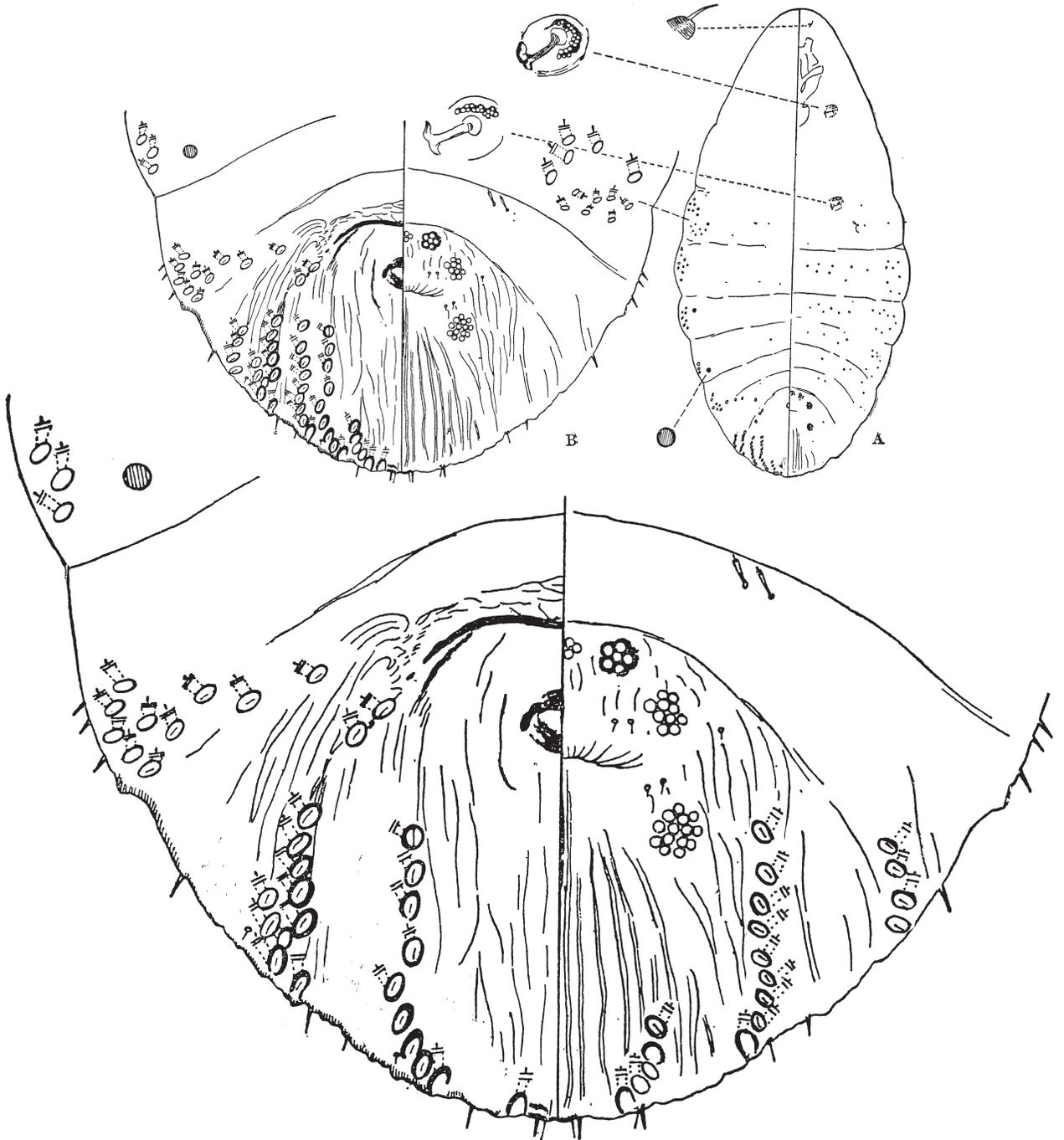


Fig. 1. *Nanhaiaspis communis* (= *Rugaspidotus communis* Hu), adult female. Upper: reproduced from Hu (1987); lower: pygidium from Hu, with macroducts rearranged onto dorsal and ventral surfaces.



Fig. 2. *Nanhaiaspis chiulungensis*, adult female (holotype). B, apical area of pygidium; C, antenna; D and E, anterior (D) and posterior (E) spiracles.



Fig. 3. *Nanhaiaspis chiulungensis*, adult female: pygidium (figured from an unstained specimen observed in phase-contrast microscopy).

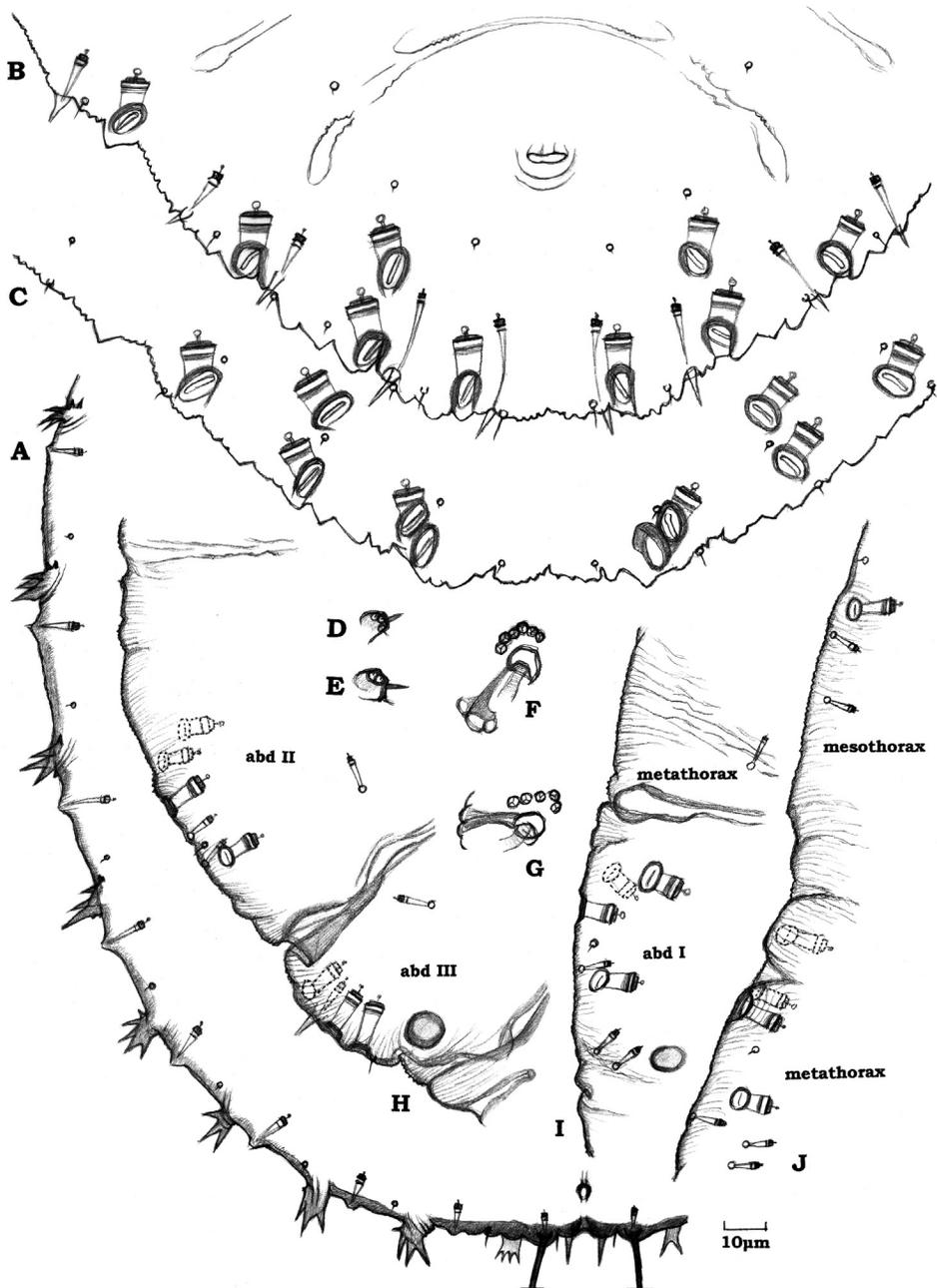


Fig. 4. *Nanhaiaspis chiulungensis*, adult female and first- and second-instar exuvial casts of female. A, first-instar exuvial cast, dorsal portion: margin of meso- and metathorax and abdomen. B and C, second-instar female exuvial cast: pygidial margins of dorsal (B) and ventral (C) portions. D–J, adult female: D and E, antenna, examples from 2 specimens; F and G, anterior (F) and posterior (G) spiracle; H–J, prepygidial body margin, dorsal surface (ducts shown by dotted lines: opening on ventral surface).

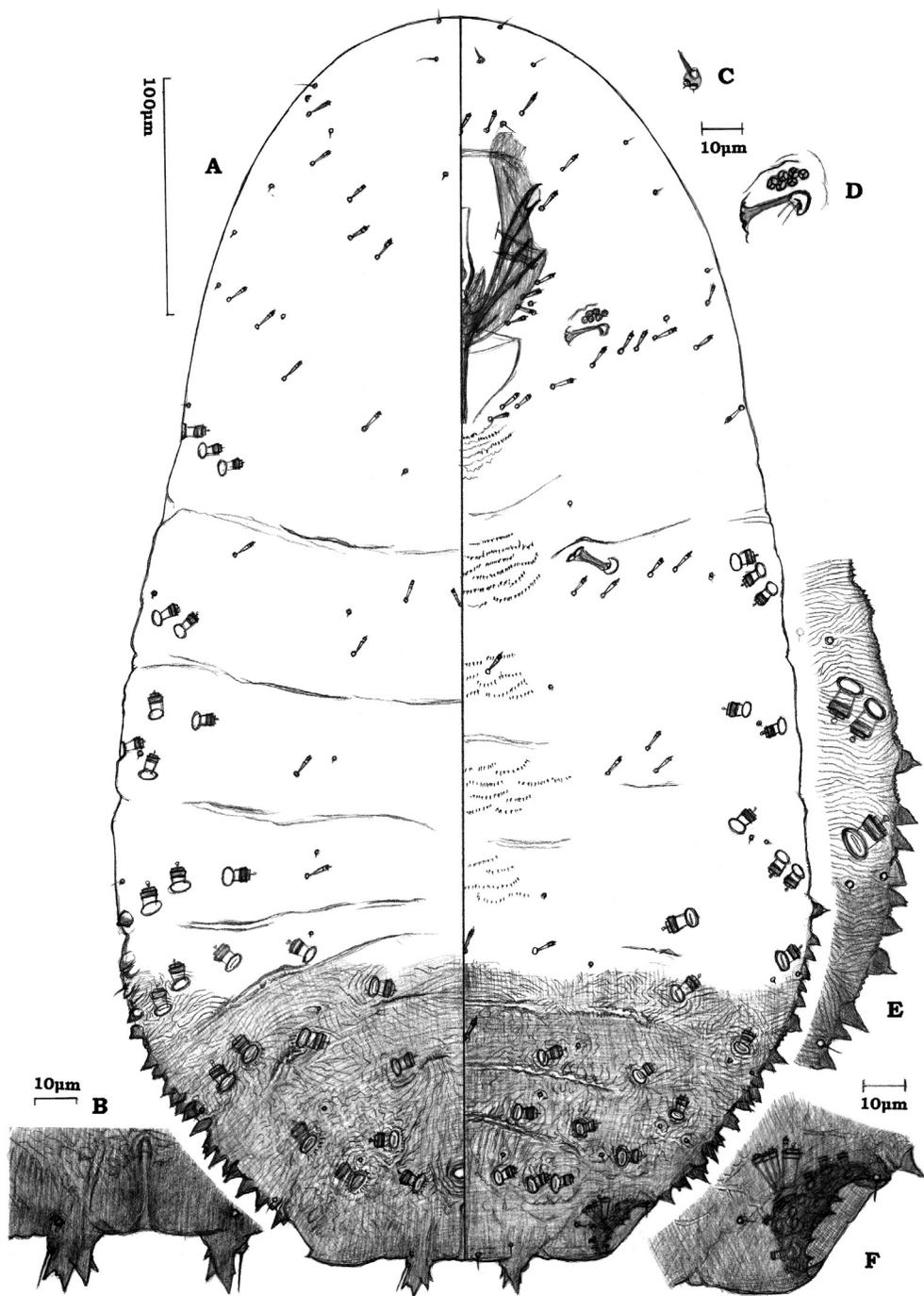


Fig. 5. *Nanhaiaspis chiulungensis*, second-instar male. B, apical processes; C, antenna; D, anterior spiracle; E, part of abdomen, showing conical processes on margin; F, dermal pouch.



Fig. 6. *Aulacaspis acronychiae*, adult female. B, dorsal boss just mesad of submarginal macroducts of abd III; C, margin of abd IV and V, dorsal surface; D, antenna; E, disc pores associated with posterior spiracle; F, third trullae; G, median and second trullae.