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**TAXONOMIC STUDY ON ODONASPIDINI, WITH PARTICULAR
REFERENCE TO SEXUAL DIMORPHISM IN THE SECOND INSTAR
(STERNORRHYNCHA: COCCOIDEA: DIASPIDIDAE)**

By MEGUMI AONO

Abstract

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Sexual dimorphism in the second-instar nymphal stage is studied in 14 species of the Odonaspidini occurring in Asia. These species and another species from North America are divided into 4 types and an extra form based on the dimorphism. The second-instar males of Type I are ‘homomorphic’, agreeing with the conspecific female nymphs in having odonaspidine characters, whereas those of Type IV are ‘heteromorphic’ and exhibit the character pattern of the distinct tribe Parlatoriini; the males of the other types and the extra form show various mixtures of odonaspidine and parlatoriine characters. Not all of the species belonging to Type IV are closely related to each other so far as based on their adult females, so that the genomic potential for the parlatoriine phenotype is assumed to be universal among species of the Odonaspidini and its manifestation to be of atavistic nature. In the other species the manifestation of the parlatoriine phenotype is suppressed completely or incompletely.

Thirteen new species found in the course of the present study and occurring in Malaysia, the Philippines, and Japan are described, and 6 species are newly recorded from Malaysia and the Philippines.

Author's address. Systematic Entomology, Graduate School of Agriculture, Hokkaidô University, Sapporo, 060-8589, Japan. (Present address: Moji Plant Protection Station Fukuoka Airport Branch, Fukuoka Airport International Terminal Bldg., 739 Ôaza Aoki, Hakata-ku, Fukuoka City, Fukuoka, 812-0851 Japan)

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Contents

Introduction

Part I: Descriptions of six new species

Odonaspis batarazaensis, sp. nov.

Odonaspis densipora, sp. nov.

Odonaspis maasinensis, sp. nov.

Odonaspis miyakoensis, sp. nov.

Odonaspis procera, sp. nov.

Odonaspis sparsa, sp. nov.

Part II: Sexual dimorphism in the second-instar nymphs of 14 species of Odonaspidini

General morphological features

Froggattiella penicillata

Odonaspis arcusnotata

Odonaspis bambusarum

Odonaspis batarazaensis

Odonaspis densipora

Odonaspis greeni

Odonaspis maasinensis

Odonaspis miyakoensis

Odonaspis morrisoni

Odonaspis oshimaensis

Odonaspis procera

Odonaspis schizostachyi

Odonaspis secreta

Odonaspis sparsa

Discussion and conclusion

Part III: Descriptions of seven other new species

Froggattiella gigantochloae, sp. nov.

Froggattiella pentapenicillata, sp. nov.

Odonaspis collarifera, sp. nov.

Odonaspis rugosa, sp. nov.

Odonaspis spinulata, sp. nov.

Odonaspis tapahensis, sp. nov.

Odonaspis trispatulata, sp. nov.

Part IV: Species newly recorded from Malaysia and the Philippines

Acknowledgments

References

Figures

INTRODUCTION

In the superfamily Coccoidea, the adult stage exhibits a remarkable sexual dimorphism, whereas the classification of this insect group has traditionally been based on the adult female, which is easily accessible as compared with the other stages. However, there is some basis for believing that, as the result of adaptation to sessile juice-sucking life on plants, the morphological evolution of the adult females involves not only drastically divergent specialization but frequently also parallelism and convergence, thus often making the composition of taxa confused and the phylogenetic relationships among taxa obscure. Sometimes ecophenotypic variation in this stage, caused by different feeding sites on the same host plants, also misled to confusion in recognizing species, genera, and even higher taxa. In this respect, the adoption of other stages for comparison may be expected to be useful for improving classification. Needless to say, ontogeny is an essential unit in biology. In coccoid taxonomy, however, detailed studies on the adult male and nymphal stages are still restricted to a small part of the superfamily.

Generally in the family Diaspididae, the second-instar males differ from the conspecific second-instar females in having much more numerous wax-secreting ducts in accord with sexual difference in test formation. In the other features, especially in the structure of the pygidial margin, the second-instar males may be similar to the conspecific females of the same instar and also of the adult stage or dissimilar from the females, showing completely different character patterns. This is true especially in the large tribe Diaspidini, in which 'homo-' and 'heteromorphic' forms of the second-instar male sometimes occur in a group of species that are similar to each other in the adult female (Takagi, 1998 and other papers; Shoubu and Kawai, 2002). This phenomenon introduces a new matter to be analysed in taxonomy, and is promising for promoting taxonomic study not only on the species concerned but also on the higher taxa to which the species belong.

The tribe Odonaspidini is a small group of the Diaspididae but, so far as represented by several known examples, it also has homo- and heteromorphic forms in the second-instar male (Takagi, 1969, 1990, 2002, and other papers; Howell and Tippins, 1978; Howell, 1980). The present study was undertaken in order to make detailed observations on sexual dimorphism in the second-instar nymphal stage of Odonaspidini and to clarify the taxonomic significance of the sexually dimorphic nymphs and especially of the heteromorphic male nymphs. The second-instar females and males of 14 species of the tribe occurring in Asia and including 6 new species have been observed. In this paper, prior to these nymphal forms, which are treated in Part II, the 6 new species are described in Part I on the basis of their adult females. (In Part II, another species from North America is included in the discussion on the basis of the description.) In the course of the present study, 7 other new species have been found, and they are described in Part III on the basis of the adult females and, except for two of them, also the second-instar females. In Part IV, 6 species are newly recorded from Malaysia and the Philippines.

PART I: DESCRIPTIONS OF SIX NEW SPECIES

Abstract. Six new species of the genus *Odonaspis* are described from Malaysia, the Philippines and Japan: *Odonaspis batarazaensis*, *O. densipora*, *O. maasinensis*, *O. miyakoensis*, *O. procera*, and *O. sparsa*. *Berlesaspidiotus* is not distinguishable from

INTRODUCTION

The tribe Odonaspidini is a small group distributed worldwide and containing 41 described species assigned to 5 genera. In the stage of the adult female it is characterized by the absence of distinct pygidial appendages, the unisetose antennae, the occurrence of numerous microducts on the dorsal and ventral surfaces of the body, the presence of segmental bands of ventral crenulae, and the possession of conspicuous intersegmental folds along the ventral and dorsal intersegmental lines; it is also characterized by the bivalve type exuviation (Balachowsky, 1958; Brown and McKenzie, 1962; Takagi, 1969 and 1987; Ben-Dov, 1988 and 1990). They are associated with bamboos or other Poaceae (Gramineae), usually occurring under the leafsheaths, and are known from all of the routine zoogeographical regions (Ben-Dov 1988). This tribe was revised by Ben-Dov (1988), who examined, however, only the adult females.

In this part, I describe and illustrate 6 species of *Odonaspis* from Malaysia, the Philippines, and Japan on the basis of the adult females. The genus *Odonaspis* Leonardi, the type genus of the tribe, has been composed of 30 known species including 13 species recorded from the Oriental Region (Ben-Dov and German, 2003).

MATERIALS AND METHODS

Five of the 6 new species were collected by S. Takagi from 1986 to 1994 in his surveys in Malaysia and the Philippines, and the remaining one by S. Kawai in 1970 in the Ryûkyû Islands, Japan.

A phase-contrast microscope (Olympus BH-2) with a camera lucida was used for observation and preparing illustrations. Each species is described on the basis of the holotype and some other specimens: counts of wax-secreting organs were made on 10 specimens or, when fewer specimens were available, on all the specimens. In interpreting the abdominal segmentation I followed Ben-Dov (1980). The figures of the bodies show the dorsal surface on the left half and the ventral surface on the right half. Some terms adopted in describing the adult females are as in Ben-Dov (1988).

The abbreviations used in the descriptions are as follows. Abd I–VIII: the first to eighth abdominal segments. FRIM: Entomology Section, Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia; UPLB: Museum of Natural History, University of the Philippines at Los Baños, Laguna, Philippines; SEHU: Laboratory of Systematic Entomology, Hokkaidô University, Sapporo; TUA: Kawai Scale Insect Collection at the Laboratory of Tropical Plant Protection, Tôkyô University of Agriculture, Tôkyô. ST: S. Takagi; SK: S. Kawai.

Odonaspis batarazaensis, sp. nov.

Material examined. Sitip Tig Wayan, Bataraza, Palawan, Philippines, on *Schizostachyum lumampao*, 18.VIII.1993 (93PL-80), ST, 57 ♀. Holotype: adult female, deposited in UPLB.

Etymology. Named after the locality where the material was collected.

Diagnosis (adult female). *Odonaspis batarazaensis*, sp. nov., is similar to *Odonaspis maasinensis*, sp. nov., but differs from the latter in the distribution of ducts on the

pygidium, the presence of ducts on the postvulvar sternite, and the presence of the median group of perivulvar disc pores.

Tests. The female test is definite in shape, coriaceous, brown, oblong, and slightly convex dorsally. The male test is slender and light grayish brown. They occur on the stem hidden under the leafsheath.

Adult female (Fig. 1; 49A)

Body oval. Pygidium broadly triangular in outline. Apex of Abd VIII projecting into a triangular protuberance, blunt on apex and serrulate on lateral sides. Margin of Abd VI and also of VII produced into an asymmetric triangle, irregularly serrate and especially strongly and jagged on Abd VI. Two pairs of pygidial scleroses between Abd VII and VIII and between VI and VII clavate; a pair between V and VI little clavate. Ventral marginal setae of Abd V–VIII situated just on margin; marginal setae on dorsum situated submarginally, obviously shorter than those on venter.

Dorsal surface. Microducts more numerous on dorsal surface than on the ventral; occurring on lateral lobes of mesothorax to Abd IV; extensively on pygidium and Abd V. Intersegmental furrow between Abd IV and V thickly sclerotized submarginally. Anus situated at about basal one-third of pygidium.

Ventral surface. Antennal tubercle situated anterior to clypeolabral shield. Anterior spiracles each with 2–4 disc pores; posterior spiracles each with 2–6 disc pores. Gland tubercles absent. Vulva situated posterior to level of anus. Perivulvar disc pores arranged in median and 2 lateral groups; median group with 1–5 disc pores, rarely lacking; lateral groups each with 46–67. Microducts occurring marginally to submarginally on mesothorax to Abd IV; submarginally on Abd V–VII; in an oblique row running caudad of anterior spiracle and labium; in a nearly transverse row laterally to posterior spiracle; medially and submedially on metathorax to Abd IV; strewn on postvulvar sternite.

Odonaspis densipora, sp. nov.

Material examined. Bukit Tapah (650m), Perak, Malaya, Malaysia, on *Schizostachyum* sp., 19.X.1986 (86ML-247c), ST, 73 ♀; Sepilok, Sandakan, Sabah, Malaysia, on *Dinorchloa pubiramea*, 20.X.1988 (88ML-175), ST, 16 ♀; Danum Valley, Sabah, on *Dinorchloa pubiramea*, 24.X.1988 (88ML-224), ST, 53 ♀; grounds of the University of the Philippines at Los Baños, Laguna, Luzon, Philippines, on *Schizostachyum diffusum*, 7.VIII.1994 (94PL-14), ST, 1 ♀. Holotype: adult female, from 88ML-224, deposited in FRIM.

Etymology. Densus+porus, referring to the spiracular disc pores densely clustered.

Diagnosis (adult female). *Odonaspis densipora*, sp. nov., is referable to *Berlesaspidiotus* as understood by authors (see Remarks below), but differs from the other species of *Berlesaspidiotus* in the absence of perivulvar disc pores, the densely clustered spiracular disc pores, and the cuticular striations of the body margin.

Female test. White.

Adult female (Fig. 2; 49B)

Body oval or somewhat obovate. Pygidium triangular in outline. Abd VIII apically with a pair of triangular projections widely separated from each other. Margin of Abd VII with a small triangular projection. Two pairs of pygidial scleroses between Abd VII and VIII and between VI and VII clavate. Dark lines perpendicular to margin (sclerotized

cuticular striations) and mingled with ducts occurring in a broad zone extending from level of antennal tubercle to Abd IV on both surfaces. Dorsal marginal setae of Abd V–VIII placed within margin; marginal setae on venter located inside as compared with those on dorsum. Ventral marginal setae of Abd VIII placed submarginally, not projecting beyond margin of pygidium.

Dorsal surface. Microducts occurring extensively on pygidium; marginally to submarginally on prosoma to Abd V; in a nearly transverse band running between cuticular striations and submarginal area on each of head, meso- and metathorax. Anus situated anterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle placed in a dermal invagination, located near body margin at level of anterior end of clypeolabral shield. Spiracles each with a dense group of small disc pores. Vulva situated anterior to level of anus. Microducts occurring extensively on pygidium; marginally and submarginally on head to Abd V; some submedially on Abd II–IV; in an oblique row laterally to clypeolabral shield; caudad of labium; in 2 short oblique rows occurring caudad of anterior spiracle and extending toward dark lines; in a transverse row laterally to posterior spiracle, with some caudad of the spiracle; along intersegmental lines on Abd I–IV submarginally; strewn over postvulvar sternite. Gland tubercles absent. Perivulvar disc pores absent.

Remarks. The genus *Berlesaspidiotus* was erected by Leonardi (1900) as *Anoplaspis* for *Aspidiotus* (*Odonaspis*) *bambusarum* Cockerell, and MacGillivray (1921) replaced the name with *Berlesaspidiotus*. It was regarded as a good genus by Ben-Dov (1988), although it was suppressed as a synonym of *Odonaspis* by some authors (Ferris, 1937; Takagi, 1959 and 1969). One of the generic characters is the invagination of each antenna in a dermal pocket. In the present study, I observed that each of the antennae is situated in a dermal invagination on specimens referable to *Odonaspis schizostachyi*. Other characters of *Berlesaspidiotus* are also found in species of *Odonaspis*, and thus there seems to be no unique combination of characters for recognizing *Berlesaspidiotus* as a distinct genus. In the present study, *Berlesaspidiotus* is treated as a synonym of *Odonaspis*, and the new species above is described as a species of *Odonaspis*. Furthermore, *B. crenulatus* should be transferred to *Odonaspis*.

Odonaspis maasinensis, sp. nov.

Material examined. Maasin Forest, Brooke's Point, Palawan, Philippines, on *Schizostachyum diffusum*, 24.VIII.1993 (93PL-147, 93PL-147a), ST, 67 ♀. Holotype: adult female, deposited in UPLB.

Etymology. Named after the locality where the material was collected.

Diagnosis (adult female). *Odonaspis maasinensis*, sp. nov., differs from other species in having no dorsal ducts in a narrow submarginal zone of the pygidium between the dorsal setae and the sclerotized area of the pygidial margin and by the absence of ducts on the postvulvar sternite.

Tests. The female test is coriaceous, brown, oblong, and a little convex dorsally; first-instar exuvial cast with white waxy secretion around, often dropped from the test. Male test is elongate and light brown. They occur on the stem hidden under the leafsheath.

Adult female (Fig. 3; 49C)

Body oval. Pygidium rounded in outline. Margin of Abd VIII produced into a rounded projection, which is not notched. Margin of Abd VI and also of VII produced into an asymmetric, apically rounded triangle. Two pairs of pygidial scleroses between Abd VII and VIII and between VI and VII clavate. Marginal setae of Abd V–VII of dorsum dislocated submarginally; marginal setae on venter situated just on margin, obviously longer than those on dorsum. Microducts in 2 sizes; those on submedian area of venter smaller than those on marginal to submarginal area of venter and dorsal microducts.

Dorsal surface. Dorsal microducts numerous on pygidium, but no ducts in a narrow submarginal zone of pygidium just anteriorly to sclerotized margin on Abd V–VIII; marginally and submarginally on mesothorax to Abd IV. Anus situated a little anterior to center of pygidium, at about basal one-third of pygidium.

Ventral surface. Antennal tubercle situated submarginally at level of anterior end of clypeolabral shield. Anterior spiracles each with 1–3 disc pores; posterior spiracles each with 1–3 disc pores. Vulva situated slightly posterior to level of anus. Gland tubercles absent. Perivulvar disc pores arranged in a pair of lateral groups each with 23–41 disc pores. Smaller microducts occurring submedially on Abd I–VI; laterally to mouth-parts. Larger microducts occurring marginally to submarginally on mesothorax to Abd IV; no microducts on postvulvar sternite; microducts on ventral Abd V–VII much fewer than those on dorsal V–VII, 4–9 on each of Abd VII, 2–7 on VI, 9–20 on V. No transverse row of microducts laterally to each spiracle.

Odonaspis miyakoensis, sp. nov.

Material examined. Miyako-jima, Okinawa Pref., Ryûkyû Islands, Japan, on *Miscanthus sinensis*, 5.XI.1970 (3049), SK, 8 ♀; Hisamatsu, Miyako-jima, on *Miscanthus sinensis*, 5.XI.1970 (3302), SK, 30 ♀; Kume-jima, Okinawa Pref., on *Miscanthus sinensis*, 21.XI.1970 (3340), SK, 21 ♀. Holotype: adult female, from 3302, deposited in SEHU.

Etymology. Named after Miyako Island, one of the islands where the species was collected.

Diagnosis (adult female). *Odonaspis miyakoensis*, sp. nov., is similar to *O. oshimaensis* and *O. morrisoni*, but is distinguishable from *O. oshimaensis* in having more disc pores associated with the posterior spiracles, and from *O. morrisoni* in the presense of a second pair of pygidial scleroses and the absence of a notch on the apex of Abd VIII.

Adult female (Fig. 4; 49D)

Body oval. Pygidium roundish in outline, with indentations. Abd VIII produced apically into a roundish conical process, which is entire or with a slight shallow notch on each lateral margin (Fig. 4C). Two pairs of marginal scleroses: clavate between Abd VII and VIII, obscure apically between VI and VII except in the specimens from Kume-jima, in which these scleroses are clearly shaped. Dorsal marginal setae of Abd VIII placed just on margin; marginal setae on venter situated within margin, their apices not reaching margin, shorter than those on dorsum. Dorsal marginal setae of Abd V–VII placed within margin; marginal setae on venter situated just on margin, longer than those of dorsum. Microducts in 2 sizes.

Dorsal surface. Larger microducts occurring on pygidium and Abd V extensively; marginally and submarginally on metathorax to Abd IV. Anus situated slightly posterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle situated submarginally and somewhat anteriorly to anterior end of clypeolabral shield. Anterior spiracles each with 41–83 disc pores; posterior spiracles each with 10–27 disc pores. Vulva located slightly anterior to level of anus. Gland tubercles present on prothorax and mesothorax. Perivulvar disc pores in a continuous band anteriorly and laterally to vulva; anterior portion with 13–20 disc pores; lateral portions each with 94–135 disc pores; total 213–279. Smaller microducts occurring medially to submedially on prosoma to Abd V. Larger microducts occurring marginally to submarginally on metathorax to Abd V; strewn over postvulvar sternite and Abd VI and VII.

Odonaspis procera, sp. nov.

Material examined. Maasin Forest, Brooke's Point, Palawan, Philippines, on *Schizostachyum diffusum*, 24.VIII.1993 (93PL-147), ST, 11 ♀. Holotype: adult female, deposited in UPLB.

Etymology. The specific epithet of this new species refers to the elongate body of the adult female.

Diagnosis (adult female). *Odonaspis procera*, sp. nov., is distinguishable from other species by the elongate, rather slender body and the knobbed pygidial scleroses of the pygidium.

Tests. The tests of the female and male are white, occurring on the stem under the leafsheaths and on the inner surface of the sheaths. The female test when occurring on the sheaths tends to become irregular in shape.

Adult female (Fig. 5; 50A)

Body elongate elliptical to elongate oval; prosoma blunt triangular, gently lobed laterally at level of mouth-parts; pygidium triangular in outline. Abd VIII projecting apically into a rather low, roundish process, which is obscurely notched laterally. Abd IV–VII indented marginally. Two pairs of pygidial scleroses between Abd VII and VIII and between Abd VI and VII knobbed; 1 pair between V and VI clavate. Marginal ventral seta of Abd VIII situated submarginally, shorter than marginal setae on dorsum. Marginal setae of Abd V–VII situated close to margin on both surfaces, their apices projecting beyond margin, the dorsal and ventral setae approximately the same in length. Microducts in 2 sizes.

Dorsal surface. Larger microducts occurring marginally and submarginally on metathorax to Abd IV; extensively on pygidium. Anus situated on about basal one-fourth of pygidium.

Ventral surface. Antennal tubercle situated submarginally and anteriorly to clypeolabral shield. Anterior spiracles each with 2–9 disc pores; posterior spiracles each with 2–7 disc pores. Gland tubercles absent. Perivulvar disc pores arranged in a pair of lateral groups each with 43–117 disc pores; in addition, 1–4 median disc pores in some individuals. Vulva placed anterior to level of anus. Smaller microducts occurring medially and submedially on prosoma and abdomen; in a transverse row running across metathorax, mingled on the way with larger microducts. Larger microducts occurring on mesothorax to Abd VIII marginally and submarginally; strewn over postvulvar sternite.

Odonaspis sparsa, sp. nov.

Material examined. Grounds of Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388c), ST, 11 ♀; Ulu Gombak (210m), Selangor, Malaya, on *Gigantochloa scortechinii*, 2.X.1986 (86ML-81b), ST, 49 ♀; Ulu Gombak (1000m), on *Gigantochloa scortechinii*, 14.XI.1986 (86ML-467b), ST, 33 ♀; Kuala Kubu Baharu, Selangor, on an undetermined bamboo, 23.X.1986 (86ML-301a), ST, 38 ♀; Kuching, Sarawak, Malaysia, on *Dendrocalamus* sp., 28.IX.1991 (91ML-3), ST, 39 ♀. Holotype: adult female, from 86ML-81b, deposited in FRIM.

Etymology. The name of this new species refers to the sparsely scattered microducts on the pygidium.

Diagnosis (adult female). *Odonaspis sparsa*, sp. nov., is similar to *O. siamensis*, but differs from the latter in the absence of microducts on the postvulvar sternite, the restricted distribution of sclerotized cuticular striations on the body margin, the little clavate pygidial scleroses, the body without lateral lobes on the prosoma, and the presence of microducts on the dorsal surfaces of the head and the thorax.

Adult female (Fig. 6; 50B)

Body obovate. Pygidium broadly trapezoidal in outline. Abd VIII apically with a shallow emargination formed by a pair of small blunt triangular projections. Margin of Abd VI and also of VII with a small triangular projection. Two pairs of pygidial scleroses between Abd VII and VIII and between VI and VII slender, a little expanded at anterior end and thus shaped like a writing brush, the apex sometimes unclear; mesal pair as long as lateral one. Dark lines (sclerotized cuticular striations) present marginally from metathorax to Abd IV on both surfaces. Ventral submarginal setae of Abd VIII longer than the others and rather fleshy. Dorsal marginal setae of Abd VIII remarkably shorter than the ventral, situated submarginally. Ventral marginal setae of Abd IV–VII located within margin.

Dorsal surface. Microducts occurring sparsely on pygidium; submarginally on prosoma and in an oblique row on each of head, meso- and metathorax; marginally to submarginally on Abd I–V; a few submedially on Abd II–IV. Anus with rim well sclerotized, situated anterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle located submarginally far laterally to mouth-parts. Anterior spiracles each with 4–16 disc pores; posterior spiracles without disc pores. Vulva located anterior to level of anus. Microducts occurring sparsely on pygidium; submarginally on head to Abd V; laterally to mouth-parts; in a nearly transverse row laterally to posterior spiracle; no microducts on postvulvar sternite but some present along outer intersegmental furrow between Abd VII and VIII. Gland tubercles absent. Perivulvar disc pores absent.

**PART II: SEXUAL DIMORPHISM IN THE SECOND-INSTAR NYMPHS OF 14 SPECIES OF
ODONASPIDINI**

Abstract. The second-instar nymphs of both the sexes in 14 species of the tribe Odonaspidini, all from Asia, are described and illustrated. Another species occurring in North America is included in the discussion on the basis of the description. The second-

instar males of these species show a broad diversity in the morphological pattern, and are classified into 4 types and an extra form. The taxonomic significance of these nymphal forms is discussed.

INTRODUCTION

The nymphal stages of the Coccoidea exhibit no basic difference in body structure between the sexes, and yet it has been known that, in the Diaspididae, the second-instar males of some species are noticeably different from the conspecific second-instar females in the characters of the pygidial margin and other features (Boratyński, 1953; Takagi, 1969, 1981, 1990, 1993, 1995, 2002, 2007, 2008; Takagi et al., 1988; Stoetzel and Davidson, 1974; Howell and Tippins, 1990). The tribe Odonaspidini, which belongs to this family, has hitherto been represented by 41 species assigned to 5 genera, and is characterized especially by lacking marginal appendages on the pygidium in the adult female (Ben-Dov, 1988). It has been reported, however, that good marginal appendages occur in the second-instar males of certain species.

Takagi (1969) illustrated the second-instar male of *Froggattiella penicillata* (Green) based on specimens collected in Taiwan: it has pygidial lobes (trullae), glanduliferous plates (pectinae), gland tubercles, and macroducts, and is very similar to *Parlatoria* species. The second-instar males of *Odonaspis secreta* Cockerell (Howell, 1980; Takagi, 1990) and *O. arcusnotata* Ben-Dov (Takagi, 2002) also proved to belong to the parlatoriine type. Furthermore, Takagi (1987) mentioned that *Parlatoria zeylanica*, which was described as based on 'Adult insect' (Rutherford, 1915), should be the second-instar male of an *Odonaspis* species (*O. secreta* or *O. greeni*). On the other hand, Howell and Tippins (1978) reported that *O. minima* occurring in North America has no pygidial appendages in the second-instar male, and thus they showed that the pattern of the sexual dimorphism in the tribe is not uniform.

In Part II, I describe and illustrate the external morphologies of the second-instar nymphs of both sexes in 14 species of the tribe Odonaspidini from Asia. These species and *O. minima* show the occurrence of diverse forms in the second-instar male, which are classified into 4 types and an extra form.

MATERIALS AND METHODS

The following 14 species have been studied: *Froggattiella penicillata*, *Odonaspis arcusnotata*, *O. bambusarum*, *O. batarazaensis*, *O. densipora*, *O. greeni*, *O. maasinensis*, *O. miyakoensis*, *O. morrisoni*, *O. oshimaensis*, *O. procera*, *O. schizostachyi*, *O. secreta*, and *O. sparsa*. The materials used were collected by S. Takagi in 1955 to 1994 mainly in Japan, Malaysia, and the Philippines, by S. Kawai in 1965 to 1972 in Japan, and by myself in 2007 in Japan.

A phase-contrast microscope (Olympus BH-2) with a camera lucida was used for observation and preparing illustrations. In each species, counts of wax-secreting organs were based on 10 specimens or, when fewer specimens were available, on all the specimens. The figures of the bodies show the dorsal surface on the left half and the ventral surface on the right half. Some terms used in describing the nymphal instars are as in Ben-Dov (1988). I have adopted the terms 'trullae' and 'pectinae', following Takagi (2002), instead of the terms 'lobes' and 'plates', which have been commonly used by

previous authors. The abbreviations used in the descriptions are as follows. Abd I–VIII: the first to eighth abdominal segments. ST: S. Takagi; SK: S. Kawai; MA: M. Aono.

GENERAL MORPHOLOGICAL FEATURES

Shape of the body. The body in slide-mounted specimens is usually broadly obovate or obpyriform in the second-instar female and oval in the second-instar male, growing elongated oval or elliptical in the male.

Antennae. The antennae are located submarginally in front of the anterior end of the clypeolabral shield. Each of them consists of a small tubercle with some small processes and a fleshy seta.

Eyes. The eyes are always visible as small spots in the second-instar males, but sometimes inconspicuous. In the second-instar females they are sometimes invisible.

Legs. The legs are absent, but in the second-instar males the vestiges of legs, slightly sclerotized protuberances, are visible.

Spiracles. Two pairs of spiracles are situated on the cephalothorax of the ventral surface. The anterior spiracles are placed laterally to the mouth-parts and the posterior spiracles on the metathorax. Quinquelocular disc pores are often associated with spiracles; their presence or absence tends to be stable, whereas their number varies to some degree in each species.

Ducts. Microducts are scattered on both surfaces in the second-instar females and males except for some species, which have no microducts on the dorsum. Macroducts generally occur in the second-instar males. They are scattered usually on the mesothorax to the abdomen of the dorsal surface and on the prosoma to Abd I of the ventral surface.

Gland tubercles. When occurring, gland tubercles are situated submarginally on the prosoma to Abd I of the ventral surface.

Marginal appendages on the pygidium. Trullae are present or absent in both sexes and, when present, variable in development according to species, forming a continuous series from a reductive, hardly recognizable state to a well-developed, prominent state. Pectinae are usually absent in the second-instar females, but present on Abd VI to VIII in both sexes of some species. Gland spines are present on the apex of the pygidium in the second-instar female of *Froggattiella penicillata*.

Body setae and body segmentation. On the ventral surface, the mesothorax has 2 pairs of setae submedially and each of the metathorax and Abd I–VII 1 pair submedially; each of Abd III–VII has a pair of setae submarginally and 2 setae on the posterolateral corner. On the dorsal surface, a marginal seta occurs on each segment; each of the meso- and metathorax has a pair of setae submedially and also submarginally; some on head marginally. In the second-instar males, 4 pairs of setae are located between clypeolabral shield and the anterior end of the body, those in some species occurring each on a tubercle. On the dorsum, in the second-instar males, a pair of setae is located submedially on each of Abd I–III, but in the second-instar females no submedian setae occur on Abd I. The intersegmental furrows, the body setae, and the crenulae are helpful in interpreting the body segments.

Pygidial scleroses. The margin of the pygidium in both sexes are normally well sclerotized except in some species. Some species carry 1–3 pairs of scleroses on the pygidial margin.

Froggattiella penicillata (Green)

Material examined. Ipilan, Brooke's Point, Palawan, Philippines, on *Schizostachyum lumampao*, 23.VIII.1993 (93PL-135), ST, 1 2nd ♀; Heng-Ch'un, Taiwan, on bamboo, 03.IV.1965, ST, 5 2nd ♀, 27 2nd ♂; Koniya, Amami-Ōshima, Kagoshima Pref., Japan, on bamboo, 17.V.1957, ST, 3 2nd ♀, 14 2nd ♂; Ao-Shima, Miyazaki Pref., Japan, on bamboo, 29.IV.1967 (1683), SK, 19 2nd ♂; Tsushima-Handayama, Okayama, Okayama Pref., Japan, on *Phyllostachys bambusoides*, 16.VI.1965 (1199), SK, 7 2nd ♂; Tsushima-Handayama, on *Phyllostachys nigra* var. *henosis*, 16.VI.1965 (1217), SK, 4 2nd ♂; Tsushima-Niino, Okayama, on *Bambusa multiplex* var. *elegans*, 22.VI.1965 (1241), SK, 1 2nd ♀; Haruno-Rindō, Haruno, Shizuoka Pref., Japan, on *Sasa* sp., 8.VII.2007, MA, 1 2nd ♀, 11 2nd ♂.

Second-instar female (Fig. 7; 50C)

Body broadly obovate or somewhat circular. Pygidium triangular or somewhat roundish in outline, apex with a broad notch bearing a tuft of 6 gland spines, each gland spine with a long duct. Margin of Abd VII with an apically pointed projection. A pair of pygidial sclerites between Abd VII and VIII slender. Marginal setae of pygidium situated within margin on both surfaces, those of Abd VIII on venter obviously shorter than on dorsum.

Dorsal surface. Microducts strewn on pygidium extensively; on Abd IV–V marginally to submarginally. Anus situated slightly anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 2–3 disc pores; posterior spiracles without disc pores. Gland tubercles absent. Microducts scattered submarginally on prosoma to Abd VII; in a transverse row between body margin and posterior spiracle, with a few caudad of the spiracle; in a submarginal row on Abd I–III each.

Second-instar male (Fig. 8; 50D)

Body oval or elliptical; lateral sides parallel. Pygidium broadly roundish in outline. Marginal notch between Abd V and VI deep. Median trullae as long as wide, with serrations, separated from each other by a space about as wide as one of them. Second trullae wider than the median, with serrations. Third trullae as wide as but shorter than the second, obscurely serrate. Two pectinae between median trullae; 2 between the median and second, a little wider than those between the median and second. No pygidial sclerites. Marginal setae of Abd V–VIII placed within margin on both surfaces, those of Abd VIII on dorsum conspicuously longer than on venter.

Dorsal surface. Microducts occurring on Abd I–III submedially and medially. Macroducts scattered on metathorax to Abd VII marginally to submarginally, and also submedially on Abd IV–VII; 1–3 submarginally and 4 submedially on Abd IV; 2–3 submarginally and 3–5 submedially on Abd V. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 1–4 disc pores; posterior spiracles without disc pores. Three groups of 1–3 gland tubercles on meso- and metathorax submarginally. Microducts strewn over abdomen; a few anteriorly and also laterally to clypeolabral shield; in a row between labium and anterior spiracle; in a transverse row laterally to posterior spiracle. Macroducts scattered on prosoma marginally to submarginally.

Odonaspis arcusnotata Ben-Dov

Material examined. Gobô, Wakayama Pref., Japan, on dwarf bamboo, 02.XI.1971, ST, 8 2nd ♂; Hi-no-Misaki, Wakayama Pref., on *Pleioblastus* sp., 02.VIII.1986, ST, 16 2nd ♀, 62 2nd ♂; Tôkyô, Japan, on *Sasa* sp., 27.X.1965, SK, 1 2nd ♀, 2 2nd ♂; Kitaizumi, Nerima-ku, Tôkyô, on *Pseudosasa chino*, 04.VIII.1965 (1305), SK, 2 2nd ♀, 53 2nd ♂; Kitaizumi, on *Pseudosasa chino*, 05.X.1965 (1373), SK, 2 2nd ♀; Shinozaki-chô, Edogawa-ku, Tôkyô, on *Pseudosasa chino*, 27.X.1965 (1409), SK, 1 2nd ♀.

Second-instar female (Fig. 9; 51A)

Body rather obovate or somewhat obpyriform. Pygidium triangular in outline. Median trullae prominent, as wide as long, rounded apically, deeply notched once on mesal side and once or twice on lateral side, separated from each other by a space about one-half to two-thirds as wide as one of them. Second trullae wider than long, serrate on oblique lateral margin. Third trullae reduced to serrate processes. Two pectinae between median trullae and also between the median and second slender, longer than median trullae; 1 pectina on Abd VII, and 1 or 2 on Abd VI, approximately the same in size as the others. No pygidial scleroses. Marginal setae situated within margin on both surfaces, projecting beyond margin, approximately the same in length.

Dorsal surface. A few microducts occurring submedially on each of Abd V–VII, some marginally to submarginally on Abd III–VIII. One submarginal boss on posterolateral corner of metathorax to Abd V each. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–11 disc pores; posterior spiracles without disc pores. Five groups of 1–2 gland tubercles on prosoma and Abd I submarginally. Microducts occurring on thorax and abdomen, in a short transverse row laterally to posterior spiracle; a few laterally to labium and also caudad of anterior spiracle; in marginal to submarginal area on Abd II–VII each; no microducts on Abd VIII.

Second-instar male (Fig. 10; 51B)

Body broadly obovate. Pygidium broadly roundish in outline. Median trullae as long as wide or a little longer than wide, notched once on lateral side, separated from each other by a space about two-thirds as wide as one of them. Second trullae wider than the median, rounded apically, deeply notched once on each side. Third trullae wider than long, with some serrations. A pair of pectinae between median trullae slender; 2 somewhat wider pectinae between the median and second; 3 pectinae between the second and third, larger than those between the median and second; 2 or 3 pectinae on posterolateral corner of Abd V and VI each, a pair on Abd IV, all baculiform. No pygidial scleroses. Marginal setae of pygidium the same in length on both surfaces.

Dorsal surface. Microducts few, scattered on Abd I–III submedially. Macroducts occurring marginally to submarginally on mesothorax to Abd VII; 1–2 macroducts on Abd II–VI each submedially. One submarginal boss on posterolateral corner of metathorax to Abd IV each. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 7–11 disc pores; posterior spiracles without disc pores. Five groups of 1–2 gland tubercles on prosoma and Abd I

submarginally. Microducts scattered marginally to submarginally and also submedially on prosoma and abdominal segments. Macroducts occurring submarginally on thorax and Abd I.

Odonaspis bambusarum (Cockerell)

Material examined. Kechi, Tsushima, Nagasaki Pref., Japan, on bamboo, 16.V.1969, ST, 3 2nd ♀; Izu-Ōshima, Tōkyō, Japan, on bamboo, 25.V.1955, ST, 1 2nd ♀; Gobō, Wakayama Pref., Japan, on a dwarf bamboo, 02.XI.1971, ST., 1 2nd ♀; Gobō, on *Pleioblastus* sp., 01.VIII.1986, ST, 2 2nd ♀, 63 2nd ♂; Kōbe University, Rokkōdai-chō, Nada-ku, Kōbe, Hyōgo Pref., Japan, on *Sasa* sp., 16.IX.2007, MA, 4 2nd ♀; Rinshi-no-Mori park, Meguro-ku, Tōkyō, Japan, on *Semiarundinaria fastuosa*, 26.XI.1971 (1898), SK, 3 2nd ♂.

Second-instar female (Fig. 11; 51C)

Body obovate, gradually narrowing posteriorly. Pygidium triangular in outline. Abd VIII with a pair of triangular processes apically, which are separated from each other by a rather broad space. Margin of Abd VII with 2 unremarkable triangular processes, the mesal of them being broad and the lateral smaller. Abd VI with a small triangular process at posterolateral angle. Pectinae absent. Two pairs of pygidial scleroses clavate between Abd VII and VIII and between VI and VII. Marginal setae of Abd V–VIII situated near margin on both surfaces, approximately the same in length, not projecting beyond margin.

Dorsal surface. Microducts thickly strewn on head extensively; on Abd IV marginally to submarginally; numerous and extensively on V and pygidium. Anus situated anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 10–20 disc pores; posterior spiracles each with 1–4 disc pores, occasionally with no disc pore. Gland tubercles absent. Microducts occurring on head extensively; laterally to mouth-parts; in an oblique row running caudad of labium and anterior spiracle and extending to margin; in a transverse row running across metathorax; within margin on thoracic and abdominal segments, rather abundant marginally to submarginally on Abd IV–VII; a few submedian microducts on prepygidial abdomen.

Second-instar male (Fig. 12; 51D)

Body elongate elliptical. Pygidium roundish obconical in outline. Median trullae longer than wide, rounded apically, deeply notched once on each side or only on lateral side, separated from each other by width of one of them. Second trullae wider than the median, rounded apically, notched once or twice on lateral side and once on mesal side. Third trullae indistinct. A pair of pectinae between median trullae; 2 pectinae between median and second trullae, subequal in size to the median pair; 3 broader pectinae laterally to second trulla. No pygidial scleroses. Dorsal and ventral marginal setae of pygidium approximately the same in length.

Dorsal surface. Microducts few, scattered on Abd II–VI in submarginal to median region. Macroducts occurring on meso- and metathorax and Abd I–VII within margin, 3 pairs of marginal macroducts on pygidium being larger than the other macroducts.

Ventral surface. Anterior spiracles each with 2–3 disc pores; posterior spiracles without disc pores. Three groups of 2–3 gland tubercles on prosoma submarginally.

Conical gland spines (modified pectinae) occurring on posterolateral corners of metathorax and Abd I–IV, 2 on metathorax and 1 on each abdominal segment. Microducts occurring on front to Abd VII (no microducts on Abd VIII) but not numerous; in an oblique row between antenna and anterior spiracle; in another oblique row running caudad of labium and anterior spiracle; in a short transverse row caudad of posterior spiracle; in median, submedian and submarginal areas on abdominal segments. Some macroducts occurring on prosoma submarginally.

Odonaspis batarazaensis Aono

Material examined. Sitip Tig Wayan, Bataraza, Palawan, Philippines, on *Schizostachyum lumampao*, 18.VIII.1993 (93PL-80), ST, 4 2nd ♀, 9 2nd ♂.

Second-instar female (Fig. 13; 52A)

Body broadly obovate. Pygidium broadly triangular in outline. Abd VIII with a pair of broad triangular serrate projections. Margin of Abd VII and VI slightly indented. Pectinae absent. Two pairs of pygidial sclerites between Abd VII and VIII and between VI and VII little clavate; 1 pair between V and VI very small. Dorsal marginal setae of Abd VI–VII situated submarginally. Ventral marginal setae of Abd VI–VIII situated within margin, those on Abd VIII shorter than marginal setae on dorsum but those of Abd VI and VII longer than on dorsum.

Dorsal surface. Dorsal microducts larger than the ventral, strewn marginally to submedially on Abd VI–VII, marginally to submarginally on V and VIII. Anus situated slightly anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 2–3 disc pores; posterior spiracles each with 1–2 disc pores. Gland tubercles absent. Microducts occurring marginally and submarginally on abdomen; laterally to mouth-parts and near anterior spiracle; in a nearly transverse row laterally to posterior spiracle, with a few caudad of the spiracle.

Second-instar male (Fig. 14; 52B)

Body elongate obovate or elliptical. Pygidium roundish in outline. Median trullae conical, pointed apically with serrations on mesal side, separated from each other by a space as wide as one of them. Second trullae conical, nearly as wide as the median. Third trullae reduced to small serrate processes. Pectinae absent. No pygidial sclerites. Microducts in 2 sizes; on both surfaces microducts occurring on median and submedian areas smaller than those on marginal to submarginal area. Dorsal marginal setae of Abd VI and VII situated submarginally, shorter than ventral marginal setae of the segments; those of Abd VIII shorter than ventral marginal setae of the segment.

Dorsal surface. Microducts scattered on mesothorax to Abd IV marginally; thickly strewn on Abd V–VIII marginally and submarginally, but no microducts present on a narrow submarginal zone of pygidium just anteriorly to sclerotized margin, the microducts situated just in front of this zone being not interrupted segmentally; 1–2 submedian ducts on Abd II–IV each. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 2–3 disc pores; posterior spiracles without disc pores. Gland tubercles absent. Microducts scattered marginally to submedially on prosoma to Abd VII; laterally to labium; in an oblique row extending from labium to margin caudad of anterior spiracle; in a transverse row between posterior

spiracle and margin, with a few caudad of the spiracle; no ducts on Abd VIII.

Odonaspis densipora Aono

Material examined. Sepilok, Sandakan, Sabah, Malaysia, on *Dinochloa pubiramea*, 20.X.1988 (88ML-175), ST, 1 2nd ♀; Danum Valley, Sabah, on *Dinochloa pubiramea*, 24.X.1988 (88ML-224), ST, 2 2nd ♀; grounds of the University of the Philippines at Los Baños, Laguna, Luzon, Philippines, on *Schizostachyum diffusum*, 7.VIII.1994 (93PL-14), ST, 3 2nd ♂.

Second-instar female (Fig. 15; 52C)

Body obovate or obpyriform. Pygidium broadly triangular in outline. Abd VIII with a pair of eminent conical processes. Margin of Abd VII with a small triangular process. Pectinae absent. A pair of small pygidial scleroses between Abd VII and VIII. Marginal setae of Abd VI–VIII situated within margin on both surfaces, those of Abd VIII not reaching margin.

Dorsal surface. Microducts occurring marginally to submarginally on Abd II–VII; 1 submedian duct on Abd II–IV each. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 5–8 disc pores; posterior spiracles each with 4–7 disc pores. Gland tubercles and gland spines absent. Microducts scattered marginally and submarginally on head to abdomen, forming a nearly continuous band; in a short transverse row laterally to posterior spiracle. Intersegmental furrow between Abd V and VI on ventral surface thickly sclerotized medially.

Second-instar male (Fig. 16; 52D)

Body elongate obovate or elliptical. Pygidium broadly obconical in outline. Median trullae longer than wide, rounded apically, deeply notched once on each side, separated from each other by a space a little narrower than one of them. Second trullae as large as or slightly wider than the median, similar to the median in shape. Third trullae reduced to serrate processes. Two pectinae between median trullae slender; a pair of pectinae between median and second trullae wider than the median pair; 3 pectinae between the second and third, similar to those occurring between the median and second in size and shape. No pygidial scleroses. Dorsal marginal setae of Abd VIII longer than the ventral ones.

Dorsal surface. One submedian microduct on Abd I–VI each; 1–2 submarginal microducts on Abd I and II each. Macroducts occurring marginally and submarginally on metathorax and abdomen. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 3–4 disc pores; posterior spiracles without disc pores. Five groups of 1–3 gland tubercles on prosoma to Abd I submarginally. Microducts sparse on prosoma, occurring marginally to submarginally on Abd II–VII, a few on Abd II–VII each submedially. Macroducts occurring on prosoma near margin.

Odonaspis greeni Cockerell

Material examined. Jogendra Nagar, Agartala, India, on bamboo, I.1982, 1 2nd ♂; Kuala Lumpur, Malaya, Malaysia, on *Bambusa glaucescens*, 21.XI.1986 (86ML-1), ST, 48 2nd ♂; grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, on *Gigantochloa*

sp., 02.XI.1986 (86ML-388), ST, 6 2nd ♂; Bukit Fraser (1300m), Pahang, Malaysia, on *Bambusa* sp., 29.X.1986 (86ML-349), ST, 3 2nd ♀, 63 2nd ♂; Maasin Forest, Brooke's Point, Palawan, Philippines, on *Schizostachyum diffusum*, 24.VIII.1993 (93PL-147), ST, 1 2nd ♂; Takakuma-yama, Kagoshima Pref., Japan, on *Miscanthus* sp., 24.IV.1963, ST, 1 2nd ♂; Kaimon-chô, Kagoshima Pref., on *Miscanthus* sp., 17.X.1961, ST, 1 2nd ♀; Kasumi, Hyôgo Pref., Japan, on *Miscanthus* sp., 05.X.1977, ST, 1 2nd ♀, 2 2nd ♂.

Second-instar female (Fig. 17; 53A)

Body obovate or obpyriform; metathorax broadest. Pygidium broadly triangular or slightly roundish in outline. Median trullae pointed apically, deeply notched once on each side, separated from each other by a space about as wide as one of them. Second trullae not prominent. Third trullae reduced to serrate processes. Pectinae absent. A pair of pygidial scleroses small and slender between Abd VII and VIII. Ventral marginal setae of Abd VIII situated submarginally, shorter than the dorsal ones. Marginal setae of Abd VI and VII situated within margin and the dorsal and ventral setae same in length.

Dorsal surface. Microducts not numerous, occurring on marginal to submedian area on pygidium; on Abd V submarginally. Anus situated posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 2–4 disc pores; posterior spiracles each with 1–4 disc pores. Gland tubercles absent. Microducts occurring submarginally on Abd III–VII; a few laterally to posterior spiracle; a few on prosoma.

Second-instar male (Fig. 18; 53B)

Body obovate or elliptical. Pygidium roundish in outline. Median trullae as wide as long, rounded apically, deeply notched once on each side, separated from each other by a space a little narrower than one of them. Second trullae stout, wider than the median, rounded apically, deeply notched once on each side. Third trullae shorter than but as wide as or a little wider than the second, rounded apically, deeply notched once or twice on each side. A pair of pectinae between median trullae slender; 2 pectinae between median and second trullae, broader than median pair; 3 pectinae between the second and third, as large as those occurring between the median and second; 2 pectinae laterally to third trulla, and also at posterolateral corner of Abd IV. No pygidial scleroses. Ventral marginal setae of Abd VIII situated within margin, shorter than dorsal marginal setae of the segment.

Dorsal surface. Microducts few, 1 submedian microduct on Abd II–IV each, 1–2 submarginal microducts on Abd II. Macroducts occurring marginally and submarginally on meso- and metathorax and abdomen; 4 pairs of marginal macroducts on pygidium; submedially 1–3 on Abd V, 1–2 on VI, 1 on VII. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 1–4 disc pores; posterior spiracles without disc pores. Four or 5 groups of 1–4 gland tubercles on prosoma and Abd I submarginally. Microducts strewn over head to abdomen; laterally to mouth-parts; in an oblique row running caudad of anterior spiracle; in a transverse row extending from posterior spiracle toward submarginal area; a few ducts submedially and submarginally on Abd I–V each, forming longitudinal rows through the segments; within margin on Abd II–VIII each. Macroducts occurring on prosoma and Abd I submarginally.

Remarks. The disc pores associated with the anterior and posterior spiracles in the

female individuals collected on *Miscanthus* sp. are more numerous than in those on the other host plants, 8–10 disc pores being associated with each anterior and 5–7 with each posterior spiracle.

Odonaspis maasinensis Aono

Material examined. Maasin Forest, Brooke's Point, Palawan, Philippines, on *Schizostachyum diffusum*, 24.VIII.1993 (93PL-147, 93PL-147a), ST, 5 2nd ♀, 19 2nd ♂.

Second-instar female (Fig. 19; 53C)

Body obovate. Pygidium triangular in outline. Abd VIII with a pair of blunt triangular projections, which are minutely serrated. Margin of Abd VI and VII with minute serrations. Pectinae absent. Two pairs of pygidial scleroses little clavate between Abd VII and VIII and between VI and VII. Dorsal marginal setae of Abd VI and VII dislocated submarginally, shorter than the ventral ones. Ventral marginal setae of Abd VI–VIII situated within margin.

Dorsal surface. Microducts occurring marginally to submedially on Abd V–VII and within margin on IV and VIII. Anus situated slightly anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 1–2 disc pores; posterior spiracles each with 1 disc pore. Gland tubercles absent. Microducts occurring marginally and submarginally on prosoma and abdomen.

Second-instar male (Fig. 20; 53D)

Body elliptical or oblong. Pygidium broadly roundish in outline. Abd VIII apically with a pair of pointed triangular projections. Margin of Abd VII produced in an asymmetric, minutely serrate triangle. Margin of Abd VI minutely serrate. Pectinae absent. Two pairs of short pygidial scleroses between Abd VII and VIII and between VI and VII. Microducts in 2 sizes. Macroducts absent. Dorsal marginal setae of Abd VI and VII dislocated submarginally; 2 marginal setae of Abd VIII situated within margin. Ventral marginal setae of Abd VIII situated within margin, shorter than dorsal marginal setae of the segments, not extending beyond margin. Ventral marginal setae of Abd VI and VII situated within margin.

Dorsal surface. Larger microducts more numerous on dorsal surface than on ventral surface of pygidium, but no ducts occurring in a narrow submarginal zone of pygidium just anteriorly to sclerotized margin on Abd VI–VIII; 2–6 submarginal ducts on posterolateral corner of Abd IV; some small groups of microducts on the sclerotized margin. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 1–2 pores; posterior spiracles without disc pores. Gland tubercles absent. Smaller microducts occurring medially to submarginally, and laterally to mouth-parts; in a nearly transverse row caudad of anterior spiracle; in a transverse row laterally to posterior spiracle. Larger microducts occurring marginally to submarginally on mesothorax to Abd VII.

Odonaspis miyakoensis Aono

Material examined. Miyako-jima, Okinawa Pref., Ryûkyû Islands, on *Miscanthus sinensis*, 5.XI.1970 (3049), SK, 2 2nd ♀; Hisamatsu, Miyako-jima, on *Miscanthus sinensis*, 5.XI.1970 (3302),

SK, 6 2nd ♂; Kume-jima, Okinawa Pref., on *Miscanthus sinensis*, 21.XI.1970 (3340), SK, 1 2nd ♀, 2 2nd ♂, and some exuviae.

Second-instar female (Fig. 21; 54A)

Body broadly obovate. Pygidium triangular in outline. Apex of Abd VIII emarginate shallowly. Pectinae absent. A pair of pygidial sclerites little clavate between Abd VII and VIII. Dorsal marginal setae of Abd VI and VII situated within margin on both surfaces, those on venter slightly further inside than on dorsum. Ventral marginal setae of Abd VIII situated submarginally, shorter than the dorsal ones.

Dorsal surface. Microducts occurring marginally to submedially on pygidium, and marginally to submarginally on Abd IV–V. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 5–18 disc pores; posterior spiracles each with 1–6 disc pores. Gland tubercles absent. Microducts occurring in an oblique row running in front of anterior spiracle; in another oblique row running caudad of anterior spiracle and labium; in a transverse row laterally to posterior spiracle; marginally to submarginally on Abd II–VII.

Second-instar male (Fig. 22; 54B)

Body oblong or elliptical. Pygidium broadly triangular in outline, well sclerotized marginally. Abd VIII with triangular median trullae. Margin of Abd VII with an unremarkable obtuse triangular process, slightly indented. Pectinae absent. A pair of pygidial sclerites little clavate between Abd VII and VIII. Marginal setae of Abd VI and VII situated within margin on both surfaces, projecting beyond margin. Ventral marginal setae of Abd VIII dislocated submarginally, not projecting beyond margin, shorter than the dorsal ones.

Dorsal surface. Macroducts strewn marginally to submarginally on mesothorax to Abd III, marginally to submedially on Abd IV–VII; 2–6 submedian ducts on Abd IV and 3–6 on V. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 9–17 disc pores; posterior spiracles each with 1–2 disc pores, lacking disc pores in some specimens. Five groups of 1–4 gland tubercles on prosoma to Abd I submarginally. Microducts in 2 sizes. Smaller microducts strewn over ventral surface; in an oblique row in front of anterior spiracle; in an oblique row extending from labium caudad of anterior spiracle; in a transverse row laterally to posterior spiracle; extensively on Abd II–VIII. Larger microducts occurring on mesothorax submarginally. Macroducts occurring marginally to submarginally on prosoma to Abd II.

Odonaspis morrisoni Beardsley

Material examined. Iriomote-jima, Okinawa Pref., Ryûkyû Islands, Japan, on *Setaria palmifolia*, 30.X.1970 (3106), SK, 9 2nd ♀, 27 2nd ♂.

Second-instar female (Fig. 23; 54C)

Body broadly obpyriform. Pygidium triangular in outline. Apex of pygidium blunt, slightly notched. Margin of Abd VII slightly indented. Pectinae absent. A pair of pygidial sclerites between Abd VII and VIII small. Microducts in 2 sizes. Ventral marginal setae of Abd VI and VII situated within margin, further inside than dorsal marginal setae of the segments. Marginal setae of Abd VIII situated within margin on both surfaces, those on

dorsum longer than on venter.

Dorsal surface. Larger microducts scattered on marginal to submedian area on Abd V–VII and near margin on IV and VIII. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 14–21 disc pores; posterior spiracles each with 3–6 disc pores. Gland tubercles absent. Smaller microducts occurring marginally to submarginally on prosoma to Abd VII; in an oblique row running caudad of anterior spiracle; in a transverse row laterally to posterior spiracle. Larger microducts occurring on prosoma to Abd VII marginally to submarginally; laterally to clypeolabral shield, mingled with small microducts near anterior and posterior spiracles.

Second-instar male (Fig. 24; 54D)

Body obovate to elliptical. Pygidium broadly triangular in outline. Abd VIII with a pair of triangular processes, which are oblique on the lateral margin. Margin of Abd VI and VII slightly indented. Pectinae absent. A pair of pygidial scleroses between Abd VII and VIII slender. Two dorsal marginal setae of Abd VIII situated marginally, outer setae thinner than the inner, and the same in size as the ventral marginal setae of Abd VIII.

Dorsal surface. Macroducts occurring marginally to submarginally on meso- and metathorax and abdomen; on Abd VI and VII submedially, too; 3 pairs of marginal macroducts on pygidium; 4–7 submedian macroducts on Abd V. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 10–20 disc pores; posterior spiracles each with 2–8 disc pores. Six groups of 1–3 gland tubercles on prosoma and Abd I submarginally. Microducts strewn on head to abdomen, some ducts in a longitudinal row between anterior end of body and clypeolabral shield on each side of body; in an oblique row in front of anterior spiracle; in another row running caudad of anterior spiracle; in a transverse row laterally to posterior spiracle; abundant ducts on abdominal segments. Macroducts occurring marginally to submarginally on prosoma to Abd IV.

Odonaspis oshimaensis Kuwana

Material examined. Iriomote-jima, Okinawa Pref., Ryûkyû Islands, Japan, on an undetermined grass (Poaceae), 30.X.1970 (3105, 3107), SK, 2 2nd ♂; Kume-jima, Okinawa Pref., on *Hemarthria sibirica*, 21.XI.1970 (3354), SK, 4 2nd ♀, 4 2nd ♂, and on an undetermined grass (Poaceae), 21.XI.1970 (3339), SK, 1 2nd ♂; Higashihenna, Miyako-jima, Okinawa Pref., on an undetermined grass (Poaceae), 06.XI.1970 (3282), SK, 1 2nd ♀, 12 2nd ♂; Nase, Amami-Ôshima, Kagoshima Pref., Japan, on an undetermined grass (Poaceae), 20.V.1957, ST, 2 2nd ♀, 5 2nd ♂; Nagasakibana, Kagoshima Pref., on *Digitaria ciliaris*, 30.IV.1967 (1651), SK, 9 2nd ♀, 10 2nd ♂.

Second-instar female (Fig. 25; 55A)

Body obpyriform. Pygidium broadly triangular in outline. Apex of pygidium emarginate shallowly, angulate laterally. Margin of Abd VII with a small triangular process. Pectinae absent. A pair of pygidial scleroses between Abd VII and VIII baculiform. Dorsal marginal setae of Abd VIII situated just on margin. Ventral marginal setae of Abd V–VIII situated within margin, not reaching margin; ventral marginal setae of Abd VIII shorter than the dorsal ones.

Dorsal surface. Microducts scattered marginally to submedianly on Abd IV–VIII.

Anus situated posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–10 disc pores; posterior spiracles without disc pores. Gland tubercles absent. Microducts strewn marginally and submarginally on Abd II–VIII; in an oblique row running between antenna and anterior spiracle; in another oblique row caudad of anterior spiracle; in a transverse row laterally to posterior spiracle; a few on each of metathorax to Abd III submedially.

Second-instar male (Fig. 26; 55B)

Body oval to elliptical. Pygidium broadly roundish in outline. Abd VIII apically with a pair of triangular processes. Margin of Abd VII with 2 triangular processes. Pectinae absent. Two pairs of pygidial scleroses little clavate between Abd VII and VIII and between VI and VII. Dorsal marginal setae of Abd VIII situated just on margin. Marginal setae of Abd V–VII situated within margin on both surfaces, the same in length. Ventral marginal setae of Abd VIII situated submarginally, not reaching margin, shorter than the dorsal ones.

Dorsal surface. Macroducts occurring marginally to submarginally on mesothorax to Abd VII; submedially 2–5 on Abd IV and 1–5 on V. Microducts occurring marginally on pygidium, slightly longer than the ventral ones. Anus situated at center of pygidium.

Ventral surface. Anterior spiracles each with 7–11 disc pores; posterior spiracles without disc pores. Five groups of 1–3 gland tubercles on prosoma to Abd I submarginally. Gland spines absent. Microducts strewn over submedian to marginal area of Abd II–VIII; in an oblique row laterally to mouth-parts; in another oblique row caudad of anterior spiracle; in a transverse row laterally to posterior spiracle. Macroducts occurring marginally and submarginally on prosoma to Abd III.

Odonaspis procera Aono

Material examined. Maasin Forest, Brooke's Point, Palawan, Philippines, on *Schizostachyum diffusum*, 24.VIII.1993 (93PL-147), ST, 2 2nd ♀, 8 2nd ♂ and some exuviae.

Second-instar female (Fig. 27; 55C)

Body oblong or elongate obovate; margin of prosoma gently lobed laterally at level of mouth-parts; pygidium triangular or broadly rounded in outline. Abd VIII apically with a rather developed process, which is divided to form a pair of triangular prominences widely separated from each other. Margin of Abd VII with a pointed process. Margin of Abd VI with a smaller process. Pectinae absent. No pygidial scleroses. Dorsal marginal setae of Abd VI–VIII situated within margin, projecting beyond margin. Ventral marginal setae of Abd VI–VIII situated within margin, their apices not reaching margin, the dorsal and ventral marginal setae approximately the same in length.

Dorsal surface. Microducts occurring marginally to submarginally on Abd V–VII and also submarginally on VII, a few marginally on VIII. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 3–4 disc pores; posterior spiracles each with 2 disc pores. Gland tubercles absent. Microducts occurring in a row between labium and margin; in a transverse row between posterior spiracle and margin; submedially on Abd I–IV, marginally to submarginally on Abd I–VII.

Second-instar male (Fig. 28; 55D)

Body obovate to elongate obovate. Pygidium bluntly triangular or broadly trapezoid in outline. Apex of Abd VIII flat, Abd VII and VIII with possible rudiments of trullae. Margin of Abd VI and VII with serrations. Pectinae absent. A pair of pygidial scleroses between Abd VII and VIII little clavate. Microducts in 2 sizes. Marginal setae of Abd VI–VIII situated within margin on both surfaces, not projecting beyond margin except on Abd VIII.

Dorsal surface. One larger microduct on each of Abd I–III submedially. Macroducts scattered marginally to submarginally, 2–4 submedian macroducts on Abd VI and also on V. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 2–4 disc pores; posterior spiracles each with 1–2 disc pores (1 individual without disc pores). Four groups of 1–2 gland tubercles on prosoma submarginally. Smaller microducts occurring on median to submarginal area; laterally to mouth-parts; in a transverse row caudad of anterior spiracle; in a transverse row laterally to posterior spiracle; some on each of Abd I–VI medially to submedially. Larger microducts scattered marginally to submarginally on mesothorax to Abd VIII. Macroducts occurring on meso- and metathorax submarginally.

Odonaspis schizostachyi Cockerell and Robinson

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, Malaysia, on *Schizostachyum zollingeri*, 26.IX.1986 (86ML-23b), ST, 2 2nd ♀, 194 2nd ♂; Tapah, Perak, Malaya, on *Schizostachyum* sp., 19.X.1986 (86ML-247b), ST, 4 2nd ♀, 135 2nd ♂.

Second-instar female (Fig. 29; 56A)

Body rounded. Pygidium broadly roundish or obtuse triangular in outline. Median trullae wider than long, pointed apically, deeply notched once on mesal side and twice on lateral side, separated from each other by a space about two-thirds as wide as one of them. Second trullae wider than long, shorter than the median, with serrations. Third trullae reduced. Pectinae absent. No pygidial scleroses. Marginal setae of Abd V–VIII situated within margin on both surfaces, those on venter further inside and shorter than those on dorsum. Microducts in 2 sizes.

Dorsal surface. Smaller microducts occurring submarginally to submedially on Abd VI and VII. Larger microducts occurring on Abd VI–VIII marginally to submarginally. One submarginal boss on posterolateral corner of metathorax to Abd III each. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–8 disc pores; posterior spiracles each with 2–8 disc pores. Gland tubercles absent. Smaller microducts occurring submarginally on abdomen; in an oblique row caudad of anterior spiracle; in a transverse row laterally to posterior spiracle. Larger microducts occurring marginally to submarginally on Abd III–VIII.

Second-instar male (Fig. 30; 56B)

Body obovate. Pygidium broadly triangular or roundish in outline. Median trullae wider than long, rounded apically, deeply notched once on each side or with some serrations, separated from each other by a space narrower than half width of one of them.

Second trullae reduced to serrate processes. Margin of Abd VI indented. No pygidial scleroses. Ducts in 4 sizes. Ventral marginal setae of Abd VI–VIII situated within margin, those of Abd VIII shorter than dorsal marginal setae of the segment.

Dorsal surface. Macroducts of usual size strewn marginally to submedially on mesothorax to Abd VII; submedially 3–7 on Abd III, 4–8 on Abd IV and 4–7 on Abd V. A submarginal boss on posterolateral corner of metathorax to Abd IV each. Anus situated posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–9 disc pores; posterior spiracles each with 2–5 disc pores. Five groups of 1–13 gland tubercles on prosoma to Abd I submarginally. Smaller microducts strewn over prosoma and abdomen; in an oblique row in front of anterior spiracle; in another row caudad of anterior spiracle; in a transverse row running across metathorax. Larger microducts strewn on meso- and metathorax submarginally. Pectinae with very long microducts occurring on pygidial margin: 1 pair between median trullae and also on Abd V and VI, 2 pairs between the median and second and also on VII. Macroducts of usual size scattered on prosoma to Abd II marginally to submarginally.

Remarks. Forty specimens of the adult female have been examined (Fig. 31). They differ from the form occurring in the Philippines in the row of ducts on Abd VIII only a half as long as the distance between the vulva and the apex of the segment, each of the antennal tubercles situated in a dermal pocket, and the dorsal microducts less numerous. The second-instar female differs in the microducts less numerous, the posterior spiracle often with disc pores present, and the marginal duct larger (Figs 29, 32).

Odonaspis secreta (Cockerell)

Material examined. Sumiyô, Amami-Ôshima, Kagoshima Pref., Japan, on an undetermined bamboo, 15.V.1957, SK, 4 2nd ♀, 4 2nd ♂; Shiratake, Tsushima, Nagasaki Pref., Japan, on *Sasa palmata*, 17.V.1969, ST, 2 2nd ♀, 3 2nd ♂; Ariake-yama, Tsushima, on bamboo (*Pleioblastus?* sp.), 09.V.1969, ST, 1 2nd ♂; Sasuna, Tsushima, on a dwarf bamboo, ST, 14.V.1969, 1 2nd ♂; Miyazaki, Miyazaki Pref., Japan, on the branch of an undetermined bamboo, ST, 25.V.1957, 6 2nd ♂; Gobô, Wakayama Pref., Japan, on *Pleioblastus* sp., 01.VIII.1986, ST, 14 2nd ♀, 8 2nd ♂; Gôra, Hakone, Kanagawa Pref., Japan, on *Sasa* sp., ST, 19.III.1979, 4 2nd ♂; Fruit Tree Experiment Station, Hiratsuka, Kanagawa Pref., on *Pleioblastus chino* var. *viridis*, 9.II.1972 (1988), SK, 2 2nd ♀, 14 2nd ♂; Shimoda, Shizuoka Pref., Japan, on bamboo, ST, 04.X.1965, 3 2nd ♂; Kamogawa, Chiba Pref., Japan, on a dwarf bamboo (*Pleioblastus?* sp.), 11.X.1980, ST, 7 2nd ♂; Toyama, Toyama Pref., Japan, on garden bamboo, ST, 27.VIII.1955, 32 2nd ♂.

Second-instar female (Fig. 33; 56C)

Body obpyriform. Pygidium broadly round or somewhat bluntly triangular in outline. Median trullae as long as wide, rounded apically, deeply notched once on each side, separated from each other by a space about as wide as one of them. Second trullae wider than long, somewhat acute, with a deep notch on each side or with small irregular serrations. Third trullae reduced to small triangular processes. Two small pectinae between median trullae and also between the median and second. A pair of short pygidial scleroses between Abd VII and VIII and between VI and VII. Microducts of pygidium on both surfaces a little larger than those on other abdominal segments. Dorsal marginal

setae of Abd V–VIII situated marginally. Ventral marginal setae of Abd V–VII situated within margin. Ventral marginal setae of Abd VIII situated within margin, apparently shorter than the dorsal ones, not projecting beyond margin.

Dorsal surface. Microducts scattered marginally to submarginally on Abd V–VIII and also submarginally on VII. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 3–7 disc pores; posterior spiracles without disc pores. Gland tubercles absent. Four groups of 1–3 shorter microducts on prosoma and Abd I submarginally. Microducts scattered marginally to submarginally on Abd II–VII; laterally to mouth-parts; in a transverse row between submarginal area and posterior spiracle.

Second-instar male (Fig. 34; 56D)

Body obovate. Pygidium broadly roundish in outline. Median trullae longer than wide, rounded apically, with a deep notch on lateral side and a less distinct notch or no notch on mesal side, separated from each other by a space a little narrower than one of them. Second trullae wider than the median, rounded apically, deeply notched once on each side. Third trullae shorter than the second, similar to the second but slightly more acute. Two pectinae between median trullae slender; 2 pectinae between median and second trullae and 3 pectinae between the second and third. No pygidial scleroses. Marginal setae of Abd V–VIII on both surfaces situated nearly on margin, those of Abd VIII on dorsum longer than on venter.

Dorsal surface. Microducts few, 3 submedian microducts on Abd II, 1 on III and IV each. Larger macroducts occurring along margin on meso- and metathorax and on marginal to submarginal area on abdomen; 2–3 submarginally on Abd IV–VI each; 2 on VI, 1–3 on V and 2–4 on IV submedially; 2 pairs of marginal macroducts on pygidium. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 2–5 disc pores; posterior spiracles without disc pores. Five groups of 2–6 gland tubercles on prosoma and Abd I submarginally. Microducts scattered on head to Abd VII; laterally to clypeolabral shield; in an oblique row caudad of anterior spiracle; in a nearly transverse row laterally to and caudad of posterior spiracle. Two to 6 smaller macroducts on mesothorax submarginally. Larger macroducts scattered on meso- and metathorax and Abd I marginally to submarginally.

Odonaspis sparsa Aono

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388c), ST, 2 2nd ♂; Ulu Gombak (210m), Selangor, Malaya, on *Gigantochloa scortechinii*, 2.X.1986 (86ML-81b), ST, 3 2nd ♂; Kuala Kubu Baharu, Selangor, on an undetermined bamboo, 23.X.1986 (86ML-301a), ST, 2 2nd ♂; Kuching, Sarawak, Malaysia, on *Dendrocalamus* sp., 28.IX.1991 (91ML-3), ST, 1 2nd ♀.

Second-instar female (Fig. 35; 57A)

Body broadly obpyriform. Pygidium broadly roundish in outline. Median trullae as long as wide, rounded apically, deeply notched once on each side, separated from each other by a space about as wide as one of them. Second trullae reduced to triangular processes. Two pectinae slender between median trullae; 1 pectina slender between

the median and second. No pygidial scleroses. Marginal setae of Abd VI–VIII situated within margin on both surfaces, approximately the same in length.

Dorsal surface. Microducts scattered on pygidium and Abd V sparsely, 1 duct on each of metathorax to Abd IV marginally and on each of Abd I–V submedially. Anus situated slightly anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 2–4 disc pores; posterior spiracles without disc pores. Gland tubercles absent. Microducts occurring marginally to submarginally on prosoma to abdomen sparsely; in a transverse row laterally to posterior spiracle.

Second-instar male (Fig. 36; 57B)

Body oblong. Pygidium roundish in outline. Median trullae a little longer than wide, rounded apically, deeply notched once on each side, separated from each other by a space a little wider than one of them. Second trullae wider than the median but shorter, rounded apically, deeply notched once on each side. Third trullae shorter than the second but wider, the same in shape as the second. Two pectinae between median trullae and also between the median and second; 3 pectinae between the second and third. No pygidial scleroses. Dorsal marginal setae of Abd VIII slightly longer than the ventral ones.

Dorsal surface. Smaller microducts few, on Abd II medially and submedially, and also on III medially. Macroducts scattered marginally to submarginally on mesothorax to Abd VII; 2–3 submedian macroducts on Abd IV, 2–4 on V, 2 on VI and 1–2 on VII; 5 pairs of marginal macroducts on pygidium. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 3–4 disc pores; posterior spiracles each with 1 disc pore, occasionally with no disc pore. Five groups of 1–6 gland tubercles on prosoma and Abd I submarginally. Microducts in 2 sizes. Smaller microducts strewn over Abd I–VII; in an oblique row laterally to clypeolabral shield; in an oblique row running caudad of anterior spiracle and extending to labium; in a transverse row laterally to posterior spiracle, with a few caudad of the spiracle. Larger microducts occurring on mesothorax submarginally. Macroducts occurring marginally and submarginally on prosoma.

DISCUSSION AND CONCLUSION

In this section, the observations on the second-instar females and males of the 14 species of the Odonaspidini given in the preceding section are summarized and the taxonomic significance of the nymphal forms is discussed.

Second-instar females

The adult females of the tribe Odonaspidini are characterized, above all, by lacking well-differentiated marginal appendages, or practically by having no marginal appendages, on the pygidium. The second-instar females differ from the conspecific adult females in having much fewer ducts in accord with the fact that in the female the test (scale cover) is constructed largely by the adult. In other characters, especially in the state of the pygidial margin, they are generally very similar to the conspecific adult females. However, not all of them are exactly similar to the adult females in the state of the pygidial margin. *O. arcusnotata*, *O. densipora*, *O. greeni*, and *O. sparsa* possess a pair of

distinct processes, which should correspond to the median trullae in other diaspidids, and glanduliferous spines, which will be shown to be modified pectinae, on the pygidium. *O. batarazaensis*, *O. maasinensis*, *O. procera*, and *O. schizostachyi* have a pair of processes at the apex of the pygidium but no trace of pectinae. On the other hand, *O. miyakoensis*, *O. morrisoni*, and *O. oshimaensis* have no prominent processes, whereas their adult females possess a single process at the pygidial apex.

The single process occurring on the pygidial apex in the adult females of some Odonaspidini may correspond to the median trullae in other diaspidids. On this supposition, the absence of distinct marginal appendages in the adult female Odonaspidini should be derivative: the tribe should have originated from some group with differentiated marginal appendages. This view finds support in the second-instar females that are provided with distinct marginal appendages. The adult females of the Odonaspidini should have changed so much as to lose their ancestral character pattern of the pygidial margin completely or almost completely, whereas the occurrence of distinct appendages and their diversity in the second-instar females of some Odonaspidini should be attributed to change from the ancestral pattern effected in various degrees. This interpretation will find further evidence in the second-instar males.

Second-instar males

In the Diaspididae the second-instar males are remarkably different from the second-instar females in having more numerous ducts, reflecting the fact that in the male the test is completed during the second instar. They may also differ in other characters, too, and in some species of the Odonaspidini sexual dimorphism is quite conspicuous. With respect to the degree and pattern of sexual dimorphism the second-instar males examined in the present study are divided into 4 types and an extra form as given below.

Type I. The second-instar males of this type are similar to the second-instar females and also to the adult females in the ducts all replaced with microducts and in the pygidial margin which is provided with trulla-corresponding processes but with no glanduliferous spines or pectinae. *Odonaspis batarazaensis* and *O. maasinensis* belong to this type. Furthermore, the second-instar males of both species are very similar to the adult female of *O. maasinensis* in the arrangement of the pygidial microducts.

Type II. The second-instar male of *Odonaspis procera* is remarkably different from the second-instar female and the adult female in having macroducts and gland tubercles. It has no distinct apical process on the pygidium, whereas a rather developed apical process occurs in the adult and second-instar females and this process is divided to form a pair of triangular prominences in the second-instar female. The second-instar male of *O. minima*, from Georgia, U.S.A., belongs to this type, but it is very similar to the conspecific adult and second-instar females, which have no distinct apical process (the second-instar female, however, has no gland tubercles) (Howell and Tippins, 1978; the figure on p.763 should be changed with the figure on p.765).

Type III. The second-instar males of this type are very similar to those of Type II, but differ in having a pair of well-developed processes or median trullae at the pygidial apex and in the pygidial margin strongly sclerotized. They have no microducts on the dorsal surface, differing from Type II in this character, too. *Odonaspis miyakoensis*, *O. morrisoni*, and *O. oshimaensis* belong to this type.

Type IV. The second-instar males of this type possess distinct trullae in 2 or 3 pairs, glanduliferous pectinae, macroducts, and gland tubercles, and all these features are

arranged to form a pattern that is common to the distinct tribe Parlatoriini. Seven species belong to this type: *Froggattiella penicillata*, *Odonaspis arcusnotata*, *O. bambusarum*, *O. densipora*, *O. greeni*, *O. secreta*, and *O. sparsa*. ‘Adult insect’ of *Parlatoria zeylanica* described by Rutherford (1915, p.113; *Parlatoria zeylanica* on p.114 was renamed *P. rutherfordi*) from Sri Lanka should be the second-instar male of *Odonaspis secreta* or *O. greeni* (Rutherford’s description of *P. zeylanica* agrees with the second-instar male of *O. greeni*, rather than of *O. secreta*, studied in the present study).

The second-instar male of the remaining species, *Odonaspis schizostachyi*, possesses macroducts, distinct trullae, and gland tubercles as in Type IV, but it has the pygidial margin strongly sclerotized as in Type III, agreeing also with the conspecific adult and second-instar females in this character. It is also characteristic in having baculiform pectinae, each of which is provided with a very long microduct.

Takagi (2003, 2008, and other papers) states that the second-instar males of the Diaspididae are largely divisible into the ‘homomorphic’ form, which is similar to the conspecific second-instar female and, as a rule, also to the adult female especially in the pygidial margin, and the ‘heteromorphic’ form, which is quite different from the conspecific females in its character pattern. He also states that the simple dichotomy into the homo- and heteromorphic forms is not always adequate to describe the second-instar males, and that there are forms variegated between them.

Among the types of the second-instar males mentioned above, Type I and *Odonaspis minima* of Type II are homomorphic, and Type IV definitely falls in the category of the heteromorphic form. The homomorphic males are odonaspidine-patterned at least on the pygidial margin, whereas the heteromorphic males are apparently parlatoriine-patterned. The other males show various mixtures of odonaspidine and parlatoriine characters. It is natural that an odonaspidine nymph exhibits odonadpidine characters. Then, what does the occurrence of parlatoriine characters in the second-instar males of some odonaspidine species mean?

Not all of the species belonging to Type IV are closely related to each other, the adult females of some of them appearing relatively primitive and those of the others fairly derivative. This suggests that the types of the second-instar males are not necessarily associated with the phylogenetic relationship, and that genomic potential for the manifestation of the parlatoriine pattern of characters is universal among the odonaspidine scale insects. The ancestral character pattern required in the discussion on the second-instar females, therefore, should be the character pattern of the Parlatoriini, and the manifestation of the parlatoriine character pattern in the second-instar males of Type IV should be of atavistic nature. The manifestation of this ancestral pattern is suppressed completely or incompletely in the other males. It is completely suppressed in the adult and second-instar females except for the occasional presence of gland tubercles on the prosoma and also of marginal processes and spines, which should correspond to the trullae and pectinae in the Parlatoriini (and other Aspidiotinae).

As stated, the occurrence of the Type IV second-instar males itself does not mean a close relationship among the species. On the other hand, *Odonaspis batarazaensis* and *O. maasinensis*, both occurring on Palawan Island and belonging to Type I (which is homomorphic), are similar in the adult females, too, and probably closely related to each other. *O. miyakoensis*, *O. morrisoni*, and *O. oshimaensis*, all inhabiting the Ryûkyû Islands (*O. morrisoni* having a broader region) and belonging to Type III, afford another example of the correspondence between the type of the second-instar males and the

similarity of the adult females. However, *O. procera* and *O. minima* are remarkably different in the adult females in spite of the fact that their second-instar males are referable to the same type (Type II). These species may have some relationship, but this possibility is doubtful because they are separated in distribution too widely (in the Philippines and the U.S.A.). As another possibility, their agreement in the type of the second-instar male is attributable to a mere coincidence in the combination of odonaspidine and parlatoriine characters.

Sexual dimorphism in the second-instar Odonaspidini is apparently complicated, and the known examples are still too few to elucidate the taxonomic significance of the dimorphism satisfactorily. Needless to say, it arouses a question: what genetic mechanisms are responsible for such a broad phenotypic outcome involving atavism? Another question also arises: why is the atavistic pattern completely manifested only in part of the tribe and in the second-instar male alone? The second question alludes not only to genetic mechanisms but also some life-historical factors. These inevitable questions, however, are beyond the scope of the present study.

PART III: DESCRIPTIONS OF SEVEN OTHER NEW SPECIES

In Part I, 6 new species of the genus *Odonaspis* are described on the basis of their adult females, and in Part II their second-instar females and males are described. The materials collected by S. Takagi during 1986 to 1994 in his surveys in Malaysia and the Philippines include 7 other new species of the Odonaspidini. No specimens of the second-instar male are available for these species, which should be described in this part on the basis of the adult females and also on the second-instar females except for two of them.

Froggattiella gigantochloae, sp. nov.

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388b), ST, 4 adult ♀ (2 in poor condition). Holotype: adult female, deposited in FRIM.

Etymology. The scientific epithet refers to the generic name of the host plant.

Diagnosis (adult female). *Froggattiella gigantochloae*, sp. nov., is similar to *Froggattiella penicillata* and *F. mcclurei* but differs from *F. penicillata* in the antennae located distinctly anterior to the clypeolabral shield and in the distribution and number of the gland spines, and from *F. mcclurei* in the absence of perivulvar disc pores and in the gland spines on the pygidial apex occurring in separate pairs.

Adult female (Fig. 37; 57C)

Body pyriform. Pygidium broadly triangular in outline. Margin of Abd VIII with 8 very small gland spines; 1 pair between ventral marginal setae, 2 pairs between ventral marginal setae and pygidial scleroses, and 1 pair just laterally to the pygidial scleroses; gland spines each with a long microduct, which is much longer than the pygidial scleroses. Abd IV–VII with a small pointed triangular process at posterolateral angle. Margin of Abd VI and VII indented. Margin of Abd IV and V slightly indented. Two pairs of pygidial scleroses between Abd VII and VIII and between VI and VII, the lateral pair shorter than the mesal. Ventral marginal setae of Abd VIII longer than the dorsal

ones; inner ventral setae on Abd VIII fleshier than the outer ones.

Dorsal surface. Microducts occurring in a narrow zone along margin on mesothorax to Abd V; extensively on pygidium. Dark lines present marginally on mesothorax to Abd IV. Anus situated at about basal one-third of pygidium.

Ventral surface. Antennal tubercle located submarginally and distinctly anteriorly to clypeolabral shield. Anterior spiracles each with 5–9 disc pores; posterior spiracles without disc pores. No gland tubercles. Vulva situated anterior to level of anus. No perivulvar disc pores. Microducts occurring laterally to mouth-parts extending to margin; in a transverse row running laterally to posterior spiracle; medially on meso- and metathorax; submedially on Abd I–III; along margin on mesothorax to Abd V; extensively on Abd VI and VII; no ducts on postvulvar sternite.

Froggattiella pentapeniculata, sp. nov.

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia, on *Gigantochloa levis*, 30.IX.1986 (86ML-64a), ST, 79 adult ♀, 19 2nd ♀; same locality, on *Gigantochloa* sp., 2.XI.1986 (86ML-388b), ST, 5 adult ♀. Holotype: adult female, from 86ML-64a, deposited in FRIM.

Etymology. The specific epithet of this new species refers to the five tufts of gland spines on the pygidial margin.

Diagnosis (adult female). *Froggattiella pentapeniculata*, sp. nov., is distinguishable from other *Froggattiella* species in having 5 tufts of gland spines on the apex of the pygidium.

Adult female (Fig. 38; 58A)

Body circular. Pygidium trapezoid in outline, being broadly flattened apically. Flattened apex flanked on each side with a triangular projection (posterior angle of Abd VII), with 5 tufts of gland spines, each tuft composed of 3–8 spines and each spine with a long microduct, which is longer than the pygidial scleroses. Two pairs of pygidial scleroses between Abd VII and VIII and between Abd VI and VII little clavate. Two dorsal marginal setae of Abd VIII situated marginally, longer one located nearer to margin, projecting beyond margin. Ventral marginal setae of Abd VIII dislocated submarginally, not projecting beyond margin, approximately as long as or somewhat longer and fleshier than the dorsal longer ones. Dark lines present marginally from level of anterior end of clypeolabral shield to Abd III on both surfaces.

Dorsal surface. Microducts thickly strewn over pygidium and Abd V; marginally to submarginally on prosoma to Abd IV; some on Abd IV submedially. Anus situated anterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle located marginally anterior to level of anterior end of clypeolabral shield. Anterior spiracles each with 8–16 disc pores; posterior spiracles without disc pores. Perivulvar disc pores arranged in an arch; total 165–261. Vulva placed posterior to level of anus. Microducts thickly strewn on prosoma to Abd VII, but none on frontal area; in an oblique row occurring laterally to clypeolabral shield and extending to margin; some caudad of anterior spiracle; in another oblique row laterally to posterior spiracle; no ducts on postvulvar sternite.

Second-instar female (Fig. 39; 58B)

Body obovate. Pygidium broadly triangular in outline. Median trullae conical, pointed apically, separated from each other by a space narrower than one of them. Second trullae wider than long, pointed apically. Margin of Abd VII indented. A pair of gland spines between median trullae; another pair on each side laterally to median trulla. A pair of short pygidial scleroses between Abd VII and VIII. Ventral marginal setae of Abd VIII slightly longer and fleshier than the dorsal ones. Microducts occurring on ventral cephalothorax medially to submarginally slightly smaller than those occurring on mesothorax to abdomen submarginally to marginally.

Dorsal surface. Microducts occurring on pygidium extensively; on Abd IV and V submarginally and submedially; a few on Abd III submedially. Anus situated anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–8 disc pores; posterior spiracle without disc pores. No gland tubercles. Four groups of 2–3 short macroducts on cephalothorax submarginally. Microducts occurring in an oblique row running laterally to mouth-parts; in a transverse row running across metathorax; marginally and submarginally on mesothorax to Abd VII; a few on Abd VIII.

Odonaspis collarifera, sp. nov.

Material examined. Bukit Fraser (1300m), Pahang, Malaya, Malaysia, on *Bambusa* sp., 29.X.1986 (86ML-349b), ST, 9 adult ♀, 5 2nd ♀, some exuviae; Bukit Tapah (650m), Perak, Malaya, on *Schizostachyum* sp., 19.X.1986 (86ML-247e), ST, 3 adult ♀ (in poor condition). Holotype: adult female, from 86ML-349b, deposited in FRIM.

Etymology. Named after the collar-like shape of the group of perivulvar disc pores.

Diagnosis (adult female). *Odonaspis collarifera*, sp. nov., is referable to *Berlesaspidiotus* as understood by authors (see Remarks under *Odonaspis densipora*, sp. nov., Part I). It is very similar to *O. crenulata* (= *B. crenulatus*) but differs in having a pair of longitudinal rows of microducts on the perivulvar sternite and in the arrangement of the perivulvar disc pores.

Adult female (Fig. 40; 58C)

Body obovate. Pygidium broadly triangular in outline. Margin of Abd VIII produced into a rounded projection, which is not notched. Margin of Abd VI and also of VII forming an asymmetric, apically rounded triangle. One pair of pygidial scleroses obscurely but little clavate even at maturity; 2 pairs between Abd VI and VII and between V and VI, anterior end obscure. Ventral marginal setae of Abd VIII situated within margin, remarkably shorter than the dorsal ones. Dark lines present on head to Abd IV, usually on both surfaces.

Dorsal surface. Microducts occurring submarginally on head; submedially to submarginally on mesothorax to Abd VII. Anus situated posterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle placed in a dermal invagination, located anterior to clypeolabral shield. Some of spiracular disc pores piled up on others; anterior spiracles each with 12–28 disc pores; posterior spiracles each with disc pores in 2, anterior and posterior, clusters, 2–7 in anterior cluster and 8–22 in posterior cluster (2 specimens lacking the anterior cluster). No gland tubercles. Vulva placed anterior to level of anus. Perivulvar disc pores arranged in an arch, which is much thickened and curved

mesad in the lateral arms; total 388–703. Microducts occurring laterally to mouth-parts; laterally to each of anterior and posterior spiracles in a band extending to marginal dark lines; marginally to submarginally on Abd I–VII; in a pair of longitudinal rows along intersegmental furrow on postvulvar sternite.

Second-instar female (Fig. 41; 58D)

Body obovate. Pygidium broadly triangular in outline. Median trullae conical, apically pointed, with a few serrations on lateral margin, separated from each other by a space about as wide as one of them. Second trullae conical, pointed apically, slightly notched once on lateral side, smaller than the median. Third trullae reduced to a small pointed process. Margin of Abd V–VII slightly indented. No pygidial sclerites. Dorsal marginal setae of Abd VIII longer than the ventral ones.

Dorsal surface. Microducts occurring marginally to submarginally on Abd III–VIII; a few on Abd III–V. Anus situated slightly posterior to center of pygidium.

Ventral surface. Anterior spiracles each with 4–7 disc pores; posterior spiracles each with 1–5 disc pores. No gland tubercles. Microducts not numerous, occurring marginally to submarginally on prosoma to Abd VII; in a transverse row laterally to posterior spiracle.

Remarks. In the adult females of 86ML-247e each of the posterior spiracles has 36–48 disc pores, which are arranged in a ring (Fig. 40F).

Odonaspis rugosa, sp.nov.

Material examined. Sitip Tig Wayan, Bataraza, Palawan, Philippines, on *Schizostachyum lumampao*, 18.VIII.1993 (93PL-80), ST, 187 adult ♀, 2 2nd ♀, some exuviae. Holotype: adult female, deposited in UPLB.

Etymology. The scientific epithet of this new species refers to the rugose margin of the head.

Diagnosis (adult female). *Odonaspis rugosa*, sp. nov., is distinguishable from *O. lingnani* in having less numerous spiracular disc pores and microducts, in the well-sclerotized intersegmental furrows of Abd III–V of the dorsal surface, and in the absence of marginal dark lines of body margin on the head on both surfaces, and from *O. tapahensis*, sp. nov., in both spiracles having less numerous disc pores, in the absence of marginal dark lines dorsally on the prosoma, and in having microducts over the postvulvar sternite.

Female test. White in color.

Adult female (Fig. 42; 59A)

Body broadly obovate; head margin wrinkled weekly. Pygidium triangular in outline, well sclerotized. Abd V–VIII each marginally with a small rounded process. Pygidial sclerites absent. Marginal setae of Abd VI and VIII situated within margin on both surfaces, the ventral setae as long as the dorsal, the dorsal setae situated more inside than the ventral except on Abd VIII.

Dorsal surface. Microducts occurring marginally to submarginally on metathorax to Abd VI; in a nearly submarginal transverse row along intersegmental furrow between metathorax and Abd I; extensively on Abd VII and submarginally on VIII. Anus situated

at center of pygidium.

Ventral surface. Antennal tubercles located submarginally approximately at level of anterior end of clypeolabral shield. Anterior spiracles each with 4–9 disc pores; posterior spiracles each with 2–6 disc pores. No gland tubercles. Perivulvar disc pores absent. Vulva located anterior to level of anus. Microducts occurring laterally to clypeolabral shield and also to labium; in a nearly transverse row between margin and posterior spiracle; on metathorax to Abd III medially to submedially; marginally to submarginally on mesothorax to Abd V; marginally to submedially on Abd VI and VII; extensively on Abd VIII.

Second-instar female (Fig. 43; 59B)

Body obovate. Pygidium triangular in outline. Apex of Abd VIII with a pair of triangular processes. Abd V–VII each marginally with a small triangular process. Margin of Abd VII slightly indented. Pectinae absent. No pygidial scleroses. Dorsal and ventral marginal setae of pygidium the same in length.

Dorsal surface. Microducts occurring marginally to submarginally on Abd II–IV and VII and VIII; marginally to submarginally on Abd V and VI. A submarginal boss on each of Abd I–VI. Anus situated slightly anterior to center of pygidium.

Ventral surface. Anterior spiracles each with 3–5 disc pores; posterior spiracles each with 2 disc pores. No gland tubercles. Microducts occurring in an oblique row laterally to mouth-parts; in a short transverse row laterally to posterior spiracle; submarginally on Abd I–VIII.

Odonaspis spinulata, sp. nov.

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, Malaysia, on *Gigantochloa levis*, 30.IX.1986 (86ML-64b), ST, 118 adult ♀, 7 2nd ♀, some exuviae; grounds of Forest Research Institute of Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388e), ST, 1 adult ♀; Kuala Kubu Bharu, Selangor, Malaya, on an undetermined bamboo, 23.X.1986 (86ML-301d), ST, 2 adult ♀; Ulu Gombak (210m), Selangor, on *Gigantochloa scortechinii*, 2.X.1986 (86ML-81a), ST., 60 adult ♀; Ulu Gombak (1000m), on *Gigantochloa scortechinii*, 14.XI.1986 (86ML-467a), ST, 33 adult ♀. Holotype: adult female, from 86ML-64b, deposited in FRIM.

Etymology. The specific epithet of the new species refers to the occurrence of some small spine-like processes on the pygidial margin.

Diagnosis (adult female). *Odonaspis spinulata*, sp. nov., is referable to *Berlesaspidiotus* as understood by authors (see Remarks under *Odonaspis densipora*, sp. nov., Part I), but differs from the other species of *Berlesaspidiotus* in the perivulvar disc pores arranged in an arch and in the presence of marginal dark lines on the prothorax to Abd IV on both surfaces. *O. spinulata*, sp. nov., resembles *Odonaspis densipora*, sp. nov., but is distinguished by the presence of perivulvar disc pores and by the number of the spiracular disc pores.

Adult female (Fig. 44; 59C)

Body broadly obovate. Pygidium broadly triangular in outline. Apex of Abd VIII broadly flattish, with a pair of low roundish processes. Margin of Abd VII with a low rounded process, the same in size as one of the processes on Abd VIII. Margin of Abd VI

indented. Pygidial margin of Abd VI–VIII with some spine-like processes (probably each with a duct). Two pairs of pygidial scleroses little clavate between Abd VII and VIII and between VI and VII, the lateral pair shorter than the median. Ventral marginal setae of Abd VIII situated within margin, longer than the dorsal ones.

Dorsal surface. Microducts strewn over pygidium; marginally to submarginally on head to Abd V; extensively on head; in an oblique row on each of pro- and mesothorax attaining submedian area. Anus situated at about basal one-fourth of pygidium.

Ventral surface. Antennal tubercle placed in a dermal invagination, located near body margin at level of anterior end of clypeolabral shield. Anterior spiracles each with 13–30 disc pores; posterior spiracles each with 9–21 disc pores. Vulva situated anterior to level of anus. Perivulvar disc pores arranged in an arch; total 168–344. Microducts thickly strewn on mesothorax to Abd V marginally and submarginally; in an oblique row running laterally to mouth-parts; in another oblique row running caudad of anterior spiracle and extending to submarginal area; in a nearly transverse row running across metathorax; strewn over pygidium.

Second-instar female (Fig. 45; 59D)

Body broadly obovate. Pygidium broadly triangular in outline. Median trullae shorter than wide, rounded apically, oblique and serrate on lateral margin, separated from each other by a space narrower than one of them. Second trullae reduced to a small process. A pair of pectinae between median trullae slender; two pairs between the median and second the same in shape as median pectinae. A pair of pygidial scleroses between Abd VII and VIII little clavate. Dorsal and ventral marginal setae approximately the same in length.

Dorsal surface. Microducts occurring marginally to submedially on pygidium; a few marginally on Abd III and IV. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 4–8 disc pores; posterior spiracles each with 2–5 disc pores. No gland tubercles. Microducts occurring marginally to submarginally on head to Abd VII; in a short transverse row laterally to posterior spiracle.

Odonaspis tapahensis, sp. nov.

Material examined. Tapah, Perak, Malaya, Malaysia, on *Schizostachyum* sp., 19.X.1986 (86ML-247a), ST, 94 adult ♀, 2 2nd ♀, some exuviae; Keningau, Sabah, Malaysia, on *Bambusa vulgaris*, 9.XI.1988 (88ML-298), ST, 12 adult ♀, 1 2nd ♀. Holotype: adult female, from 86ML-247a, deposited in FRIM.

Etymology. Named after one of the localities where the material was collected.

Diagnosis (adult female). *Odonaspis tapahensis*, sp. nov., differs from *O. lingnani* in the antennae situated marginally, in the absence of dark lines marginally on the ventral surface of the head, and in the absence of microducts on the postvulvar sternite.

Adult female (Fig. 46; 60A)

Boby obovate; fully grown female roundish square in outline. Pygidium broadly roundish triangular in outline. Apex of Abd VIII with a pair of triangular processes situated close to each other. Margin of Abd VI and VII with a triangular process, the process on Abd VI wider. Pygidial scleroses absent. Marginal setae of Abd VI to VIII

situated within margin on both surfaces, the dorsal ones slightly longer than the ventral ones.

Dorsal surface. Microducts occurring marginally to submarginally on prothorax to Abd VIII; in a nearly transverse row between submarginal and submedian areas on each of pro- and mesothorax. Dark lines of body margin present on head to Abd IV. Anus situated slightly posterior to basal one-fourth of pygidium.

Ventral surface. Antennal tubercle located marginally and a little posteriorly to level of anterior end of clypeolabral shield, overlapping with marginal dark lines. Anterior spiracles each with 29–55 disc pores and a band of microducts; posterior spiracles each with 14–40 disc pores. Vulva located slightly anterior to level of anus. Gland tubercles absent. Perivulvar disc pores absent. Microducts occurring marginally to submarginally on mesothorax to Abd VII; in an oblique row occurring laterally to mouth-parts and extending to body margin; in a transverse row laterally to posterior spiracle; medially to submedially on Abd II–V; in a pair of longitudinal rows along intersegmental furrow on postvulvar sternite. Dark lines occurring on body margin from level of antenna to Abd I.

Second-instar female (Fig. 47; 60B)

Body broadly obvate. Pygidium triangular in outline. Apex of Abd VIII with a pair of triangular serrate processes. Margin of Abd VI and VII indented. No pygidial scleroses; no pectinae. Marginal setae of Abd VI to VIII situated within margin, approximately the same in length on both surfaces. Microducts on Abd IV–VIII forming nearly longitudinal, narrow bands each bordered with dark lines on both surfaces.

Dorsal surface. Microducts occurring marginally to submarginally along posterior borders of Abd I–VII; some submarginally on meso- and metathorax; submedially on mesothorax to Abd I; a few on Abd VIII. Anus situated approximately at center of pygidium.

Ventral surface. Anterior spiracles each with 4–12 disc pores; posterior spiracles without disc pores but with a cluster of microducts. No gland tubercles. Microducts in 2 sizes; shorter microducts occurring on prosoma; longer microducts occurring marginally to submarginally on prothorax to Abd VI.

Odonaspis trispatulata, sp. nov.

Material examined. Ulu Gombak (500m), Selangor, Malaya, Malaysia, on *Bambusa vulgaris*, 16.XI.1986 (86ML-495d), ST, 2 adult ♀, 1 exuviae. Holotype: adult female, deposited in FRIM.

Etymology. The specific epithet refers to the pygidium deeply incised apically to form 3 spatula-like structures.

Diagnosis (adult female). *Odonaspis trispatulata*, sp. nov., differs from other *Odonaspis* species in having deep notches on the pygidium between Abd VI and VII and between VII and VIII and disc pores between the clypeolabral shield and the anterior spiracles.

Adult female (Fig. 48; 57D)

Body broadly obovate, with meso- and metathorax and Abd I without segmental lateral incisions among them. Pygidium blunt triangular in outline, deeply notched between Abd VI and VII and between VII and VIII, the notched margin well sclerotized. Margin of Abd VII and VIII flat. Margin of Abd V and VI with serrations. Marginal setae

on lateral side of head to Abd VIII obviously long; on head and thorax 42.5–95.0µm; on Abd I–V 30.0–75.0µm; on VI–VII and dorsum of VIII 22.5–42.5µm; on venter of VIII 12.5–15.0µm. No pygidial scleroses.

Dorsal surface. Microducts strewn over pygidium extensively; on Abd V marginally to submedially; on metathorax to Abd IV in a zone along margin. Anus situated at about basal one-third of pygidium.

Ventral surface. Antennal tubercles located submarginally in front of anterior end of clypeolabral shield. Anterior spiracles each with 3–5 disc pores anteriorly and 2–3 between mouth-parts and the spiracle; posterior spiracles each with 6–10 disc pores. Vulva situated posterior to level of anus. Perivulvar disc pores arranged in a pair of lateral groups, 42–50 in each group. Microducts scattered in an oblique row laterally to mouth-parts; in a transverse row running across metathorax; on metathorax to Abd VI marginally to submarginally; a few (2–6 on each side) on each of Abd VII and VIII submarginally.

Remarks. In the holotype 2 ducts are present on the right half of the postvulvar sternite, whereas in the other specimen 6 or 7 ducts occur in a row on each side.

PART IV: SPECIES NEWLY RECORDED FROM MALAYSIA AND THE PHILIPPINES

In this part, 6 species, 5 from Malaysia and 1 from the Philippines, are newly recorded. Among them, *O. pacifica* and *O. schizostachyi* were described from Guam and the Philippines, respectively, and there have been no further records of them; *O. lingnani* was described from China and recorded from Indonesia; *Froggattiella penicillata* and *Odonaspis greeni* are distributed worldwide (Ben-Dov and German, 2003), but no formal records have been made of these species from Malaysia. The collection data of the adult female specimens identified with these species are given below.

Froggattiella penicillata (Green)

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia, on *Gigantochloa levis*, 30.IX.1986 (86ML-64c), ST, 2 adult ♀; grounds of the Forest Research Institute of Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388d), ST, 2 adult ♀; Sandakan, Sabah, Malaysia, on *Bambusoides* sp., 18.XI.1988 (88ML-374), ST, 22 adult ♀.

Odonaspis arcusnotata Ben-Dov

Material examined. Tapah (650m), Perak, Malaya, Malaysia, on *Schizostachyum* sp., 19.X.1986 (86ML-247b), ST, 1 adult ♀.

Odonaspis greeni (Cockerell)

Material examined. Kuala Lumpur, Malaya, Malaysia, on *Bambusa glaucescens*, 21.IX.1986 (86ML-1), ST, 111 adult ♀; grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, on *Bambusa vulgaris*, 26.IX.1986 (86ML-25b), ST, 12 adult ♀; grounds of the Forest

Research Institute of Malaysia, on *Gigantochloa* sp., 2.XI.1986 (86ML-388a), ST, 10 adult ♀ ; Ulu Gombak (500m), Selangor, Malaya, on *Bambusa vulgaris*, 16.XI.1986 (86ML-495a), ST, 20 adult ♀ ; Kuala Kubu Baharu, Selangor, on an undetermined bamboo, 23.X.1986 (86ML-301e), ST, 1 adult ♀ ; Bukit Fraser (1300m), Pahang, Malaya, on *Bambusa* sp., 29.X.1986 (86ML-349a), ST, 52 adult ♀ .

Odonaspis lingnani Ferris

Material examined. Ulu Gombak (500m), Selangor, Malaya, Malaysia, on *Bambusa vulgaris*, 16.XI.1986 (86ML-495e), ST, 2 adult ♀ .

Odonaspis pacifica Ben-Dov

Material examined. Puerto Princesa, Palawan, Philippines, on *Dinorchloa scandens*, 13.VIII.1993 (93PL-64), ST, 1 adult ♀ .

Odonaspis schizostachyi Cockerell and Robinson

Material examined. Grounds of the Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaya, Malaysia, on *Schizostachyum zollingeri*, 26.IX.1986 (86ML-23b), ST, 40 adult ♀ ; Tapah, Perak, Malaya, on *Schizostachyum* sp., 19.X.1986 (86ML-247b), ST, 3 adult ♀ .

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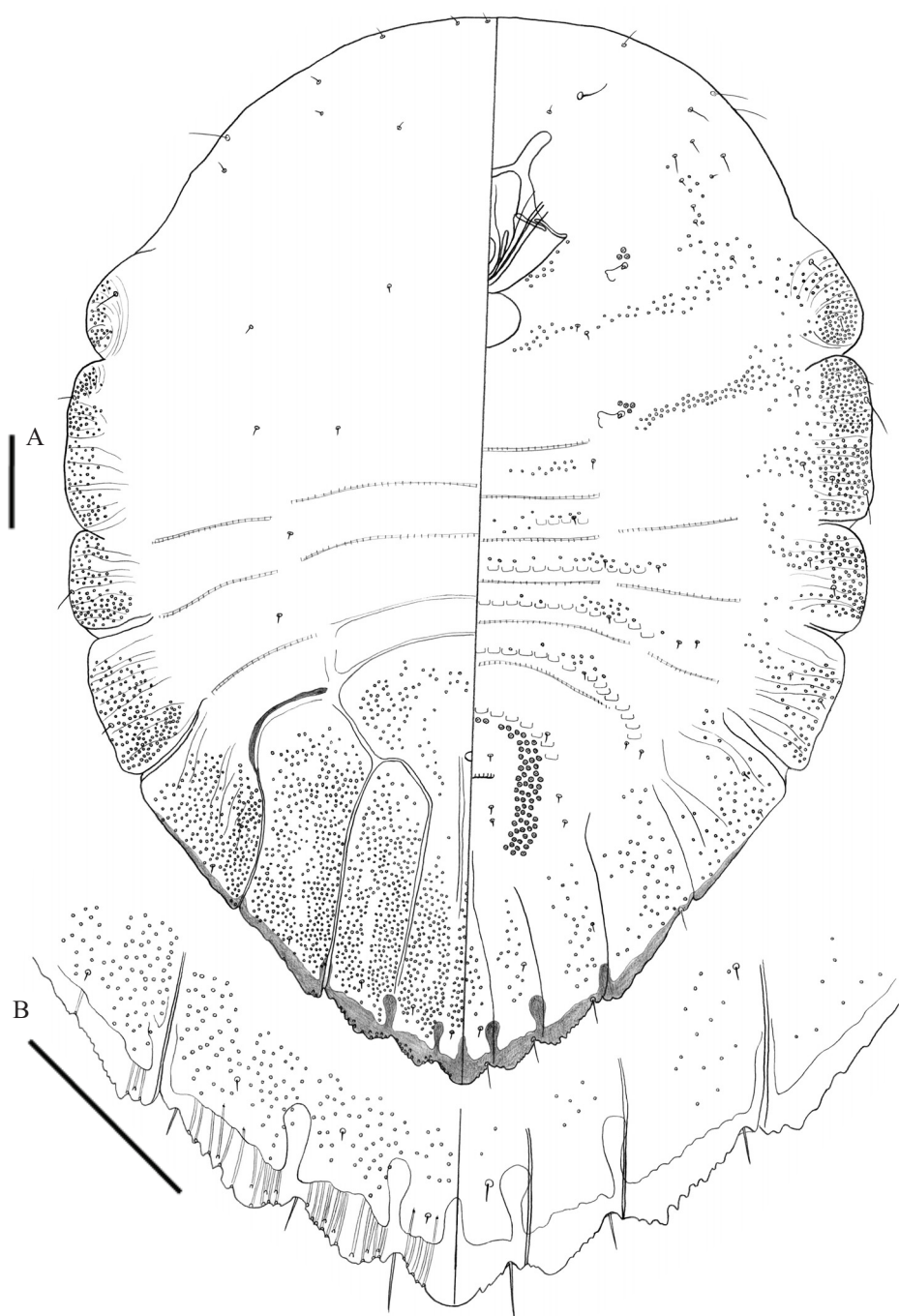


Fig. 1. *Odonaspis batarazaensis*, sp. nov., adult female. B, pygidial margin. Scale bars: A & B, 100 μ m.

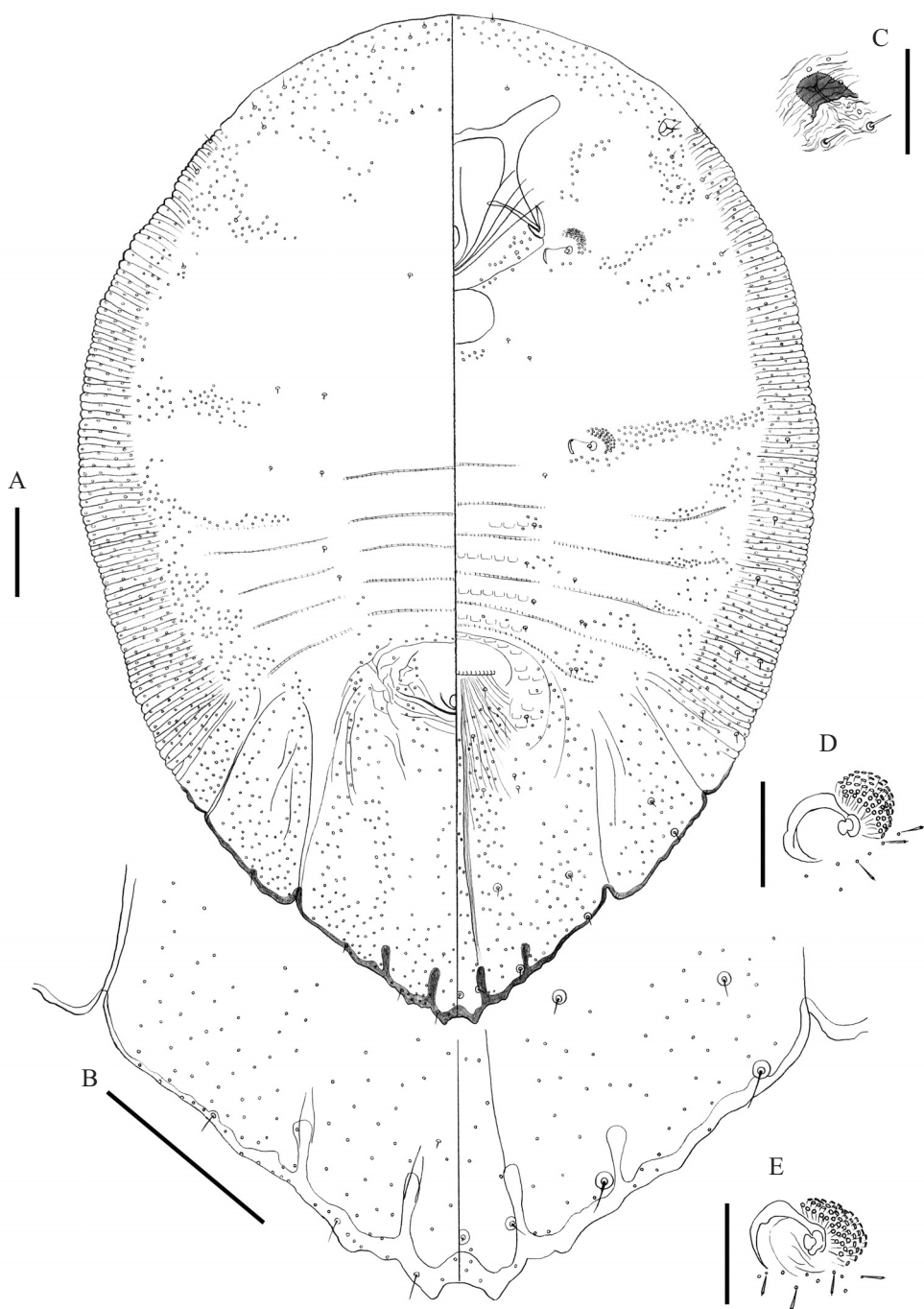


Fig. 2. *Odonaspis densipora*, sp. nov., adult female. B, pygidial margin; C, antenna; D, anterior spiracle; E, posterior spiracle. Scale bars: A & B, 100µm; C, D, E, 50µm.

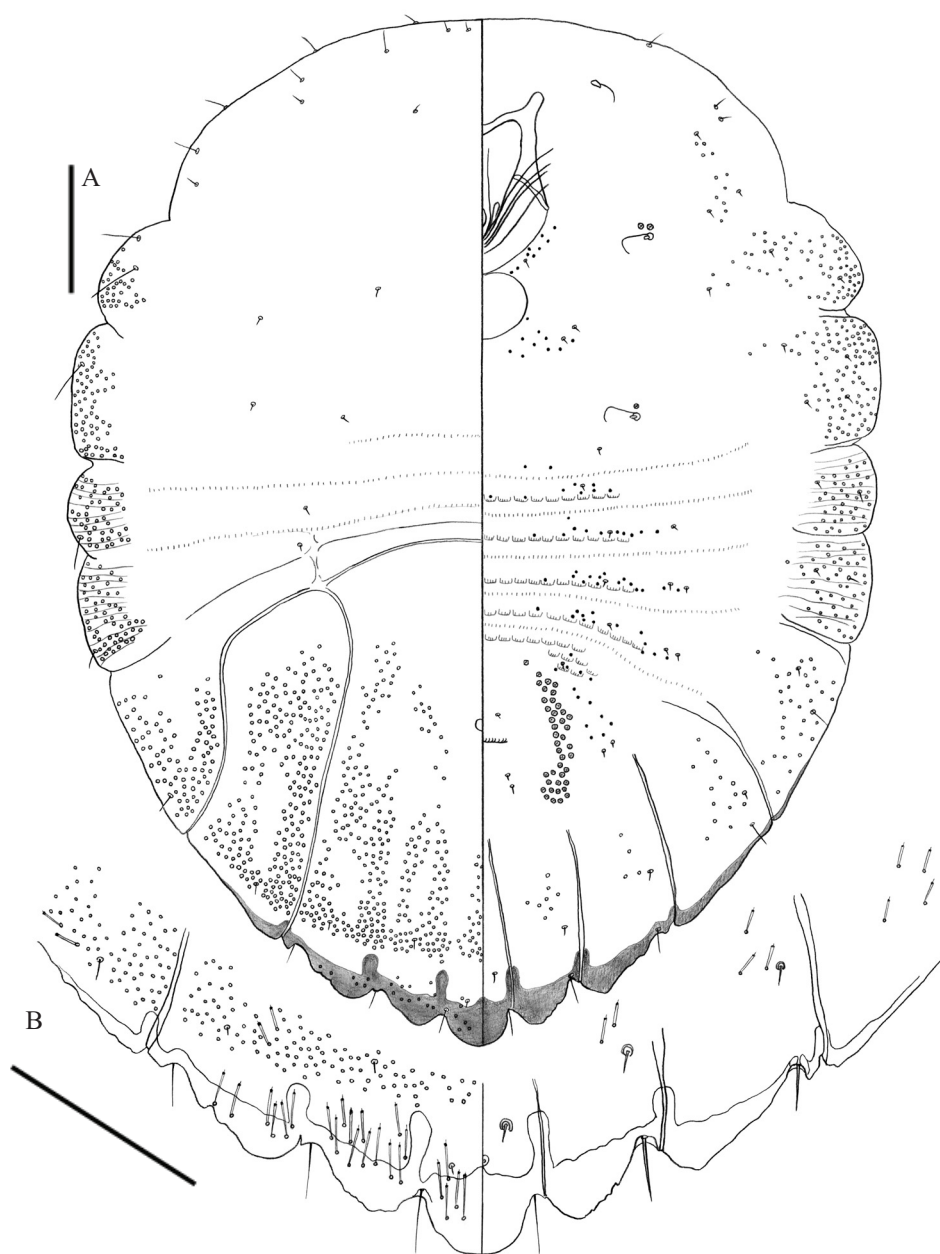


Fig. 3. *Odonaspis maasinensis*, sp. nov., adult female. B, pygidial margin. Scale bars: A & B, 100 μ m.

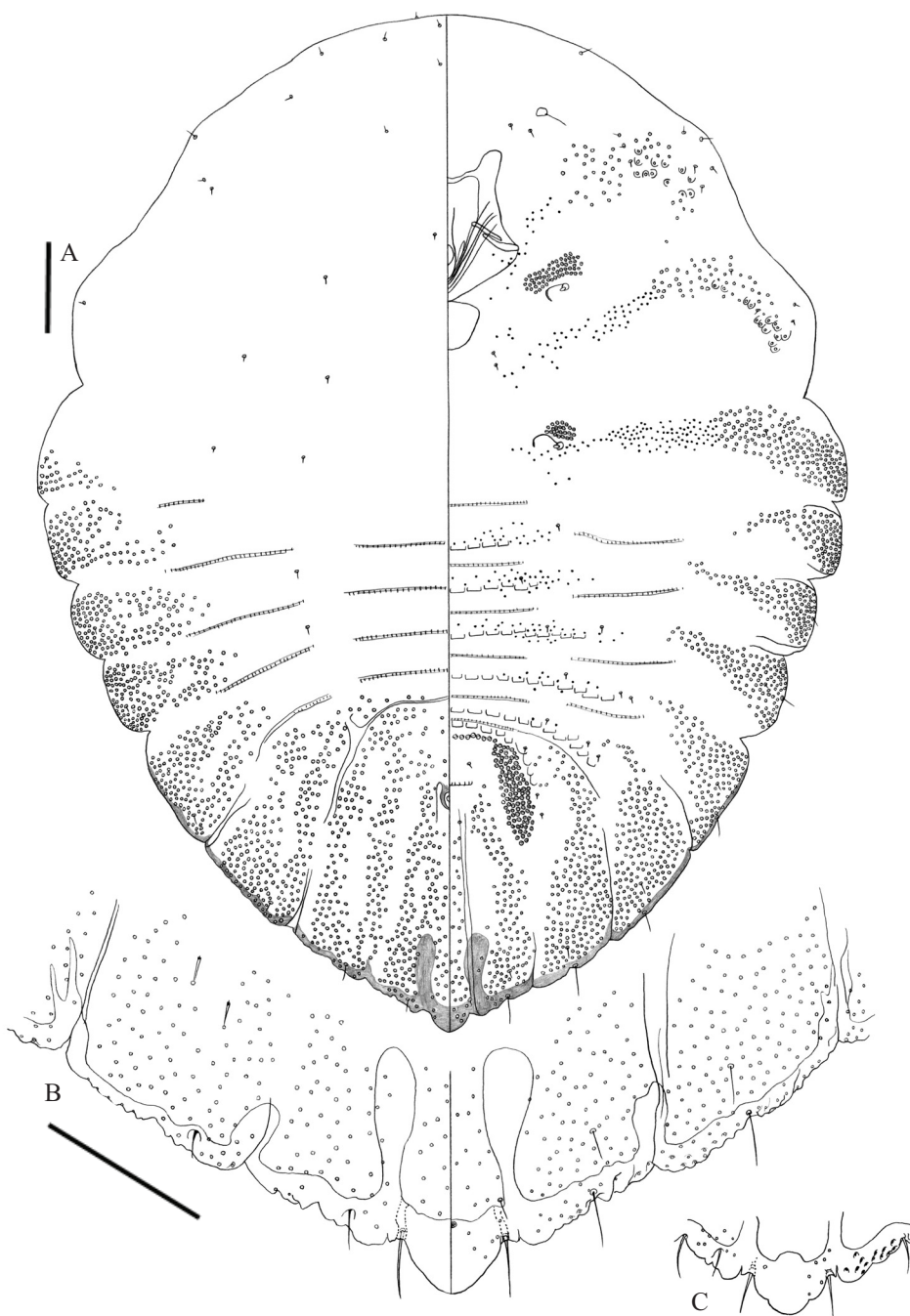


Fig. 4. *Odonaspis miyakoensis*, sp. nov., adult female. B, pygidial margin; C, apex of Abd VIII, slightly notched once on each side. Scale bars: A & B, 100 μ m.

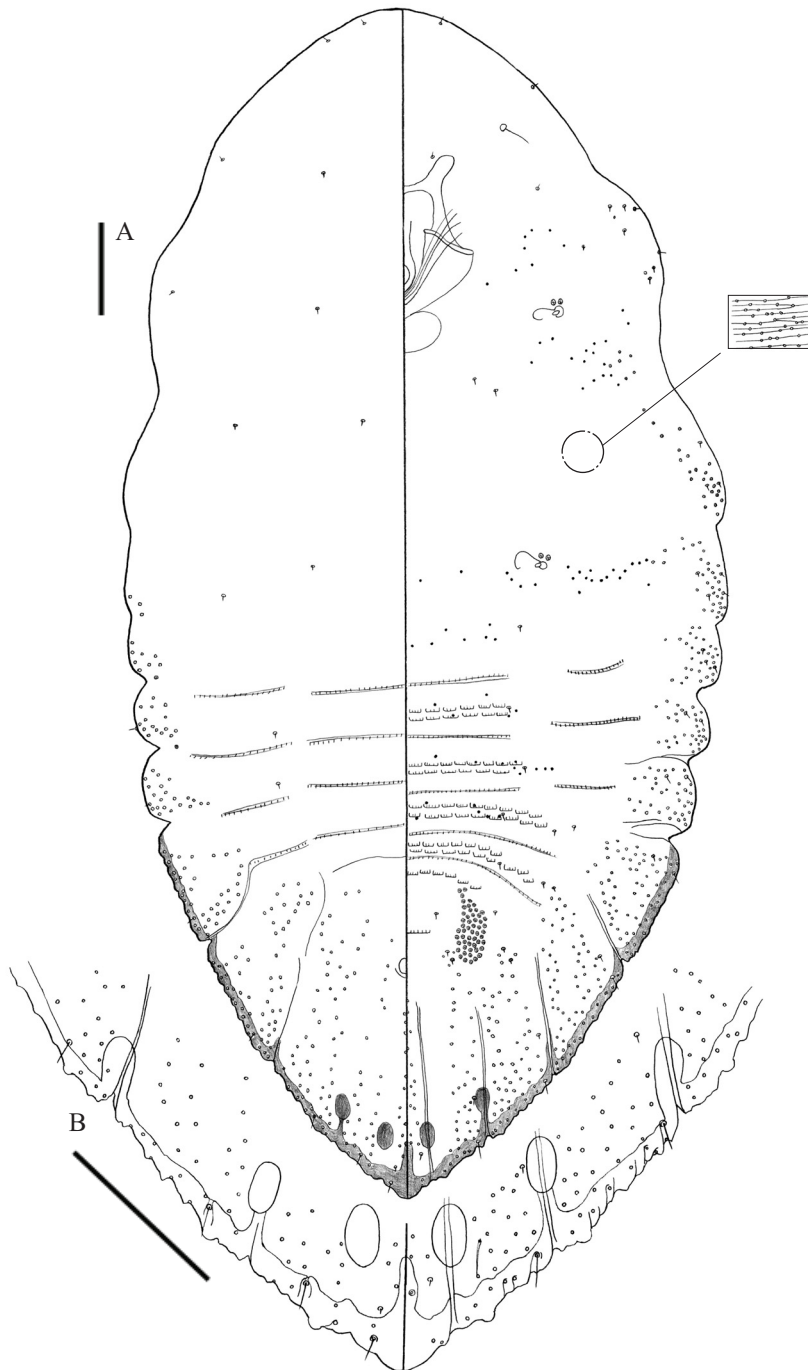


Fig. 5. *Odonaspis procera*, sp. nov., adult female. B, pygidial margin. Scale bars: A & B, 100µm.

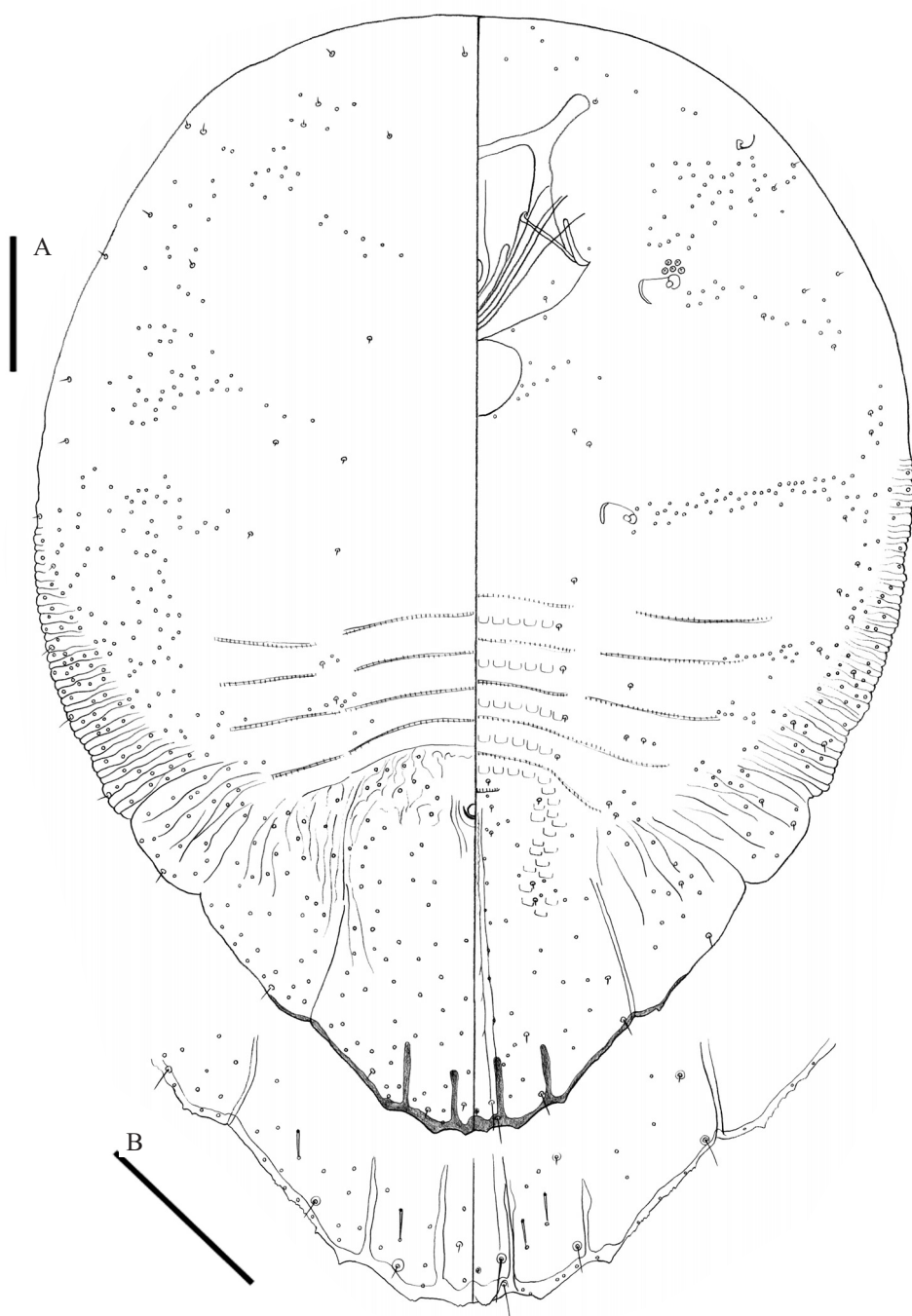


Fig. 6. *Odonaspis sparsa*, sp. nov., adult female. B, pygidial margin. Scale bars: A & B, 100 μ m.

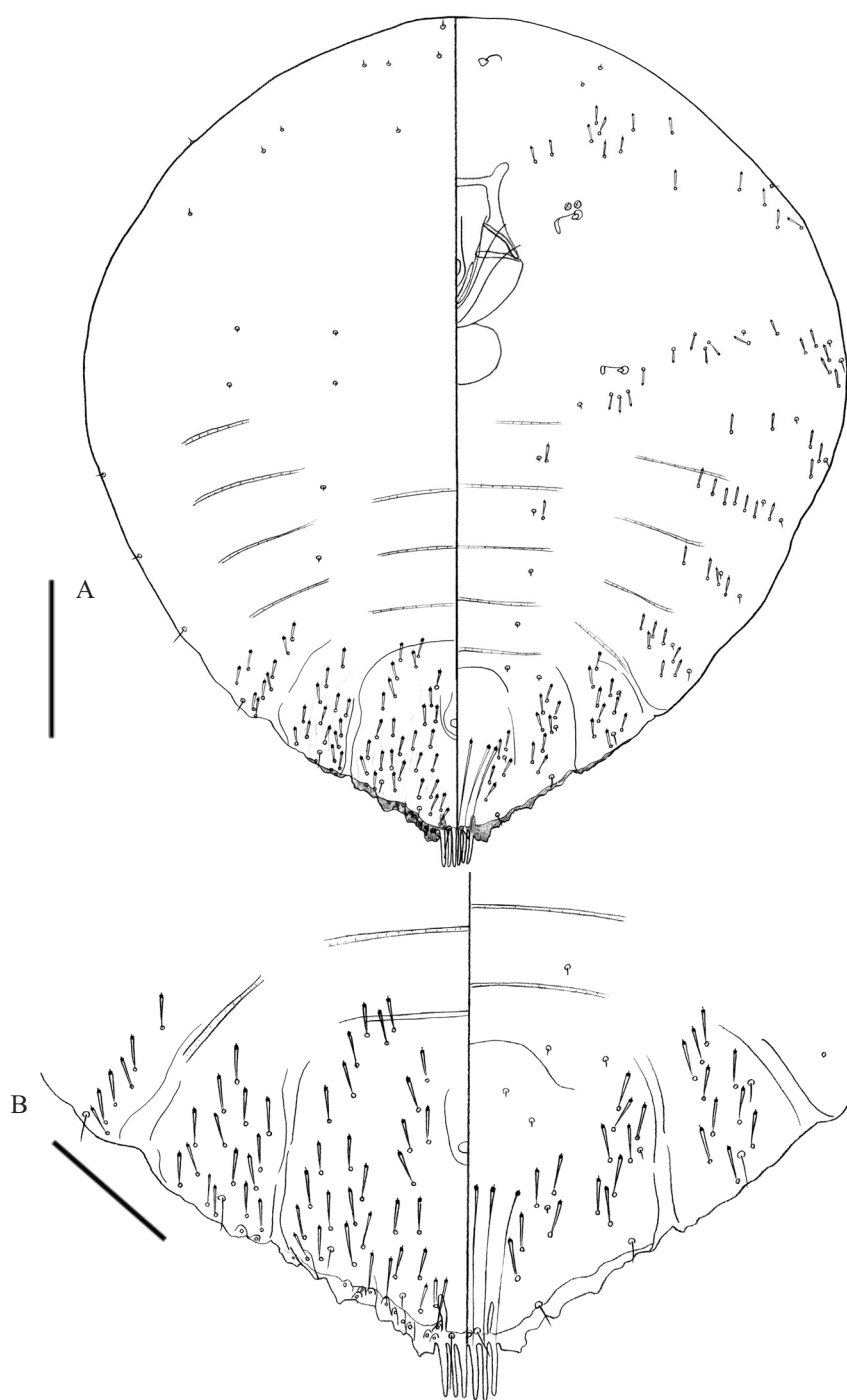


Fig. 7. *Froggattiella penicillata*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

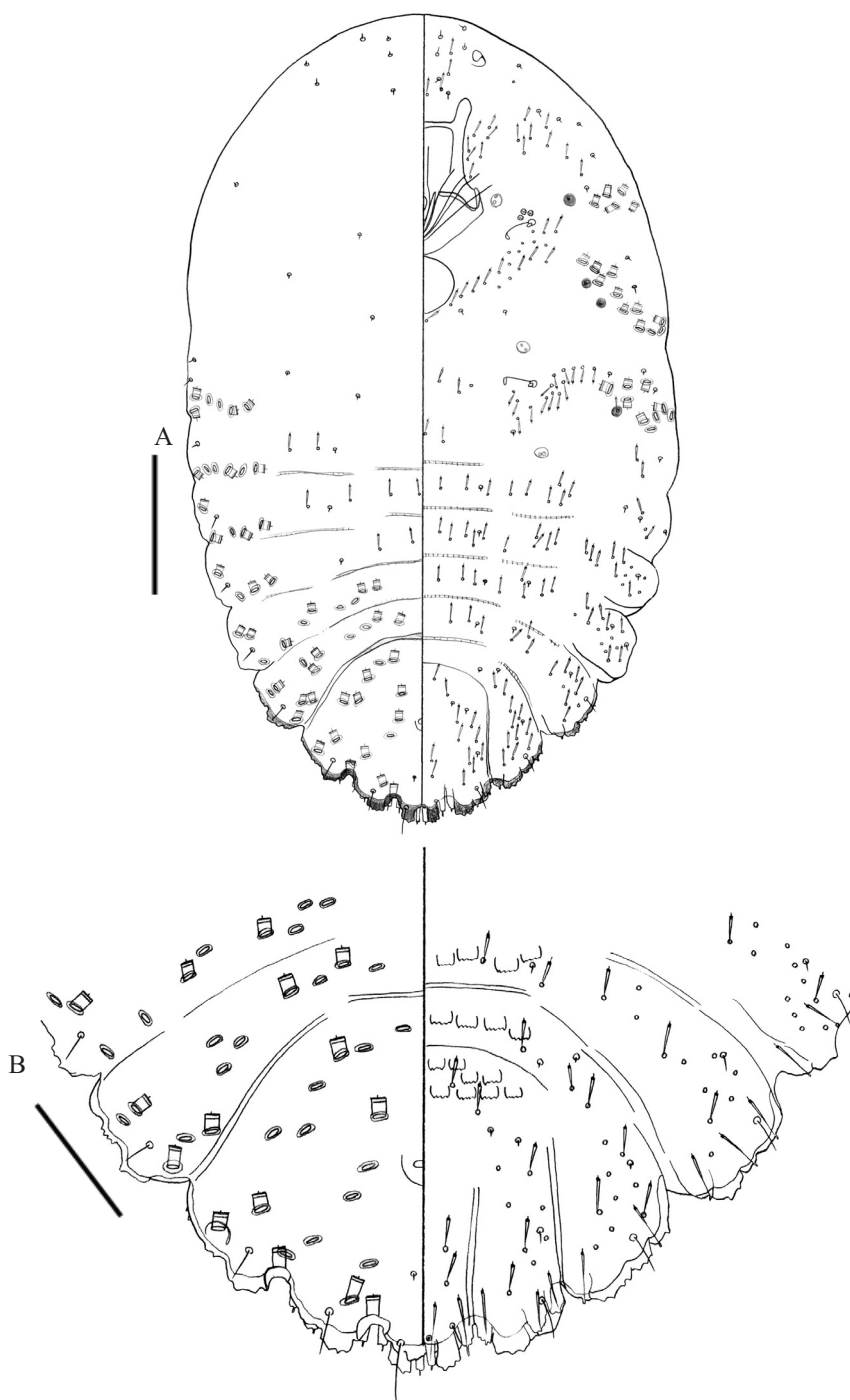


Fig. 8. *Froggattiella penicillata*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

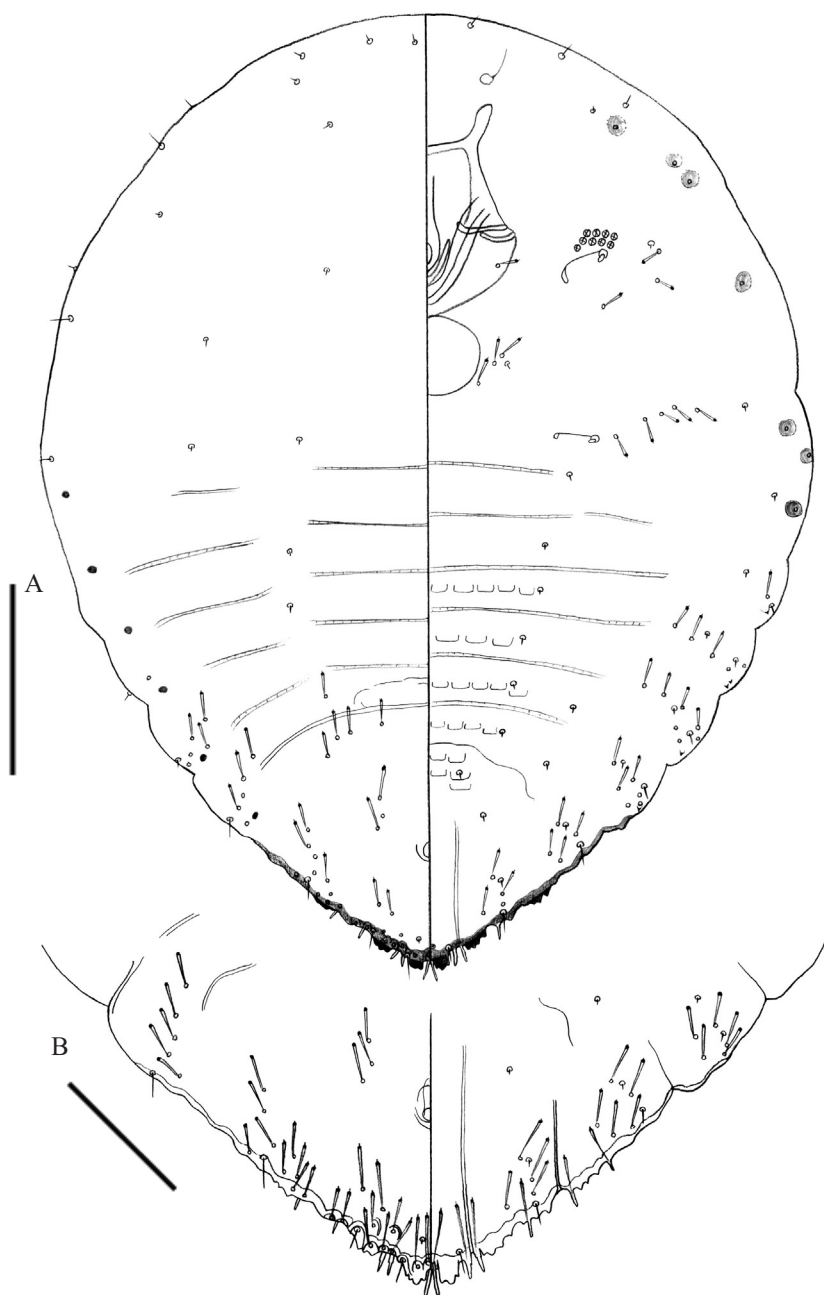


Fig. 9. *Odonaspis arcusnotata*, second-instar female. B, pygidial margin. Scale bars: A, 100 μ m; B, 50 μ m.

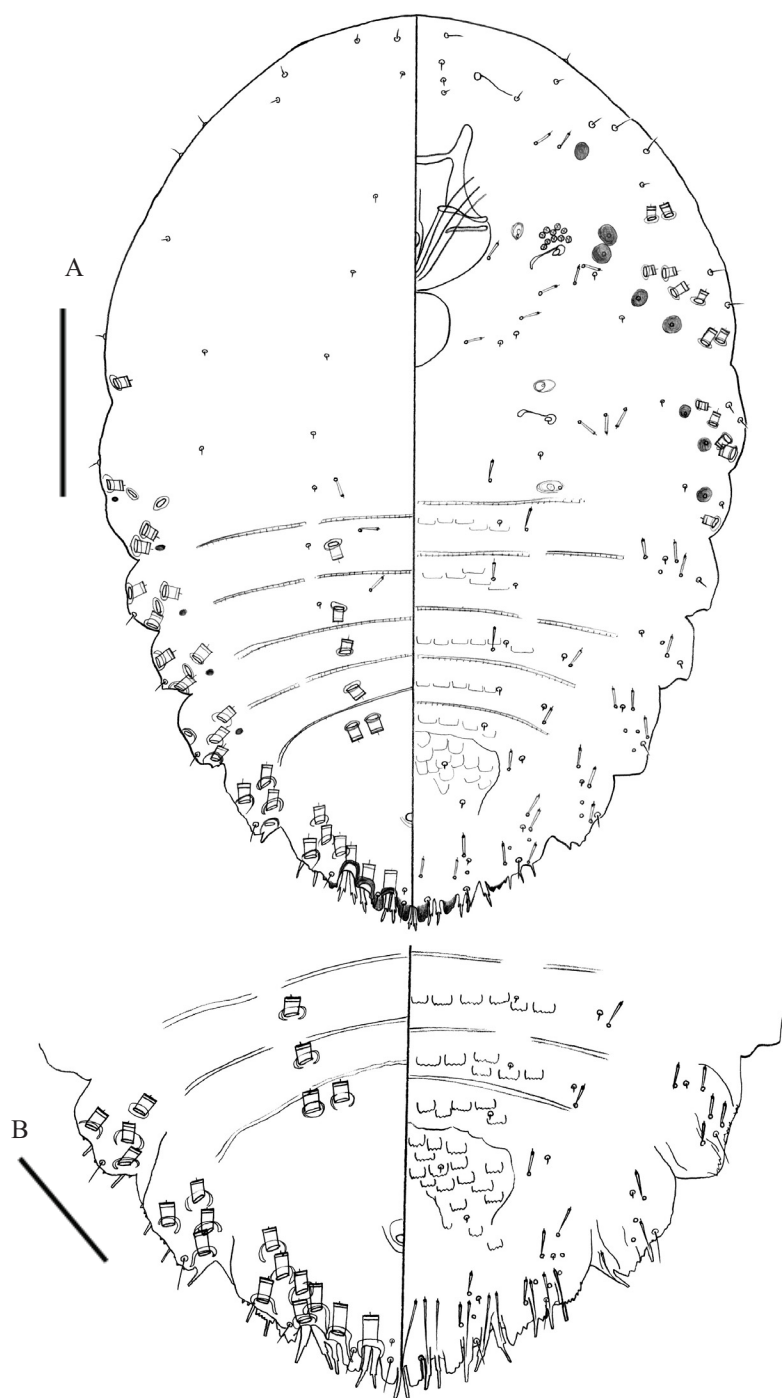


Fig. 10. *Odonaspis arcusnotata*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

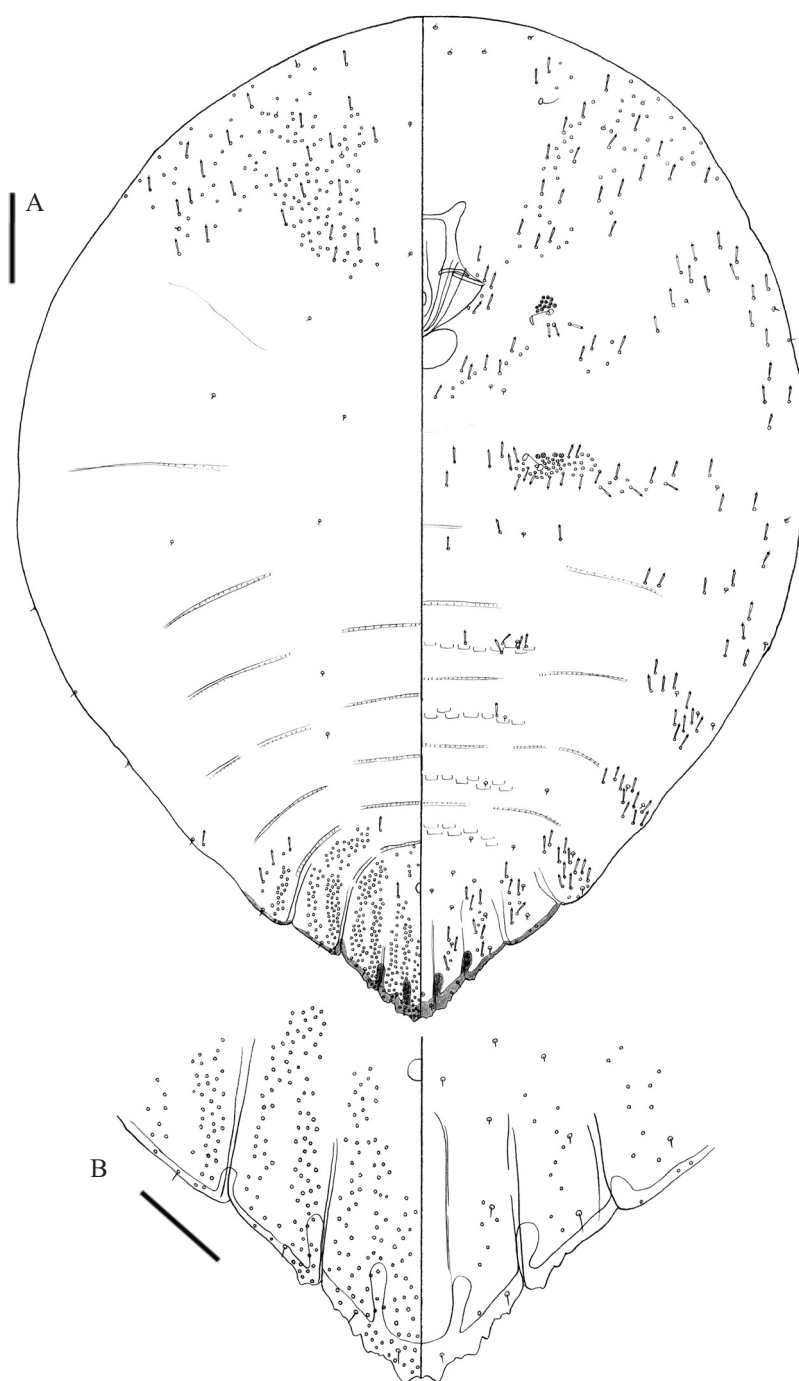


Fig. 11. *Odonaspis bambusarum*, second-instar female. B, pygidial margin. Scale bars: A, 100 μ m; B, 50 μ m.

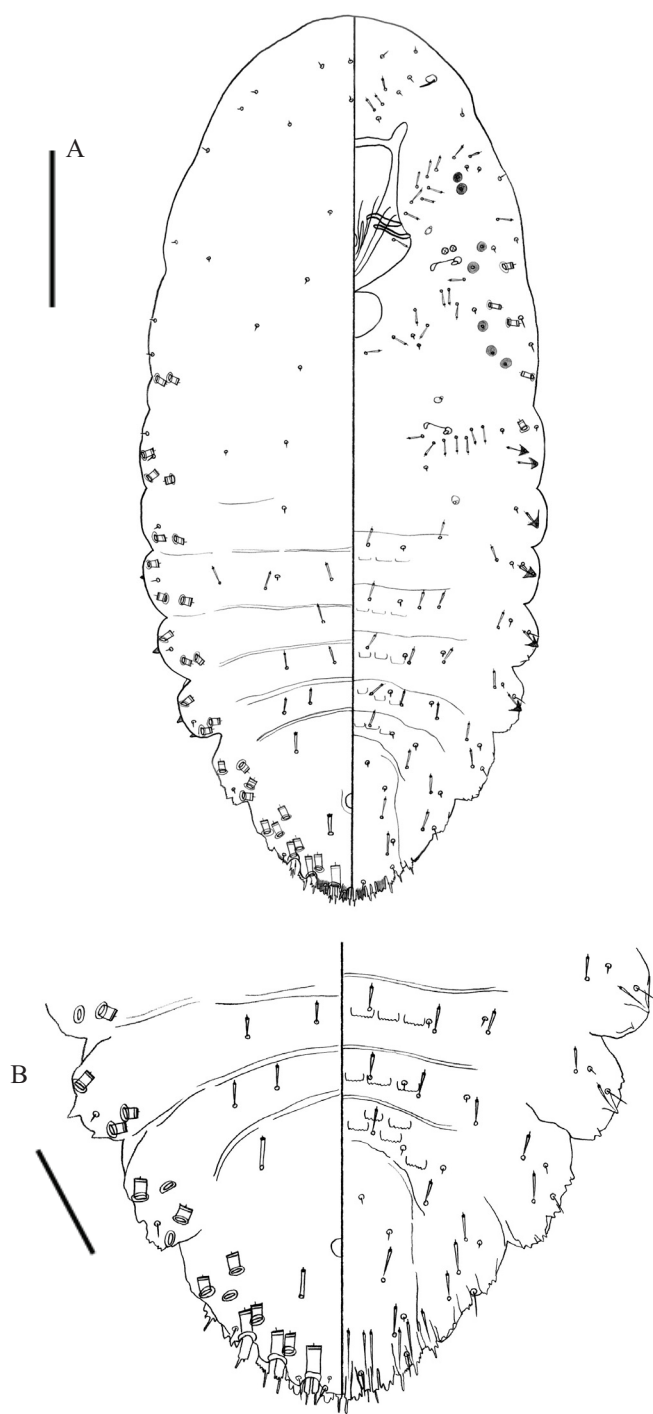


Fig. 12. *Odonaspis bambusarum*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

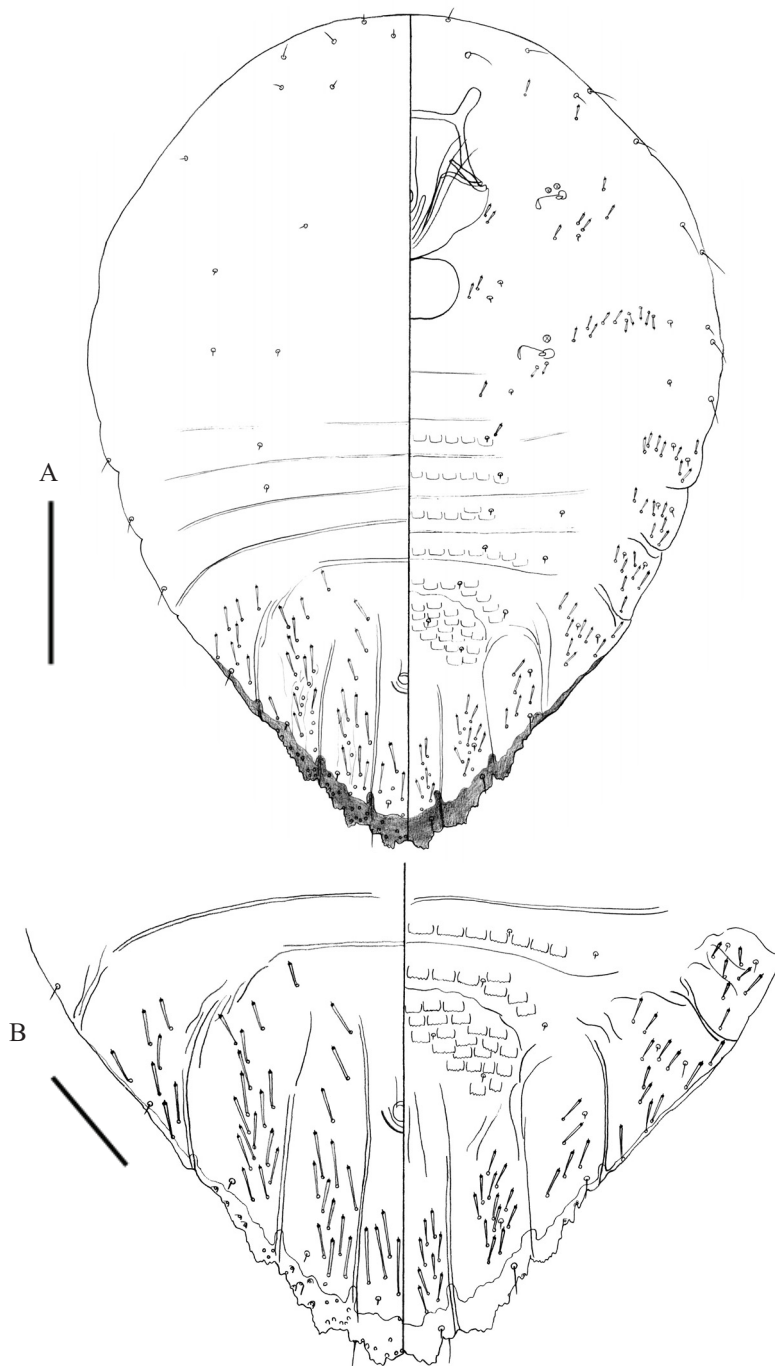


Fig. 13. *Odonaspis batarazaensis*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

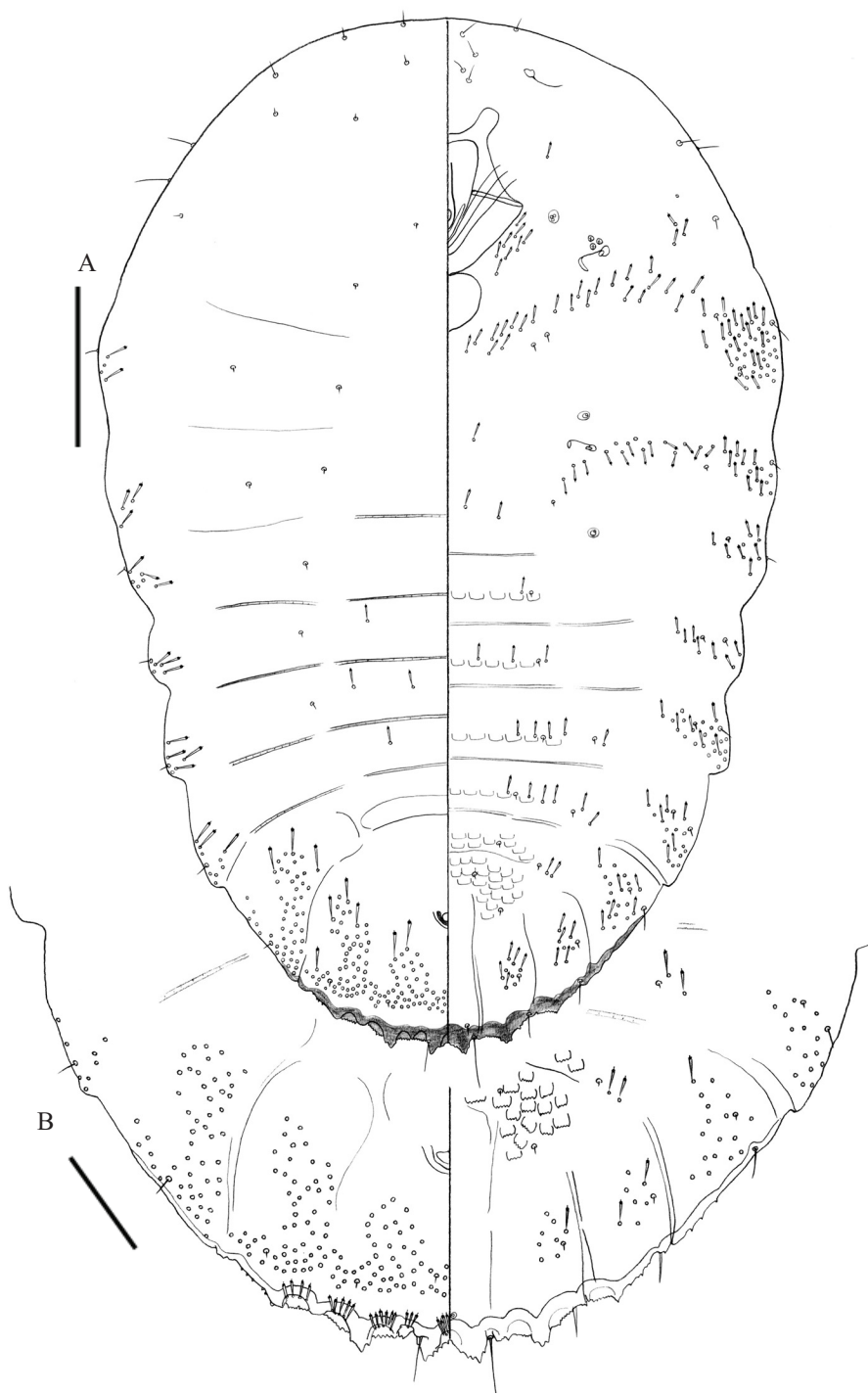


Fig. 14. *Odonaspis batarazaensis*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

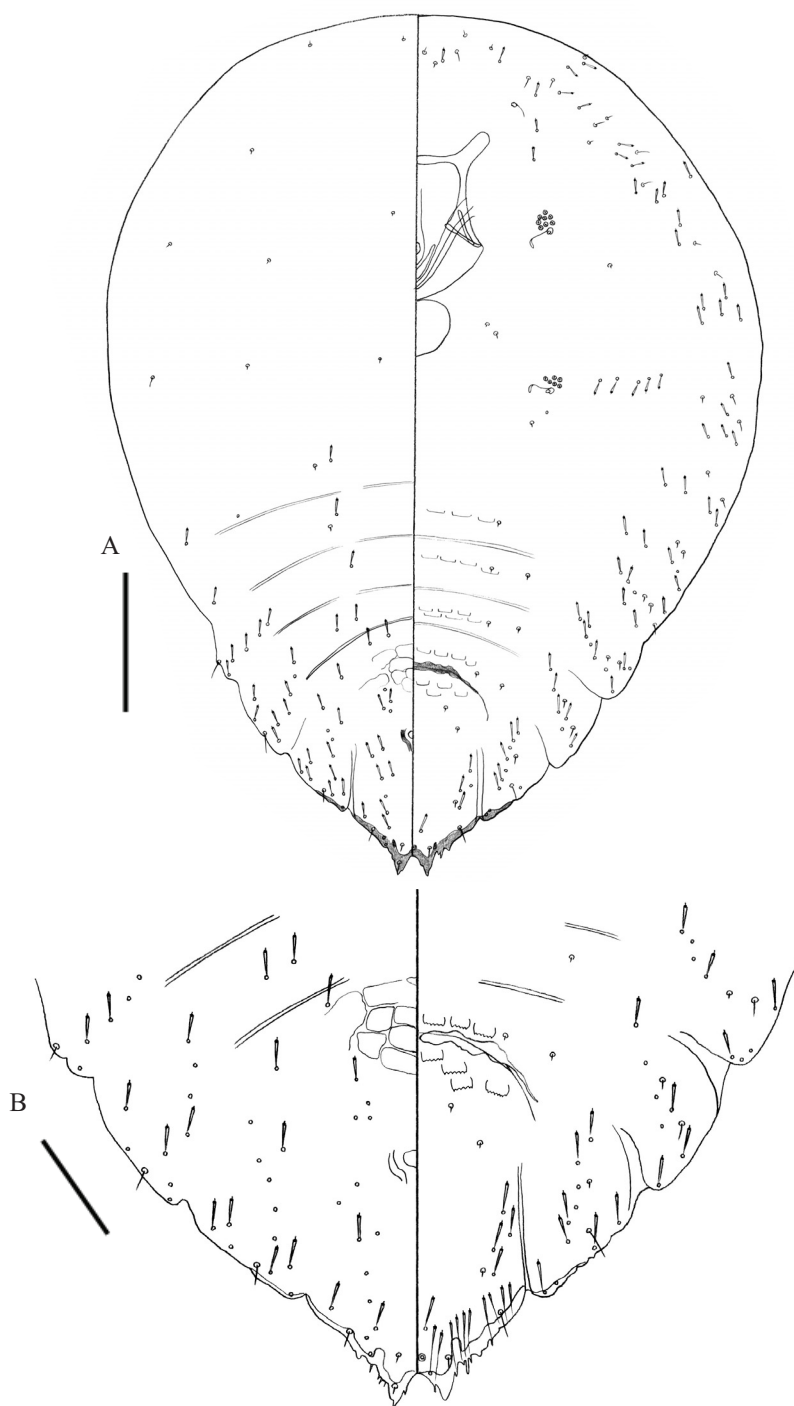


Fig. 15. *Odonaspis densipora*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

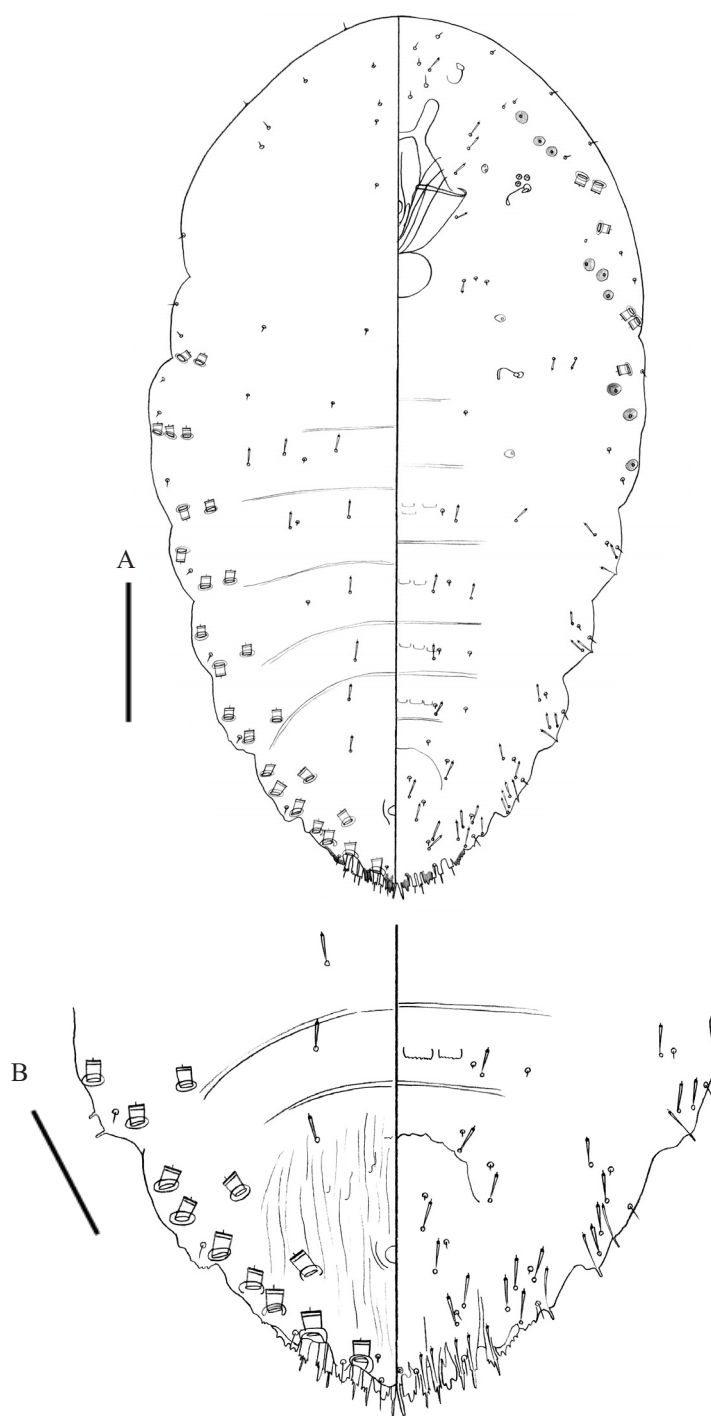


Fig. 16. *Odonaspis densipora*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

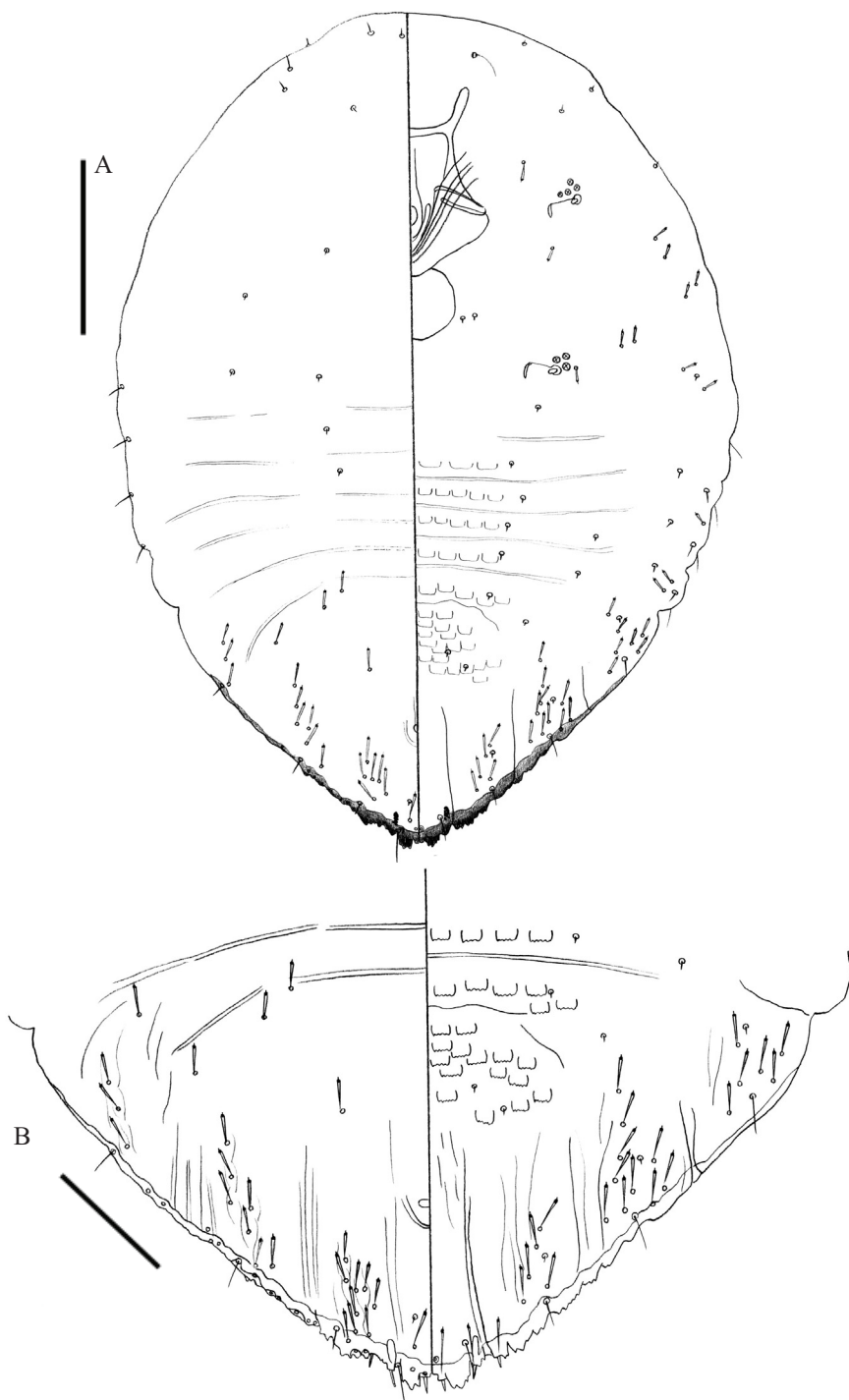


Fig. 17. *Odonaspis greeni*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

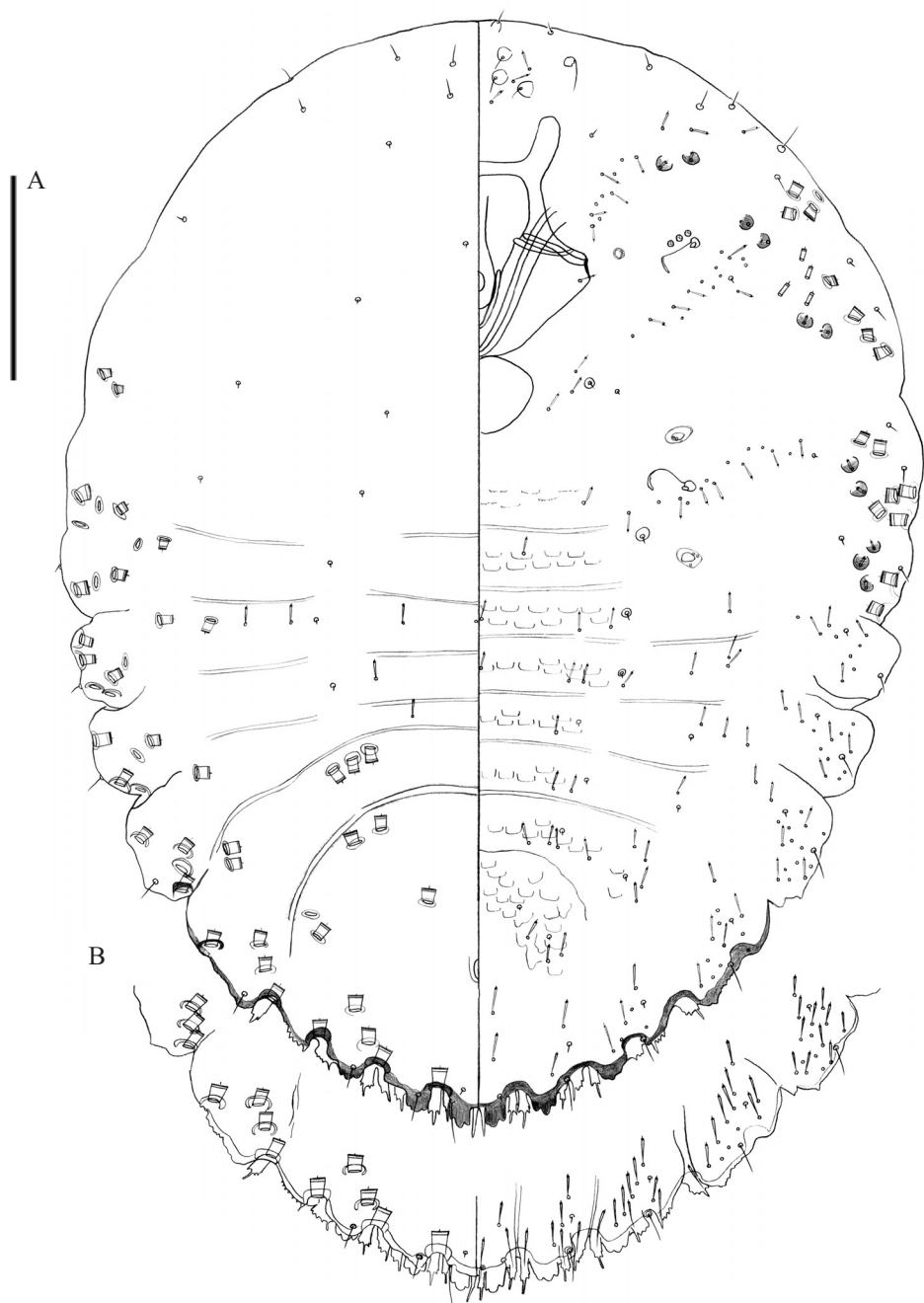


Fig. 18. *Odonaspis greeni*, second-instar male. B, pygidial margin. Scale bar: 100 μ m.

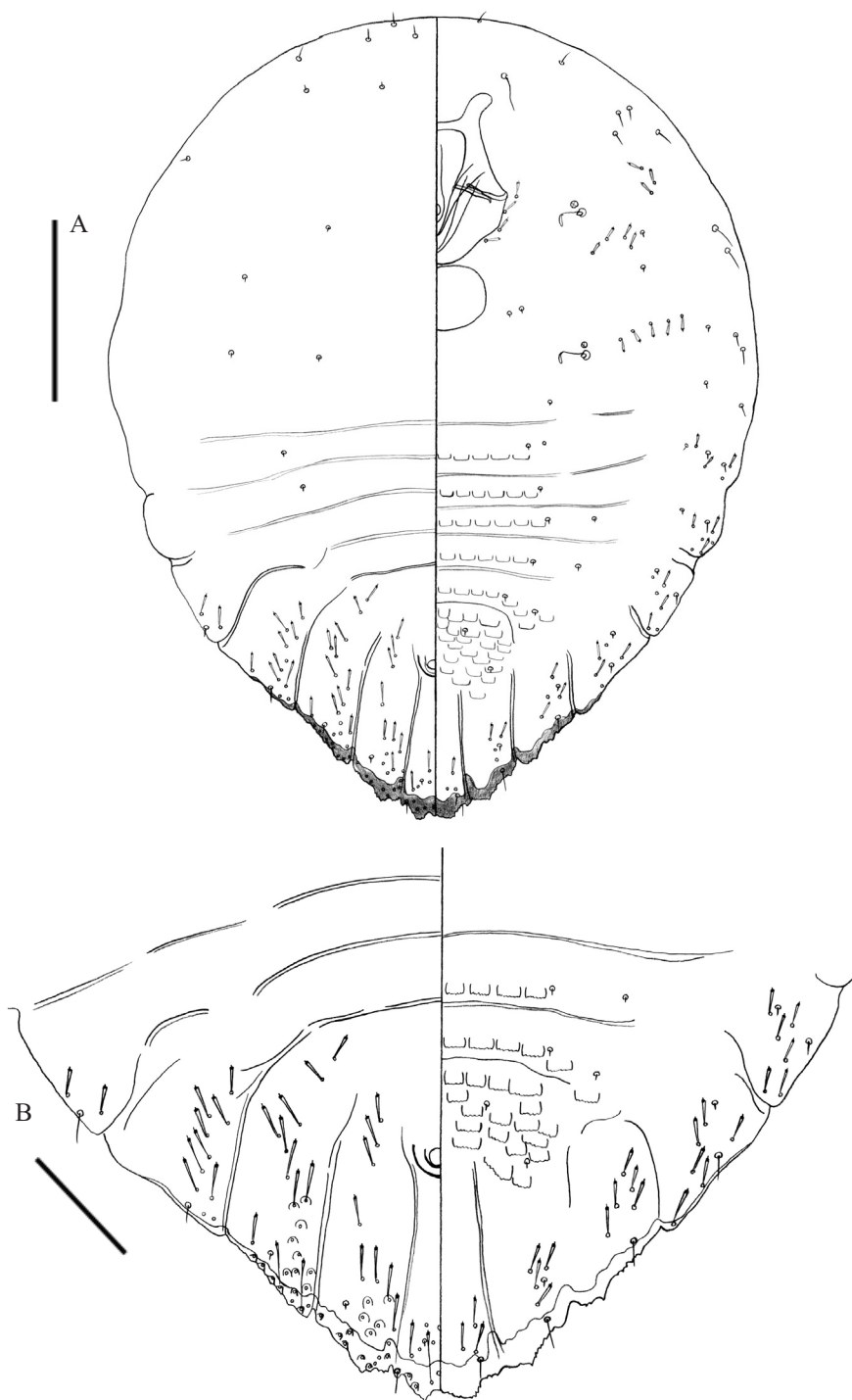


Fig. 19. *Odonaspis maasinensis*, second-instar female. B, pygidium. Scale bars: A, 100µm; B, 50µm.

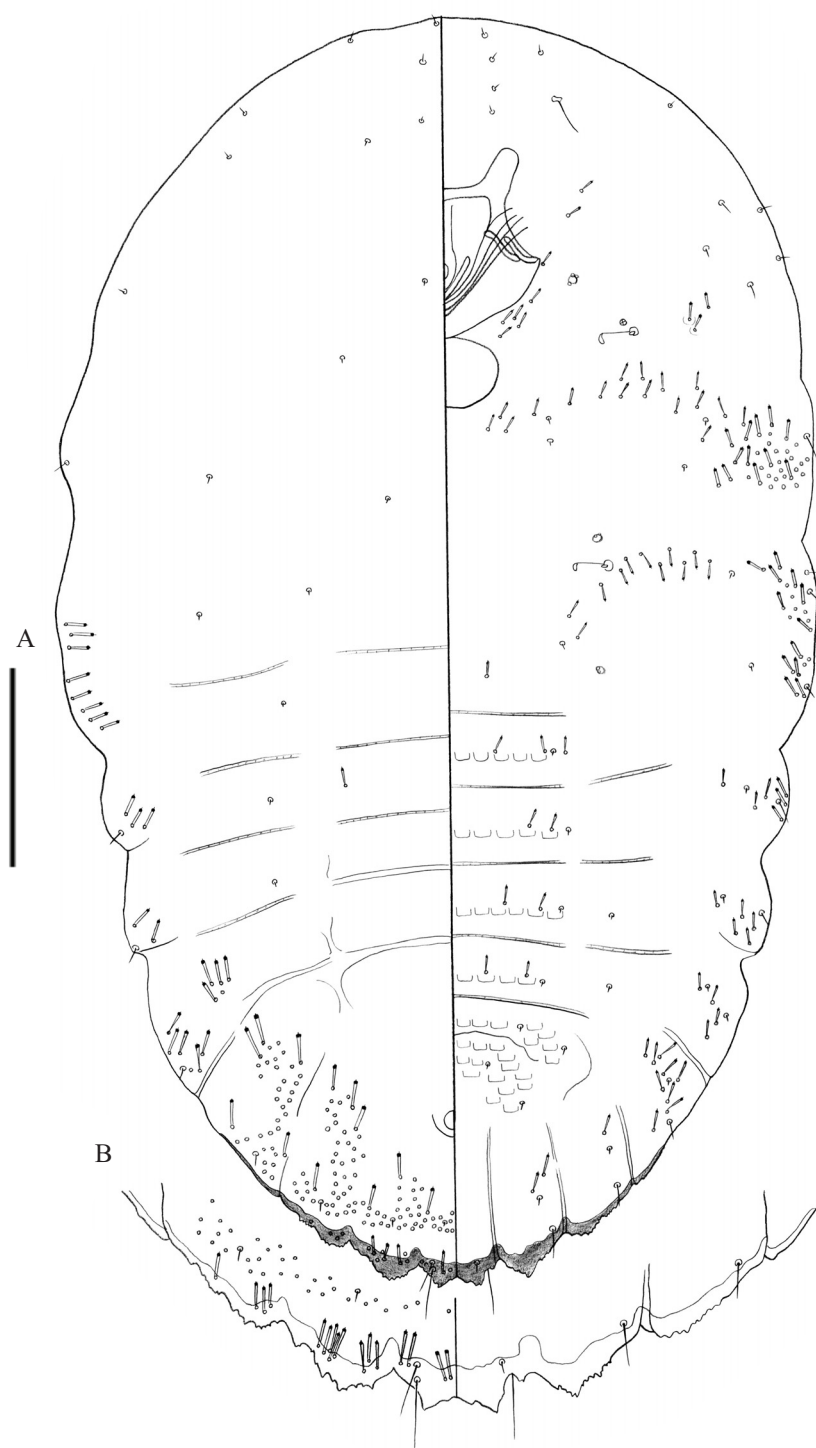


Fig. 20. *Odonaspis maasinensis*, second-instar male. B, pygidial margin. Scale bar: A, 100μm.

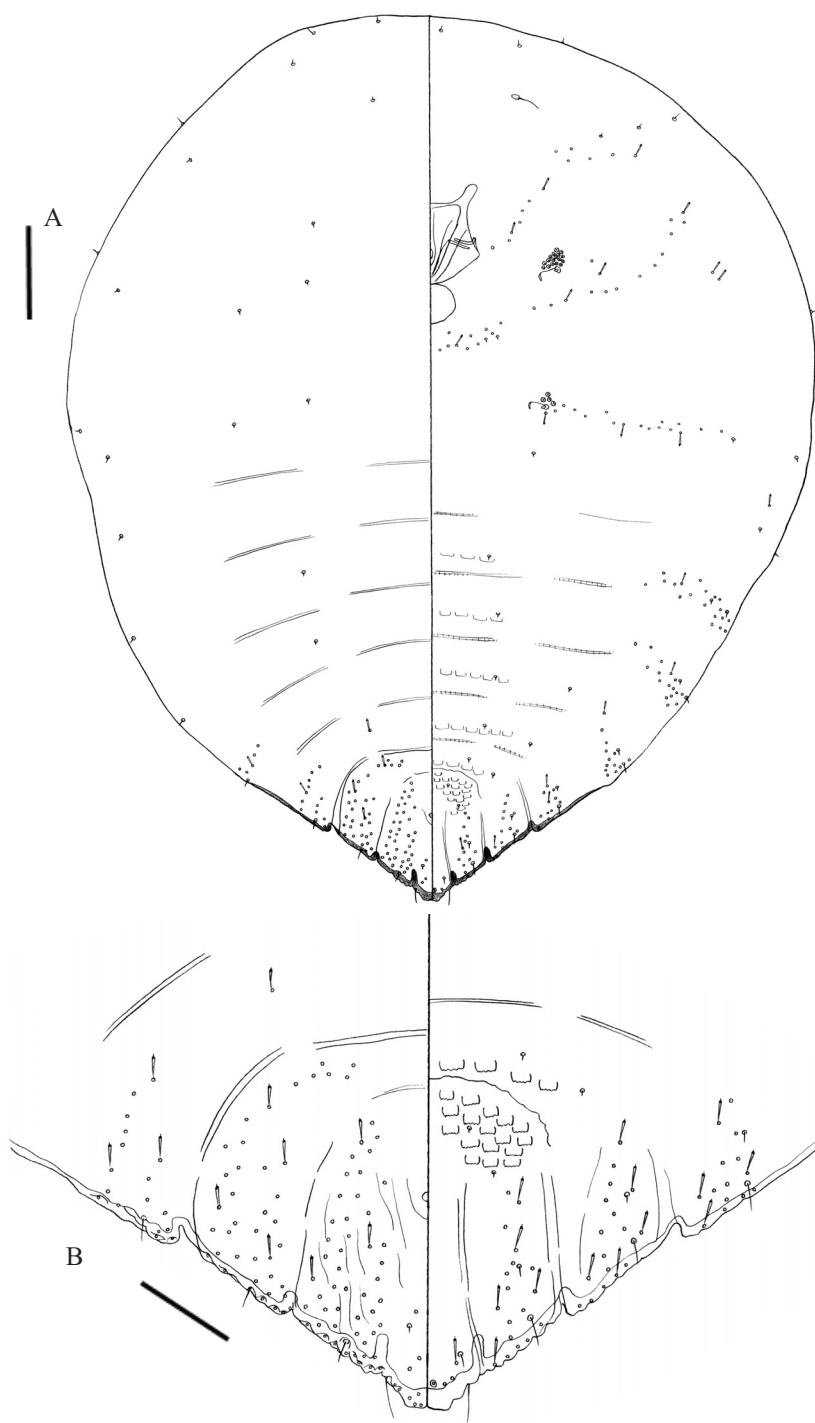


Fig. 21. *Odonaspis miyakoensis*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

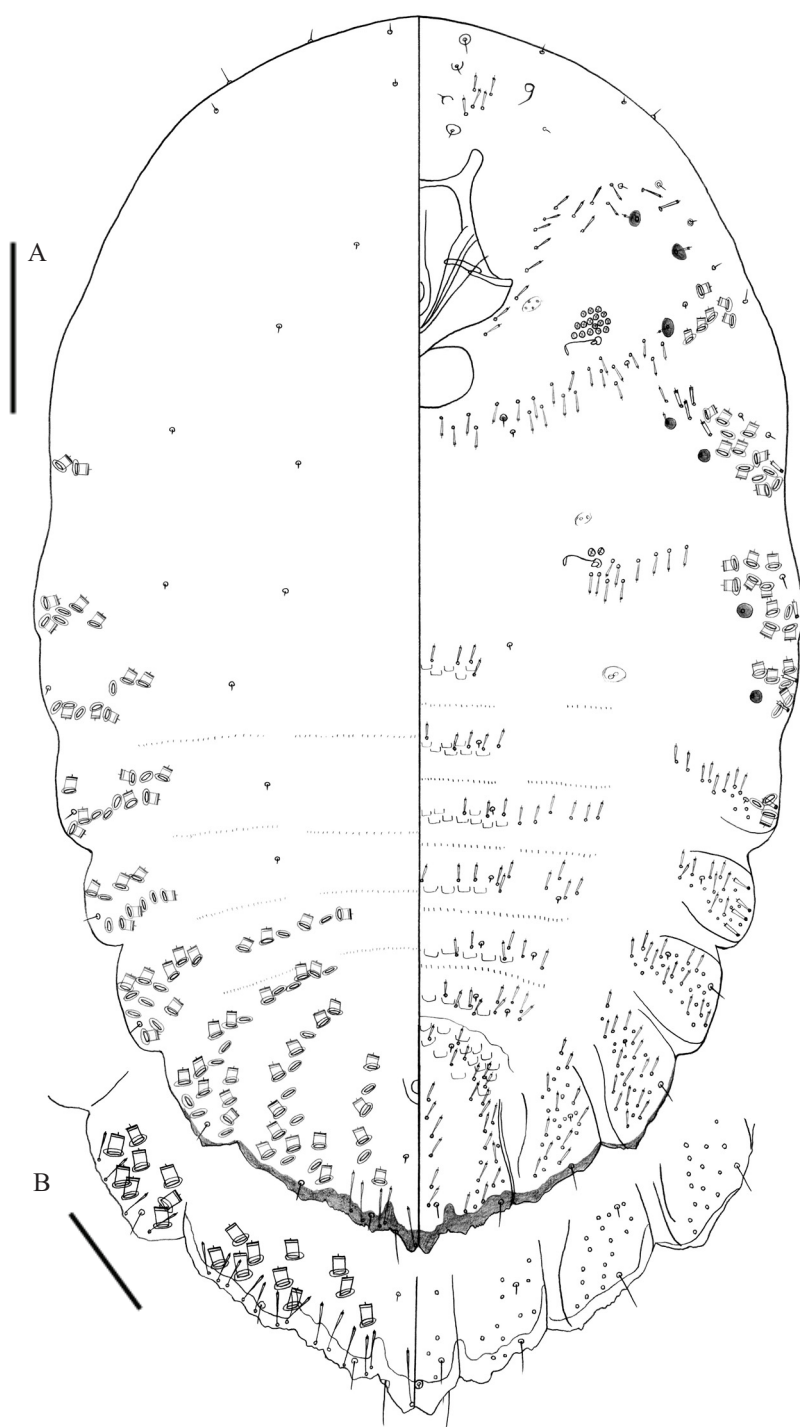


Fig. 22. *Odonaspis miyakoensis*, second-instar male. B, pygidial margin. Scale bars: A, 100µm; B, 50µm.

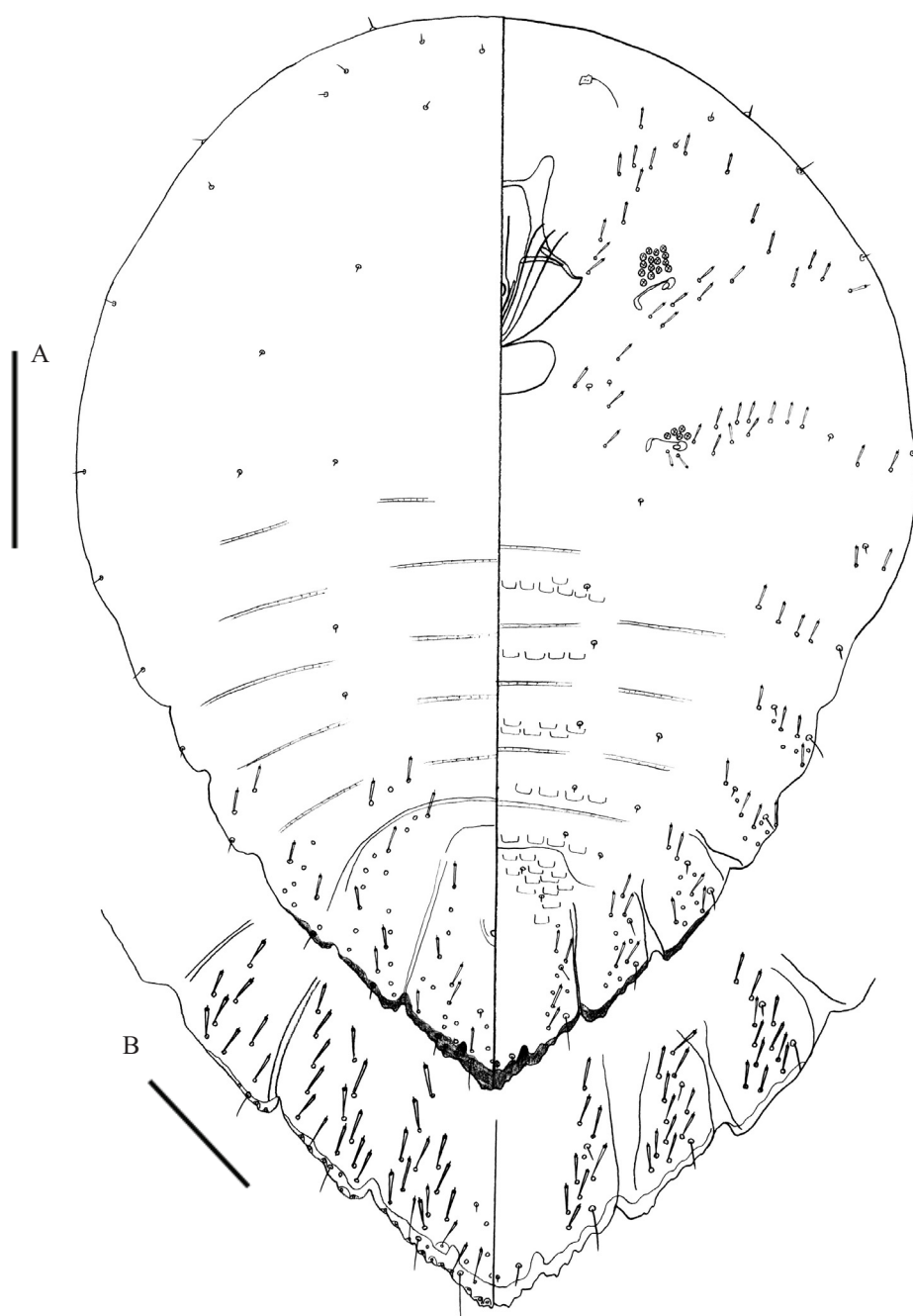


Fig. 23. *Odonaspis morrisoni*, second-instar female. B, pygidial margin. Scale bars: A, 100 μ m; B, 50 μ m.

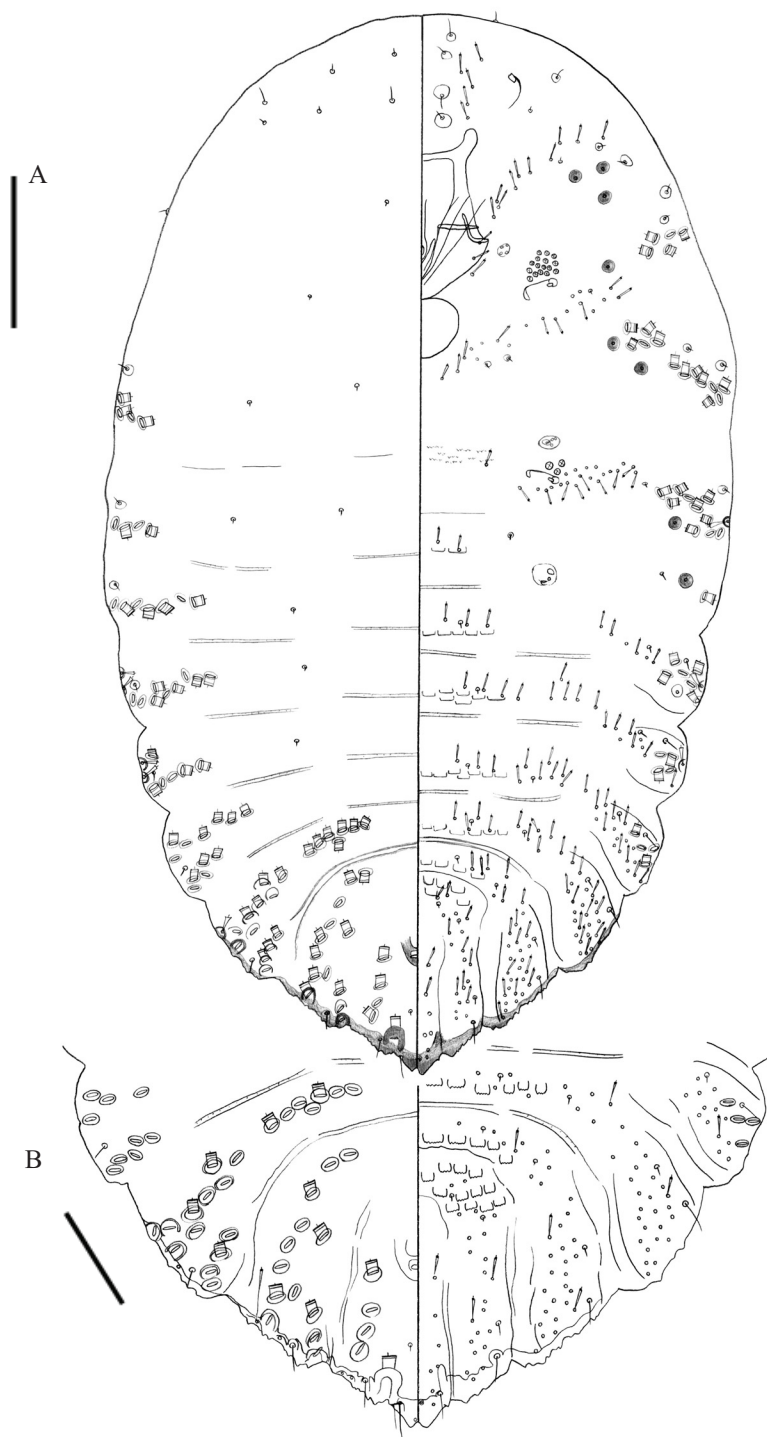


Fig. 24. *Odonaspis morrisoni*, second-instar male. B, pygidium. Scale bars: A, 100µm; B, 50µm.

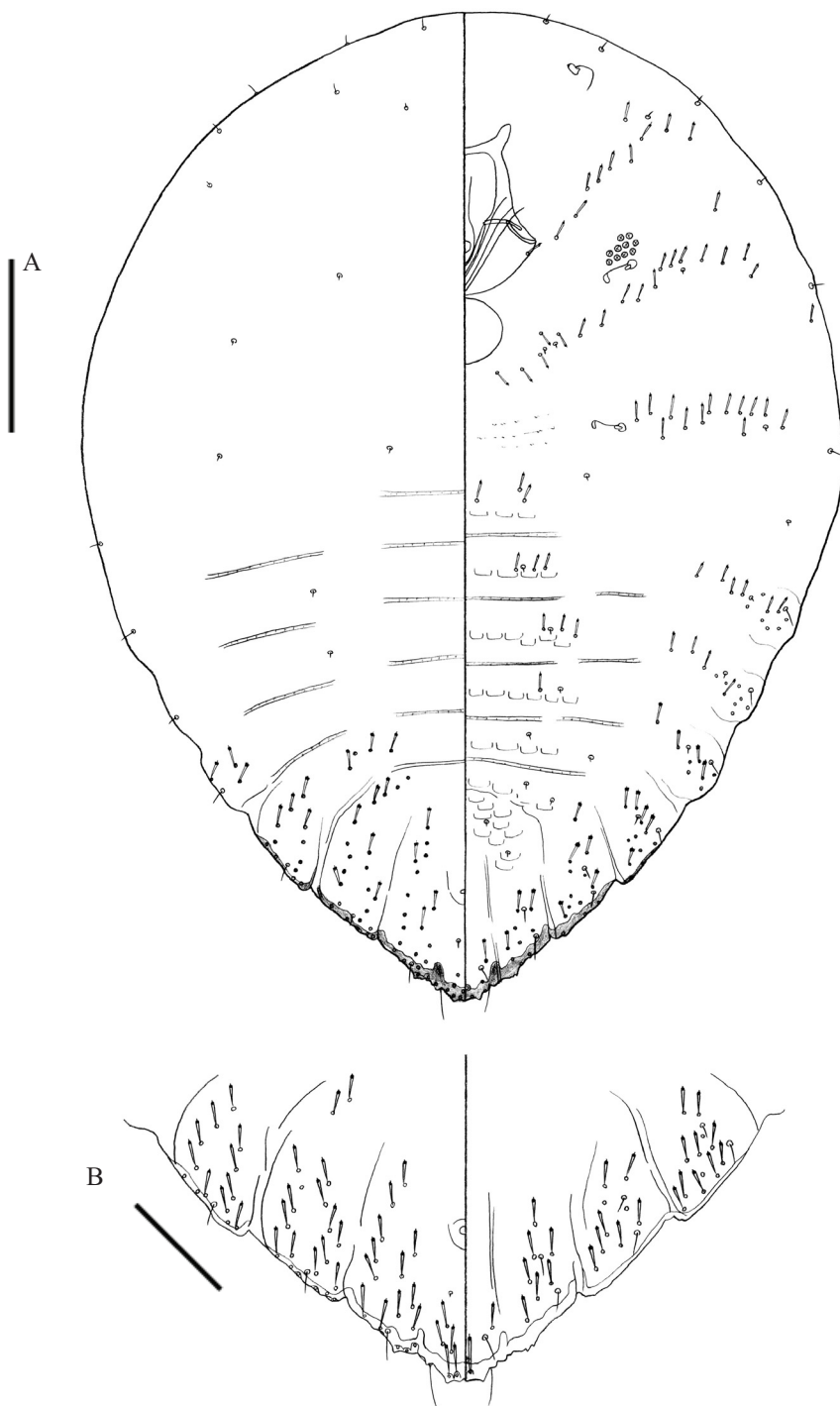


Fig. 25. *Odonaspis oshimaensis*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

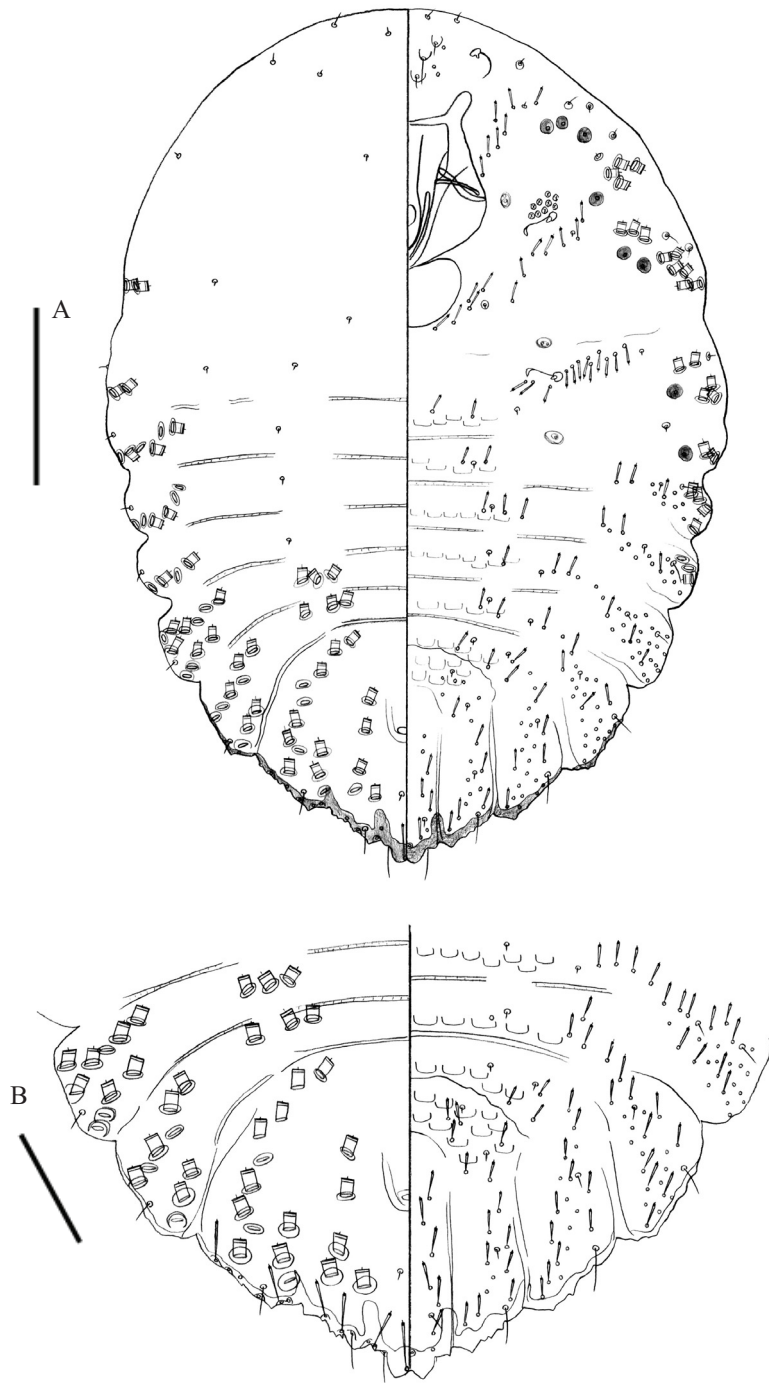


Fig. 26. *Odonaspis oshimaensis*, second-instar male. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

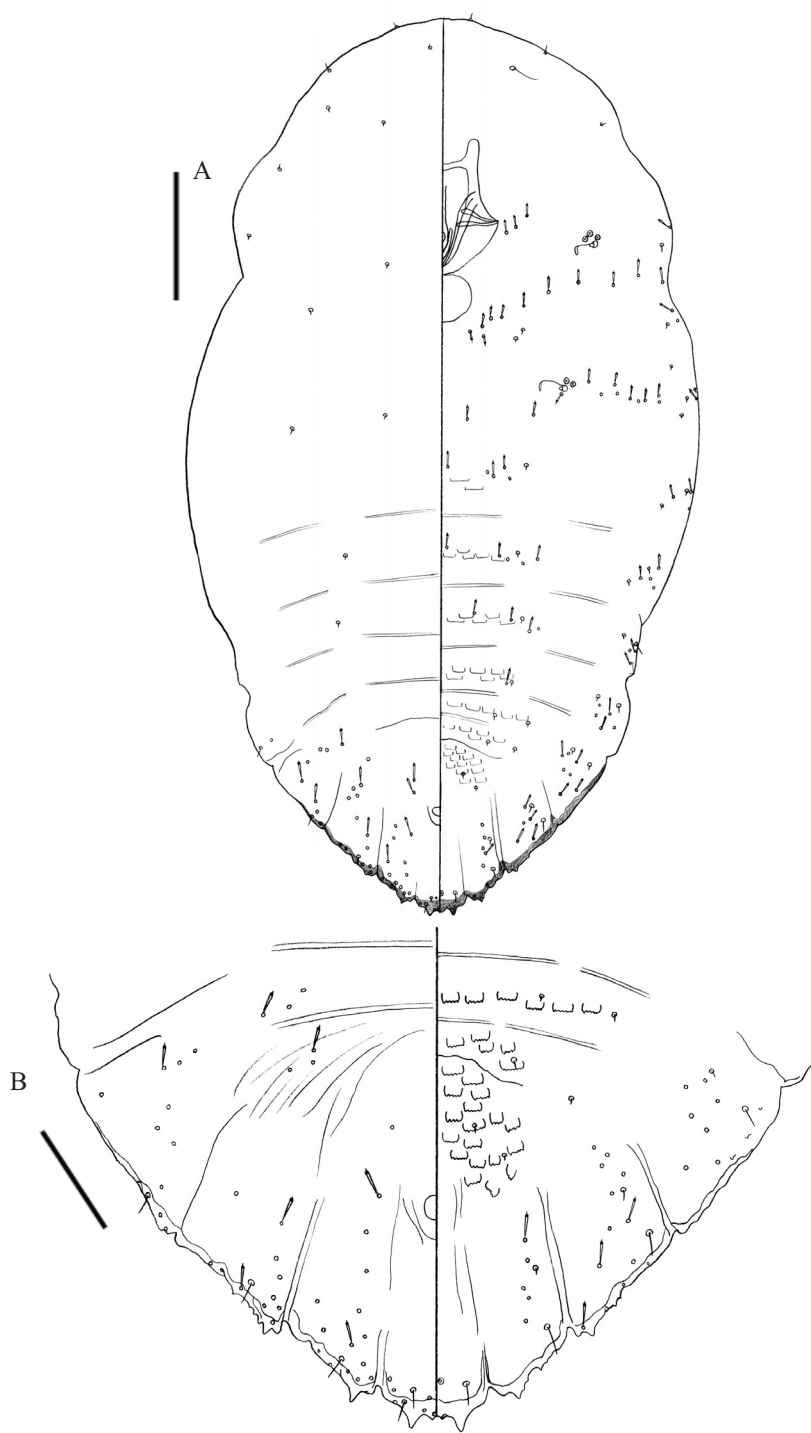


Fig. 27. *Odonaspis procera*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

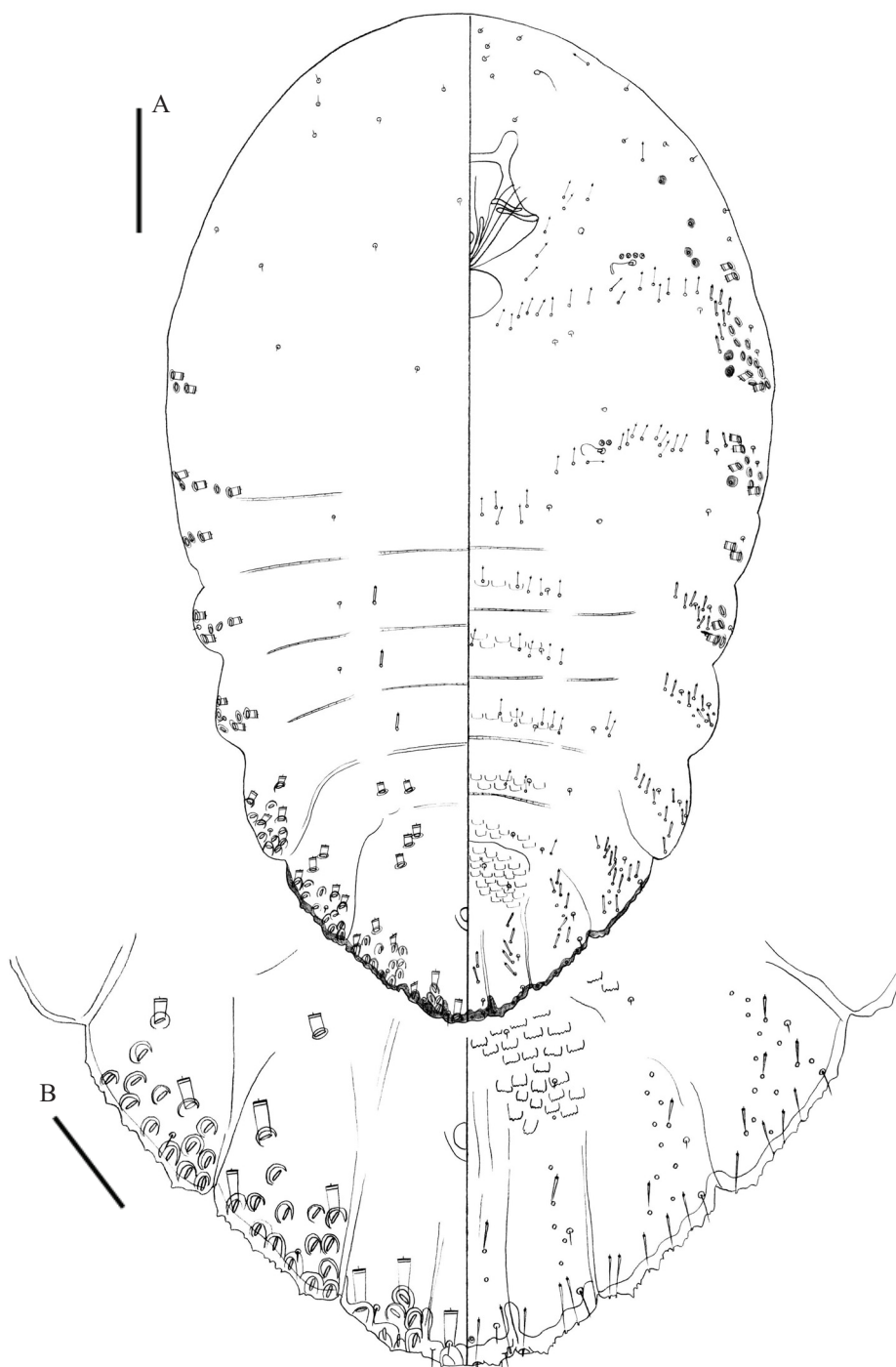


Fig. 28. *Odonaspis procera*, second-instar male. B, pygidium. Scale bars: A, 100μm; B, 50μm.

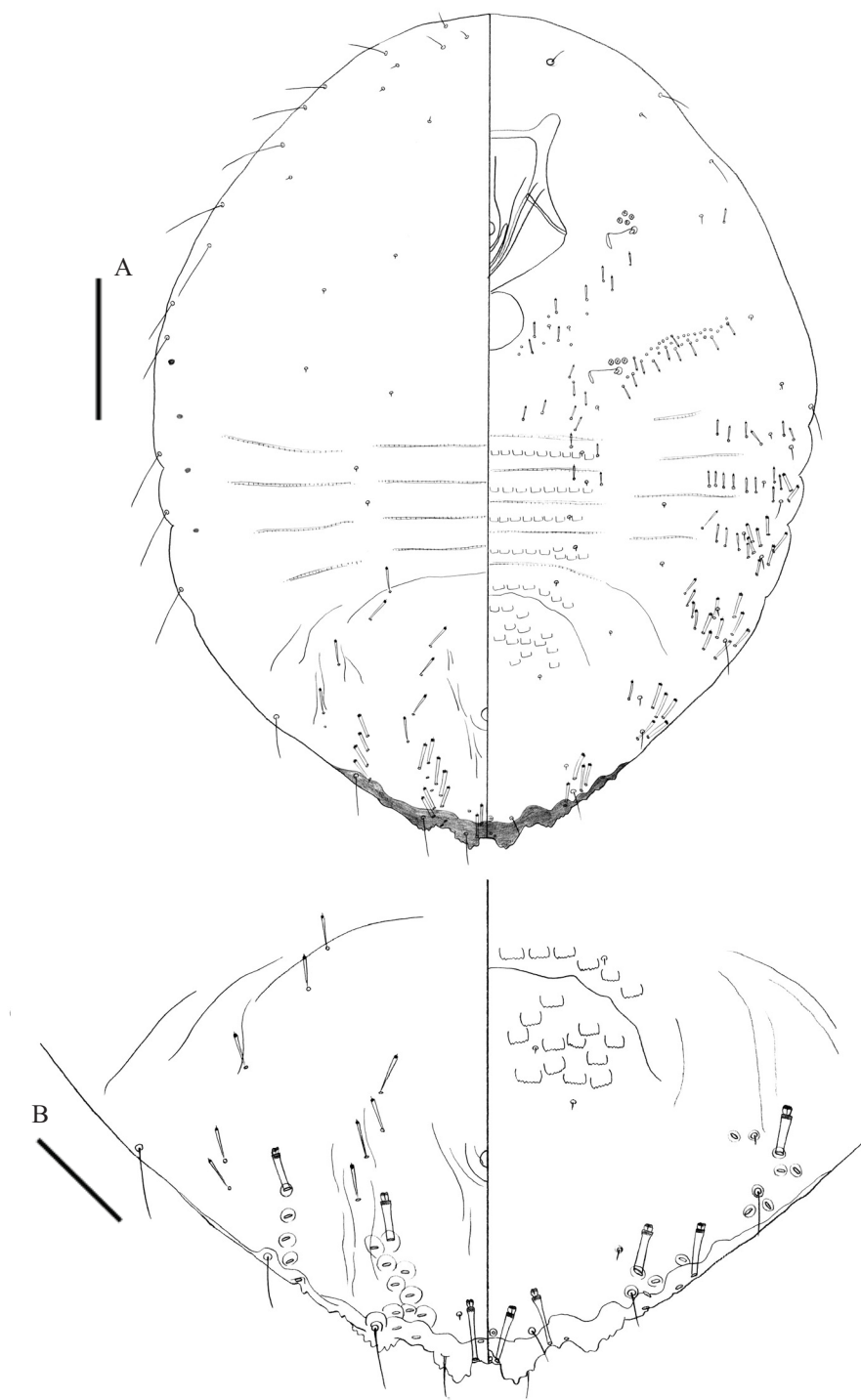


Fig. 29. *Odonaspis schizostachyi*, second-instar female (specimen from Malaysia). B, pygidium.
Scale bars: A, 100 μ m; B, 50 μ m.

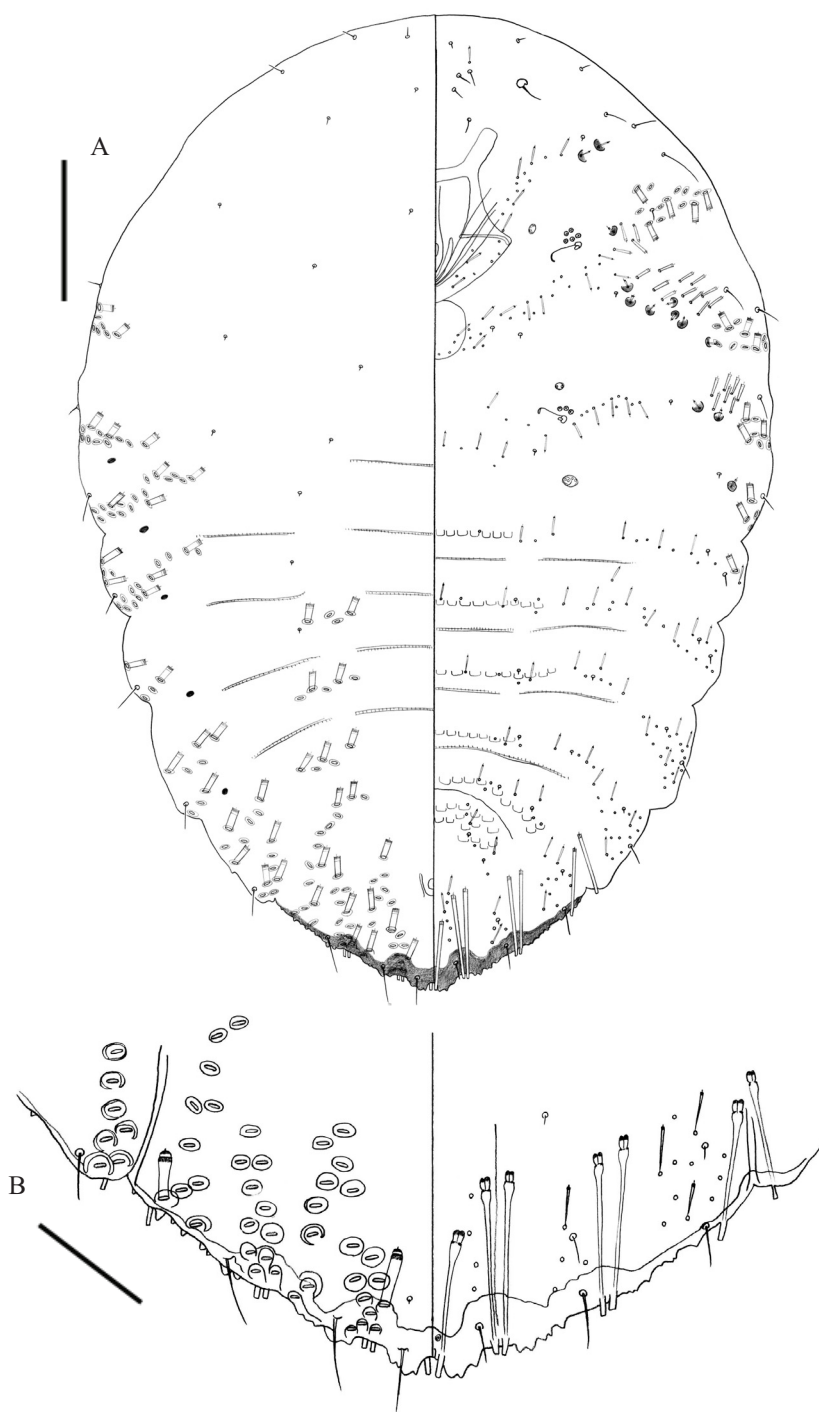


Fig. 30. *Odonaspis schizostachyi*, second-instar male (specimen from Malaysia). B, pygidial margin. Scale bars: A, 100 μ m; B, 50 μ m.

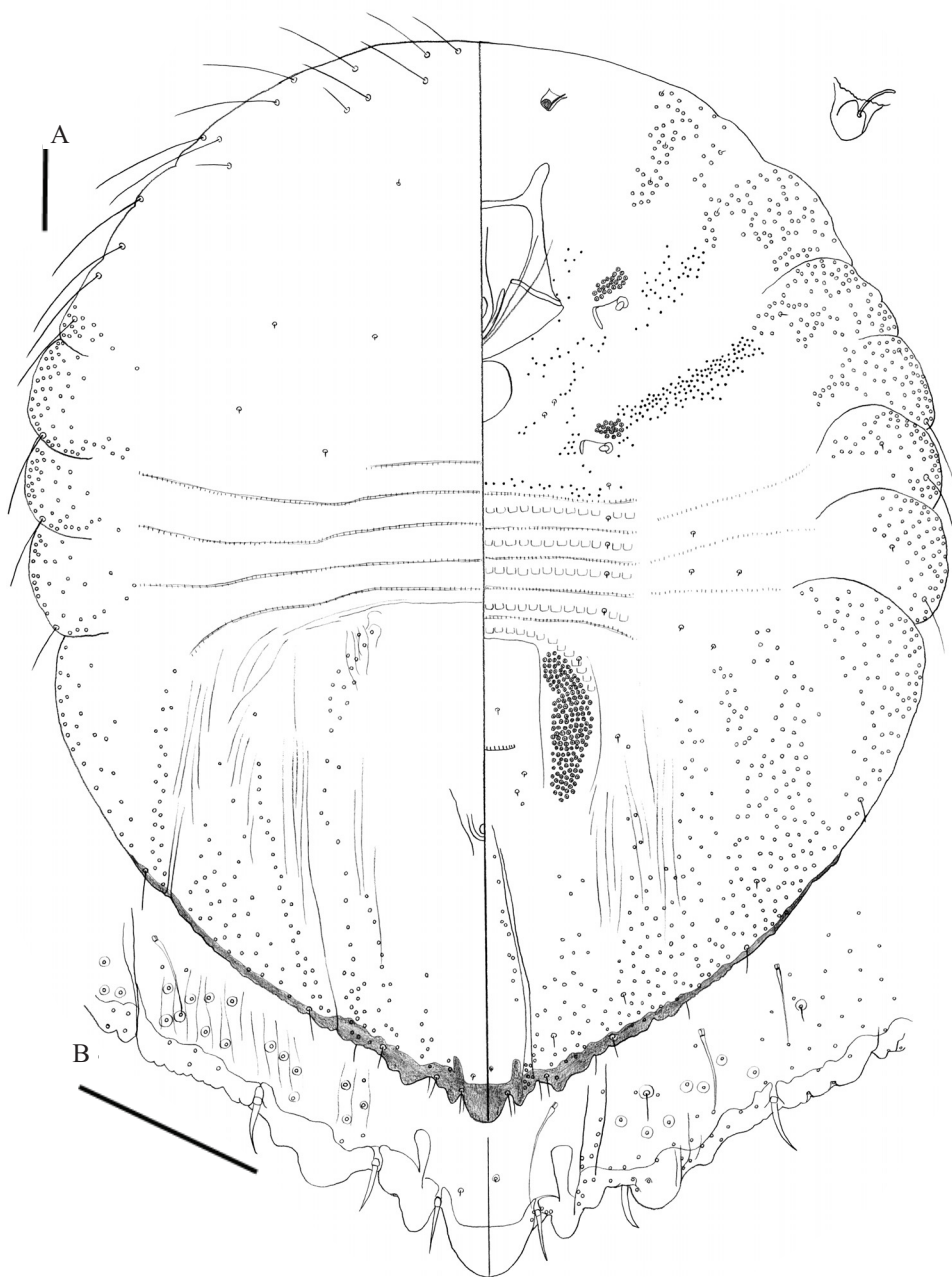


Fig. 31. *Odonaspis schizostachyi*, adult female (specimen from Malaysia). B, pygidial margin. Scale bars: A & B, 100 μ m.



Fig. 32. *Odonaspis schizostachyi*, second-instar female (specimen from the Philippines). B, pygidium. Scale bars: A & B, 100 μ m.

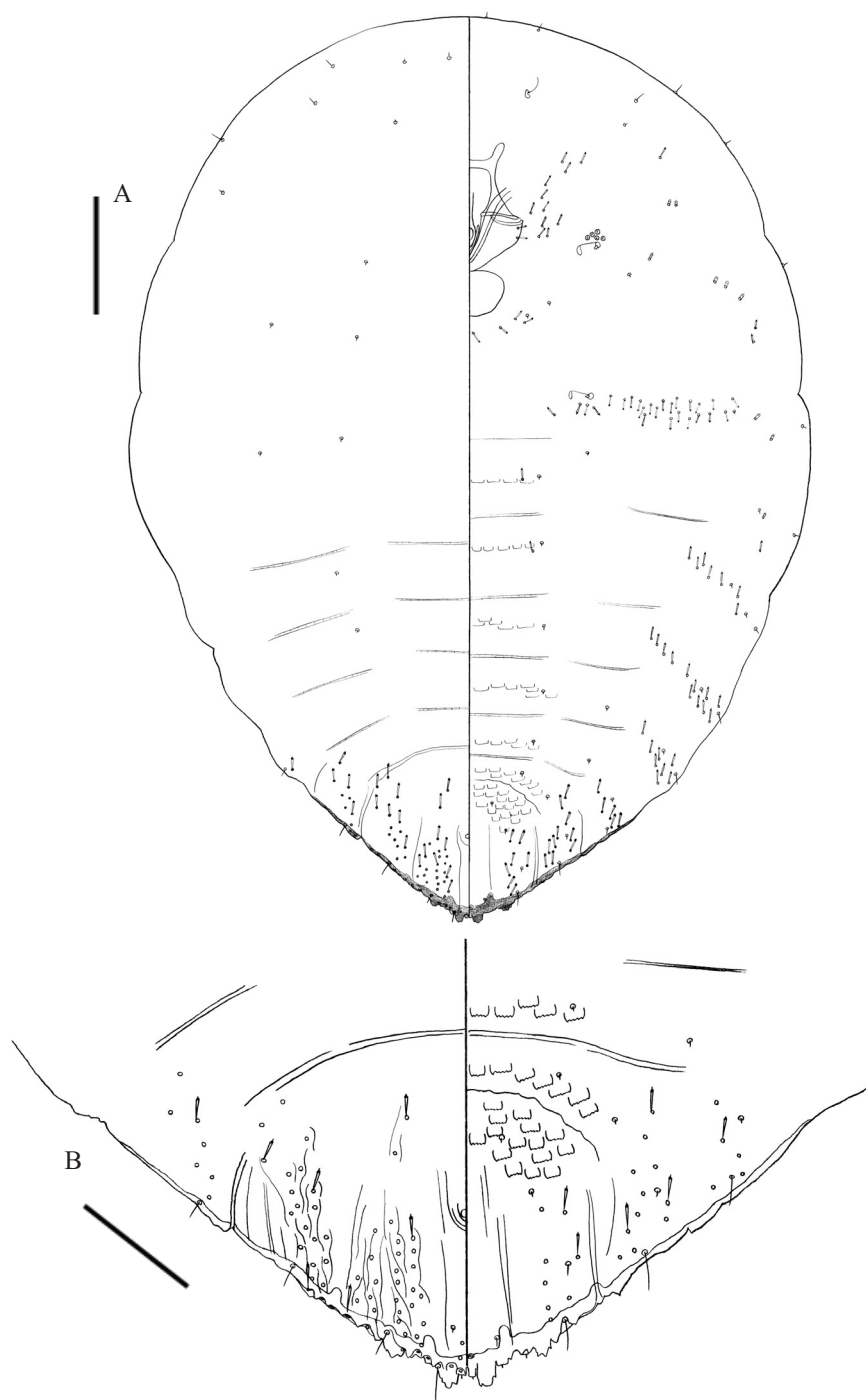


Fig. 33. *Odonaspis secreta*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

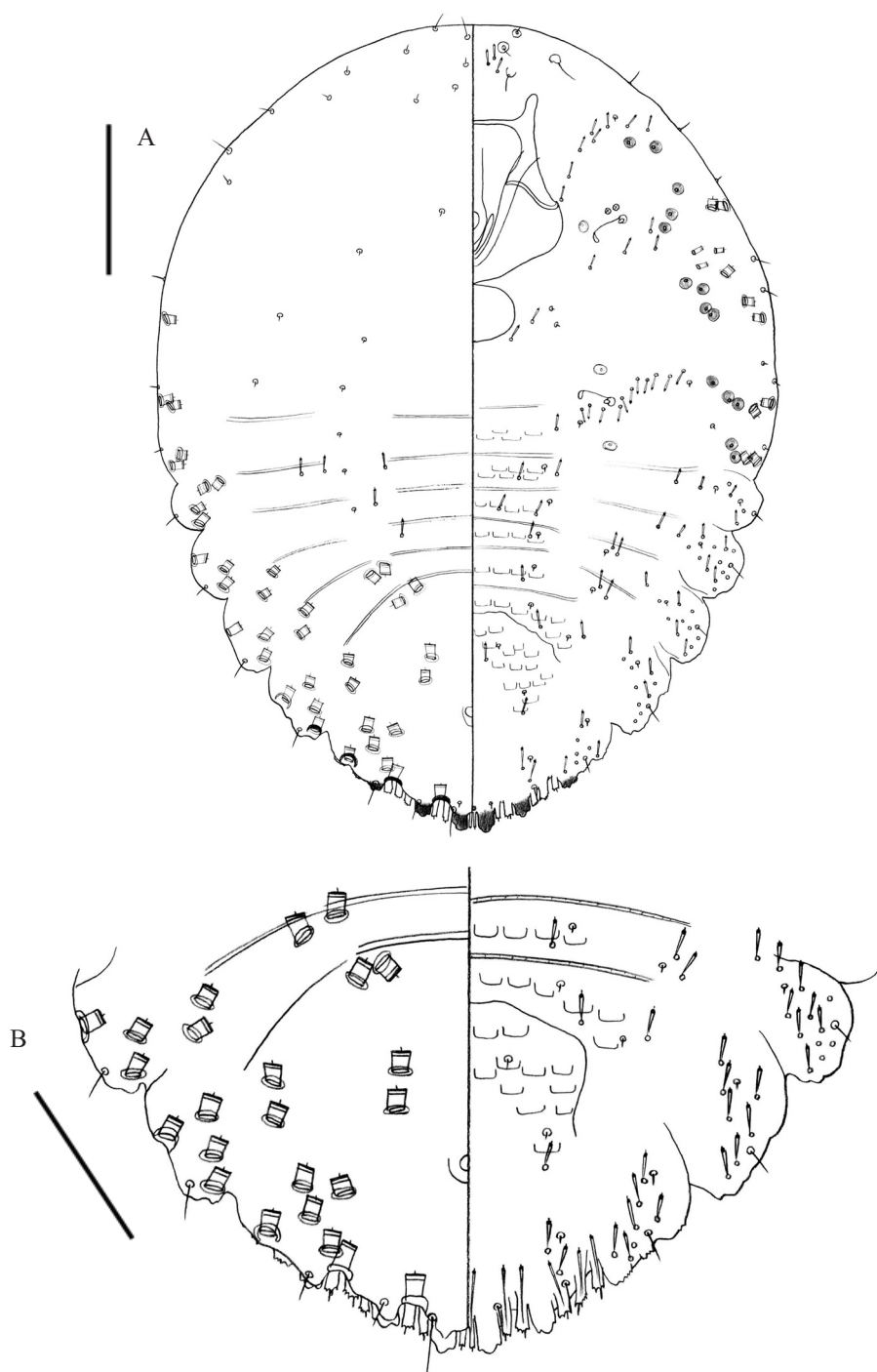


Fig. 34. *Odonaspis secreta*, second-instar male. B, pygidium. Scale bars: A & B, 100 μ m.

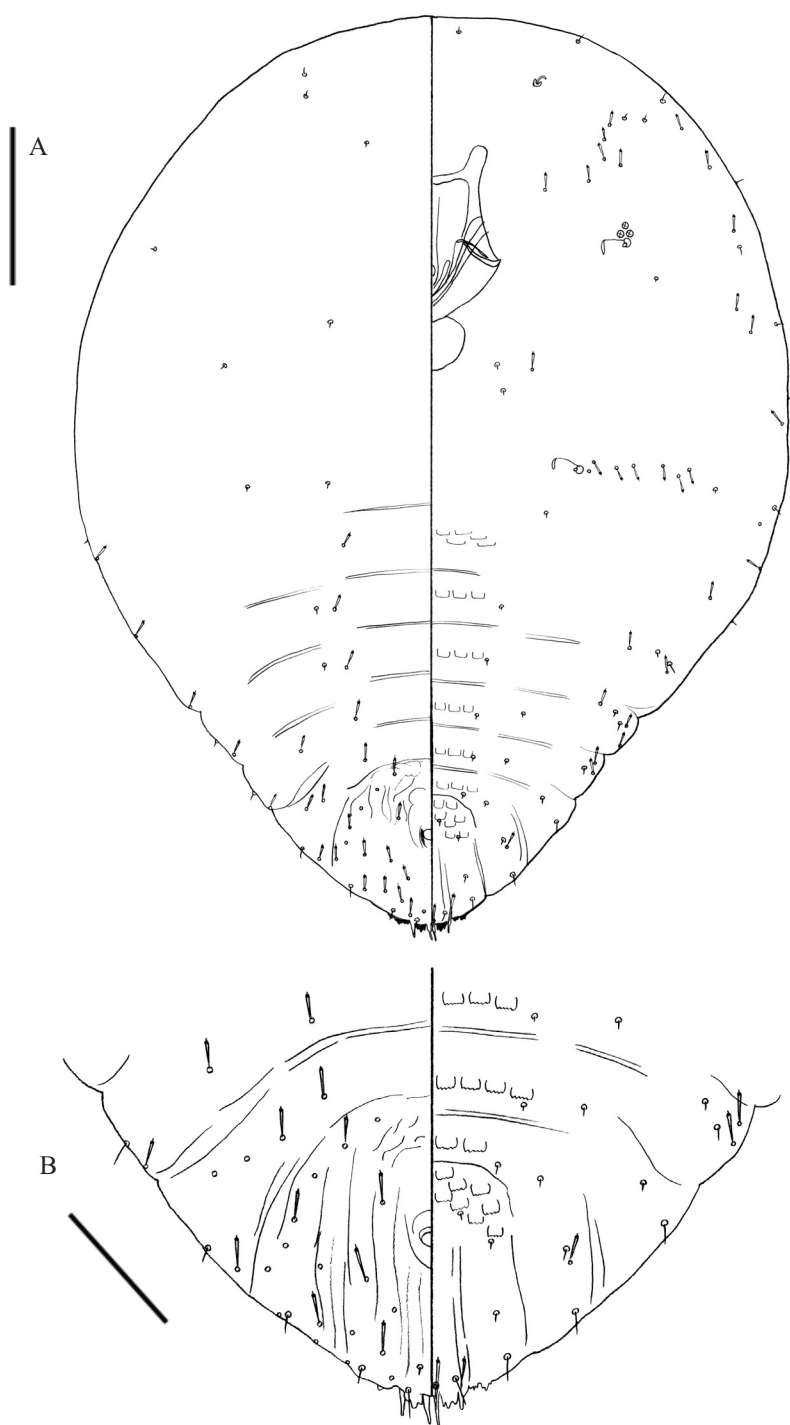


Fig. 35. *Odonaspis sparsa*, second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

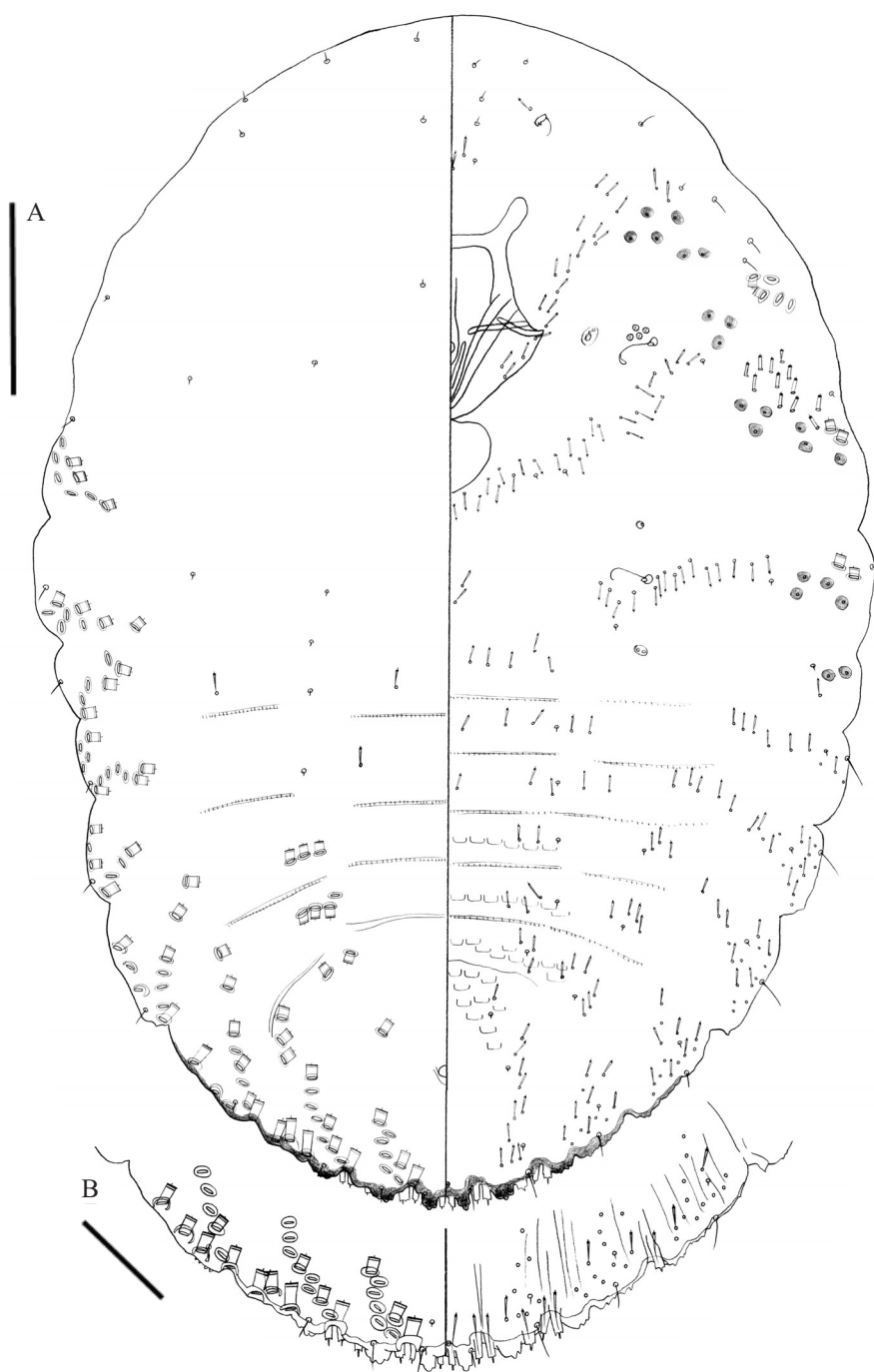


Fig. 36. *Odonaspis sparsa*, second-instar male. B, pygidial margin. Scale bars: A, 100µm; B, 50µm.

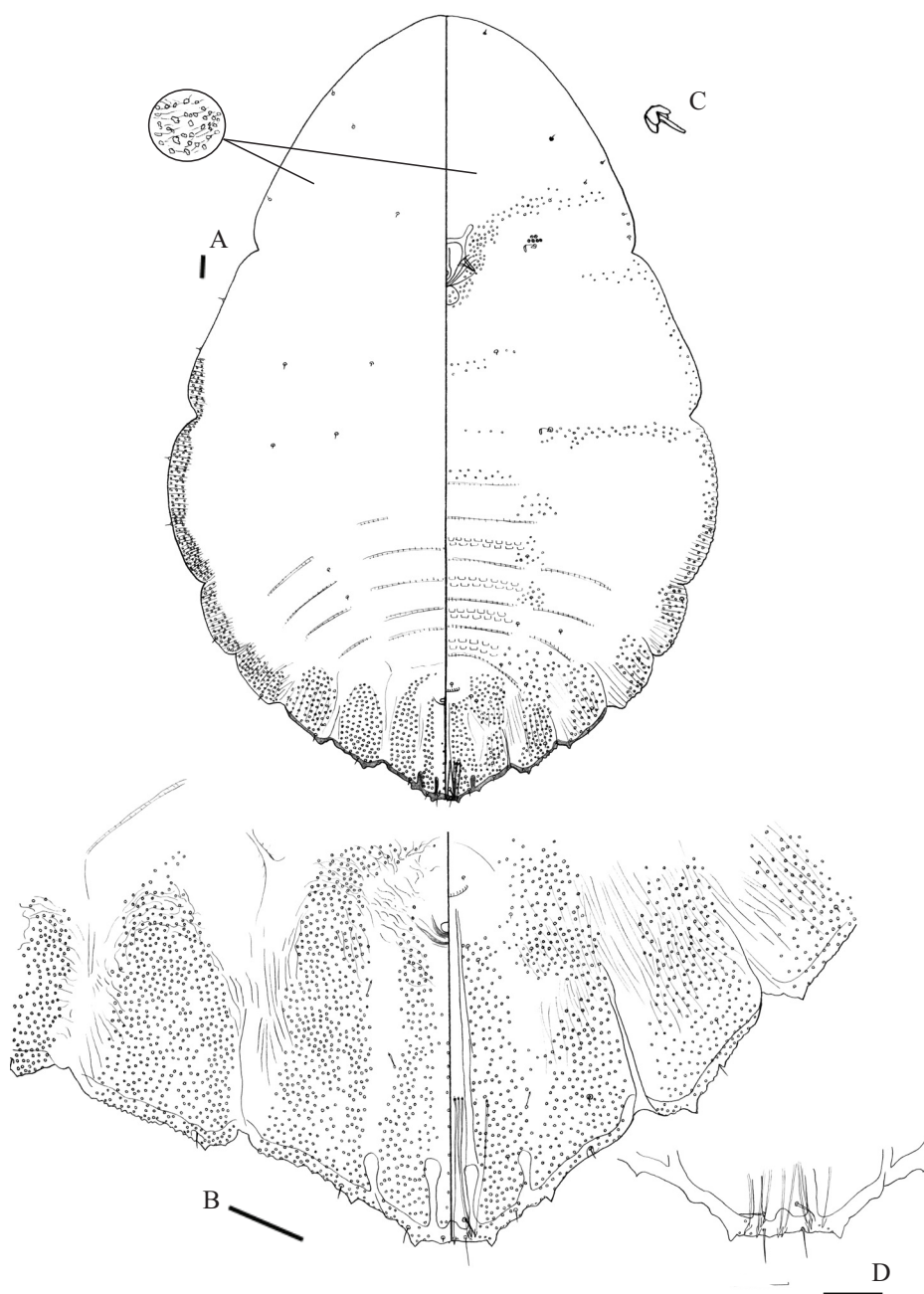


Fig. 37. *Froggattiella gigantochloae*, sp. nov., adult female. B, pygidium; C, antenna; D, apex of pygidium (ventral surface). Scale bars: A & B, 100 μ m; D 50 μ m.

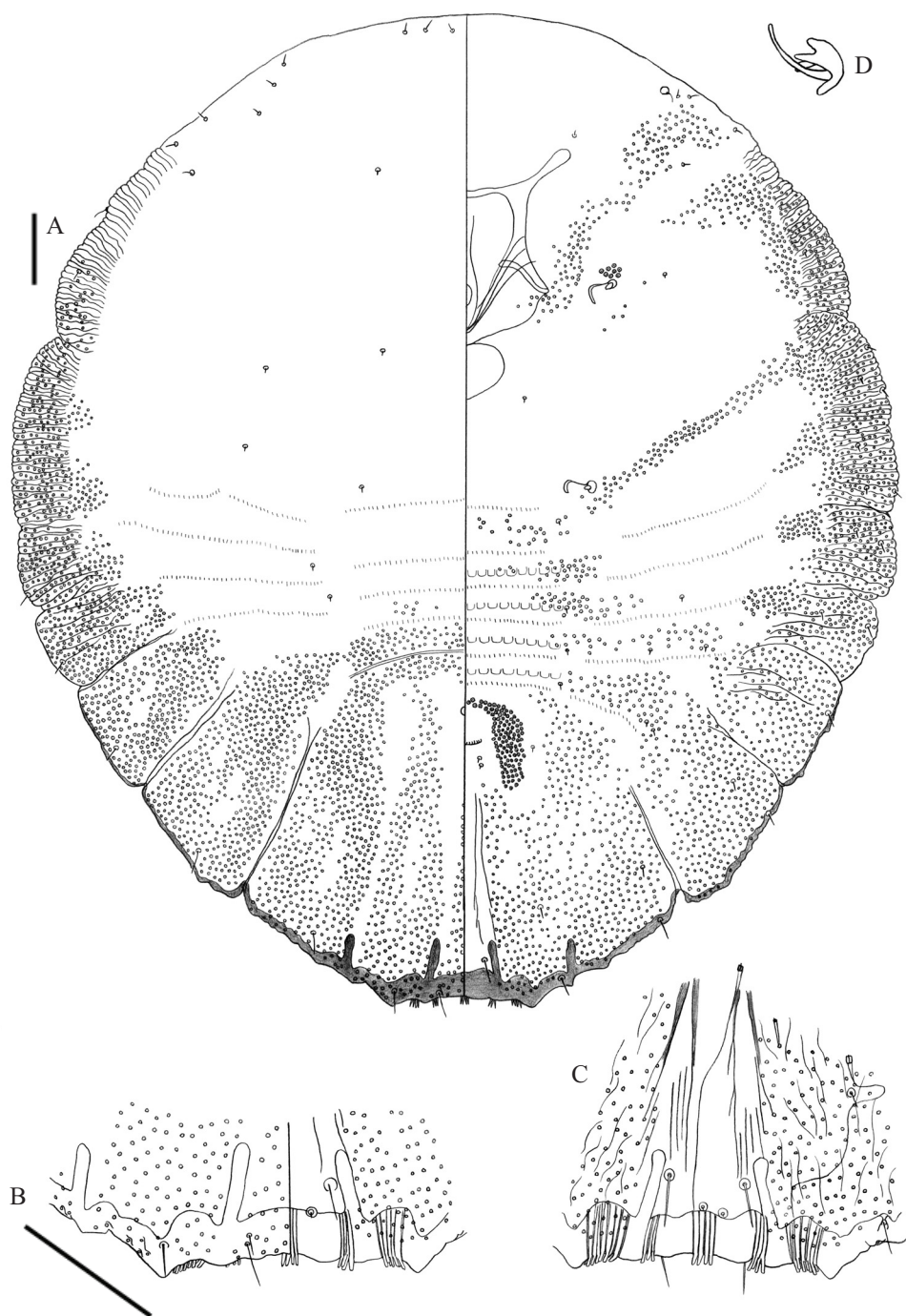


Fig. 38. *Froggattiella pentapeniculata*, sp. nov., adult female. B, pygidial margin (left half, dorsum; right half, venter); C, pygidial margin (venter); D, antenna. Scale bars: A & B, 100µm.

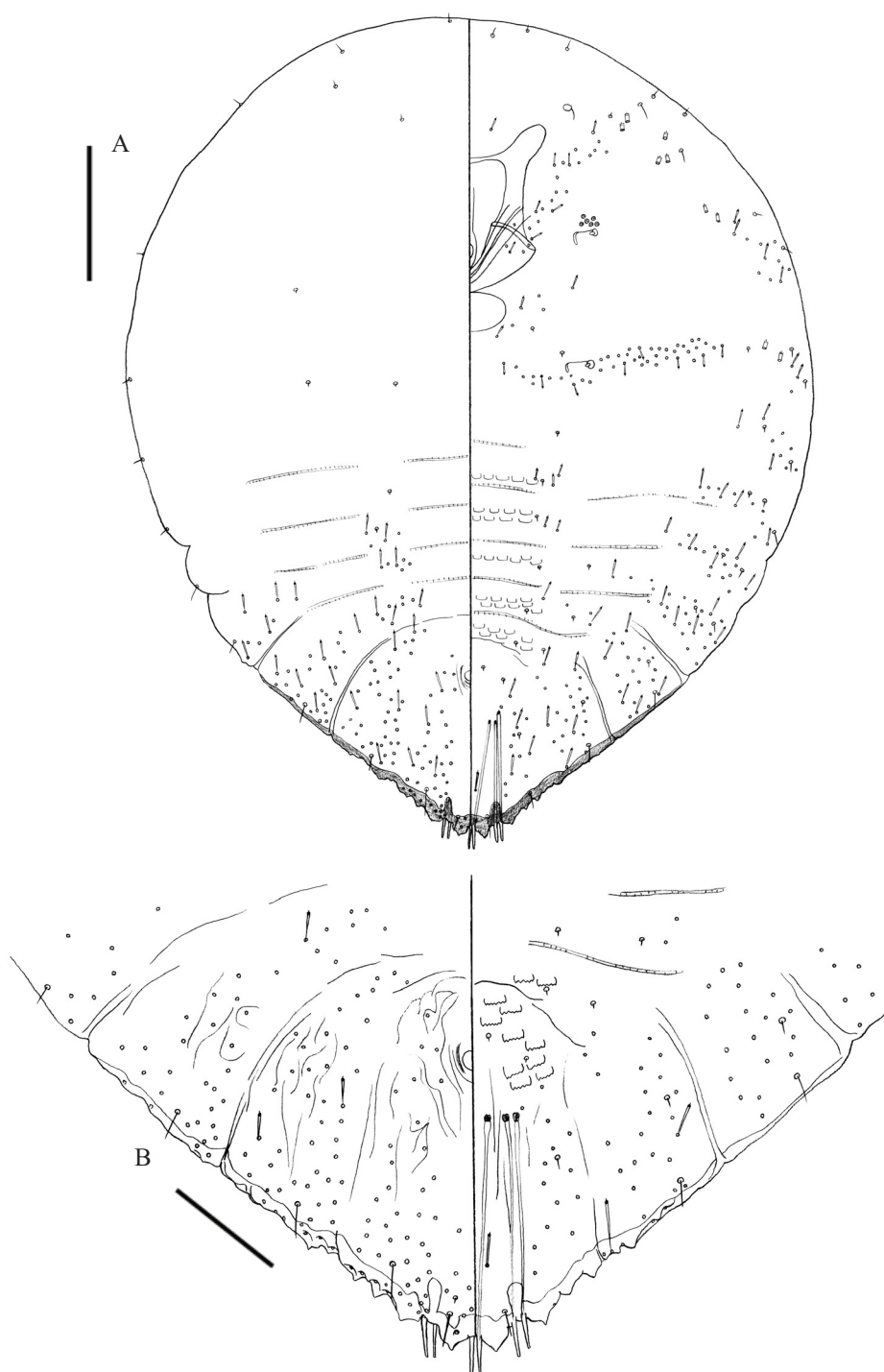


Fig. 39. *Froggattiella pentapeniculata*, sp. nov., second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

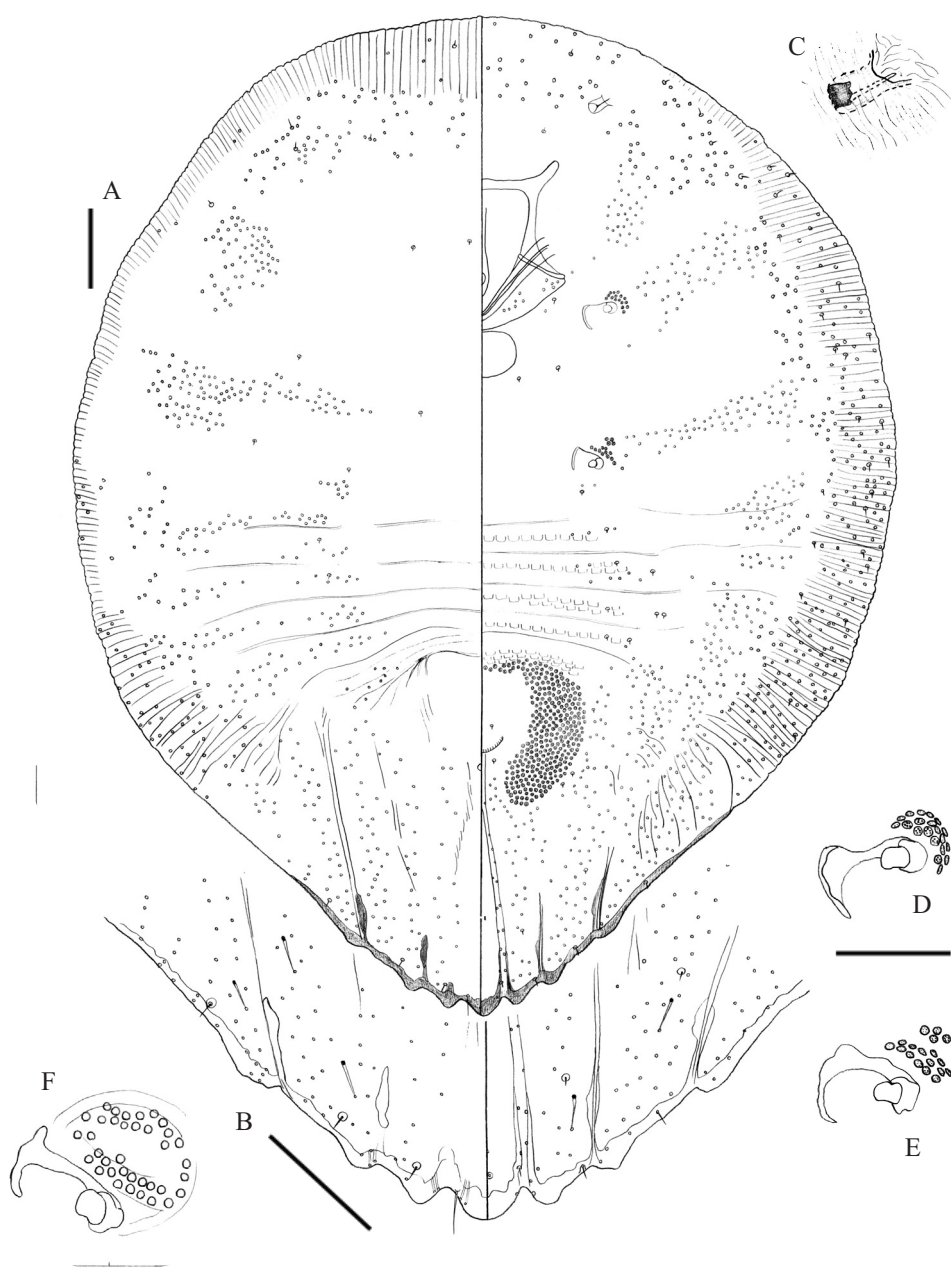


Fig. 40. *Odonaspis collarifera*, sp. nov., adult female. B, pygidial margin; C, antenna; D, anterior spiracle; E, posterior spiracle (holotype); F, posterior spiracle (specimen from 86ML-247e). Scale bars: A & B, 100 μ m; D, 50 μ m (D & E & F, the same scale).

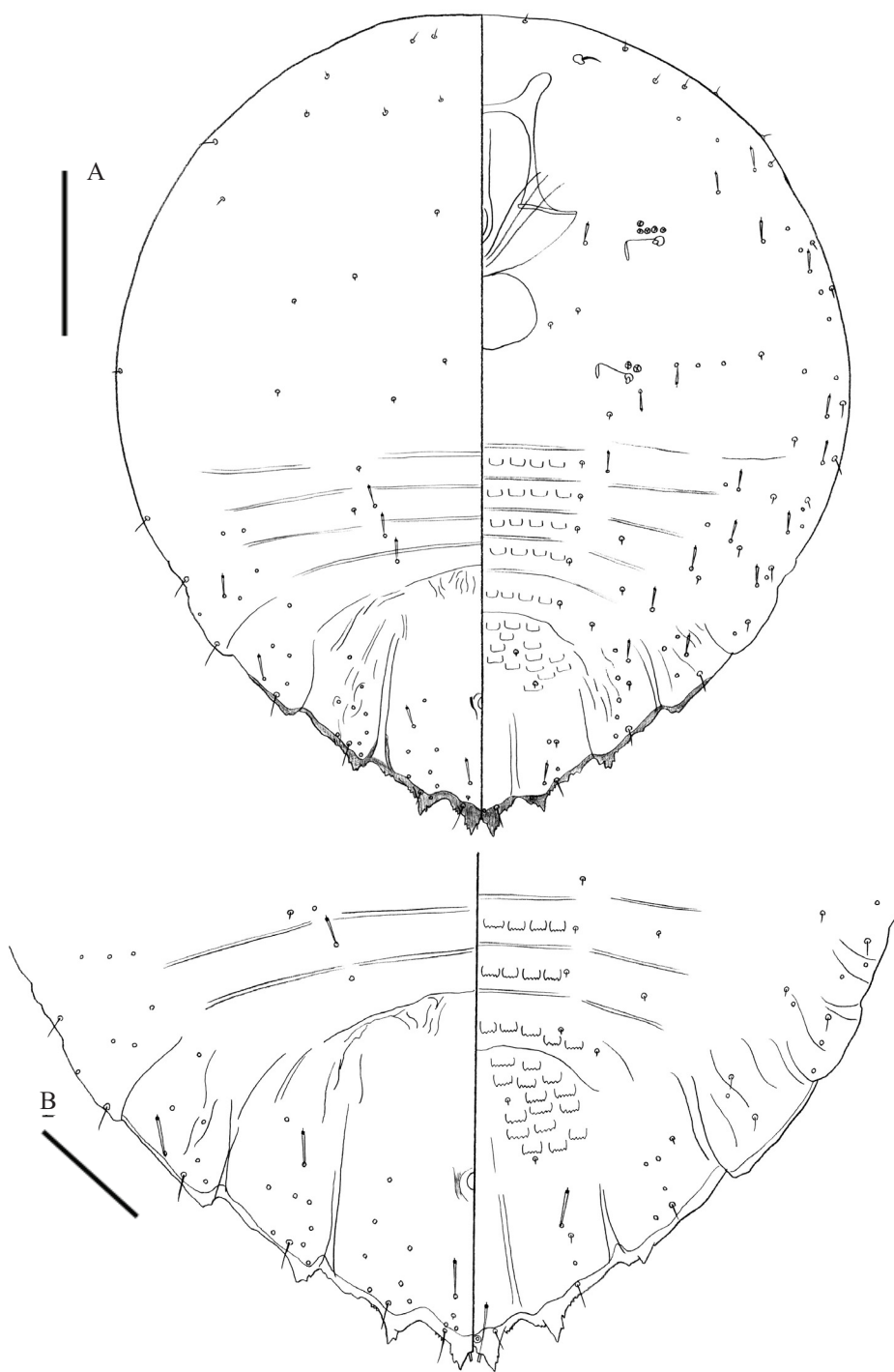


Fig. 41. *Odonaspis collarifera*, sp. nov., second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

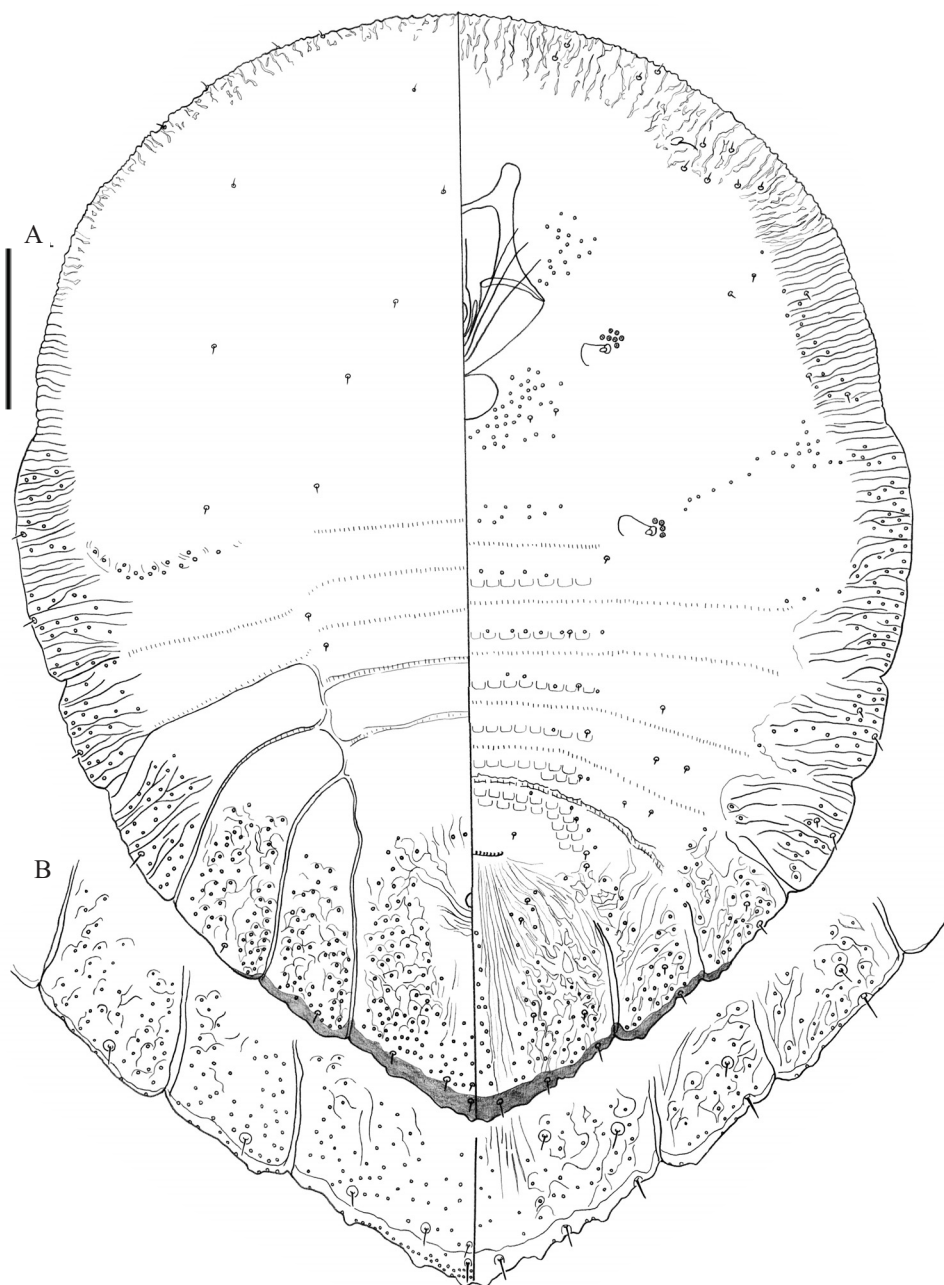


Fig. 42. *Odonaspis rugosa*, sp. nov., adult female. B, pygidial margin. Scale bar: 100 μ m.

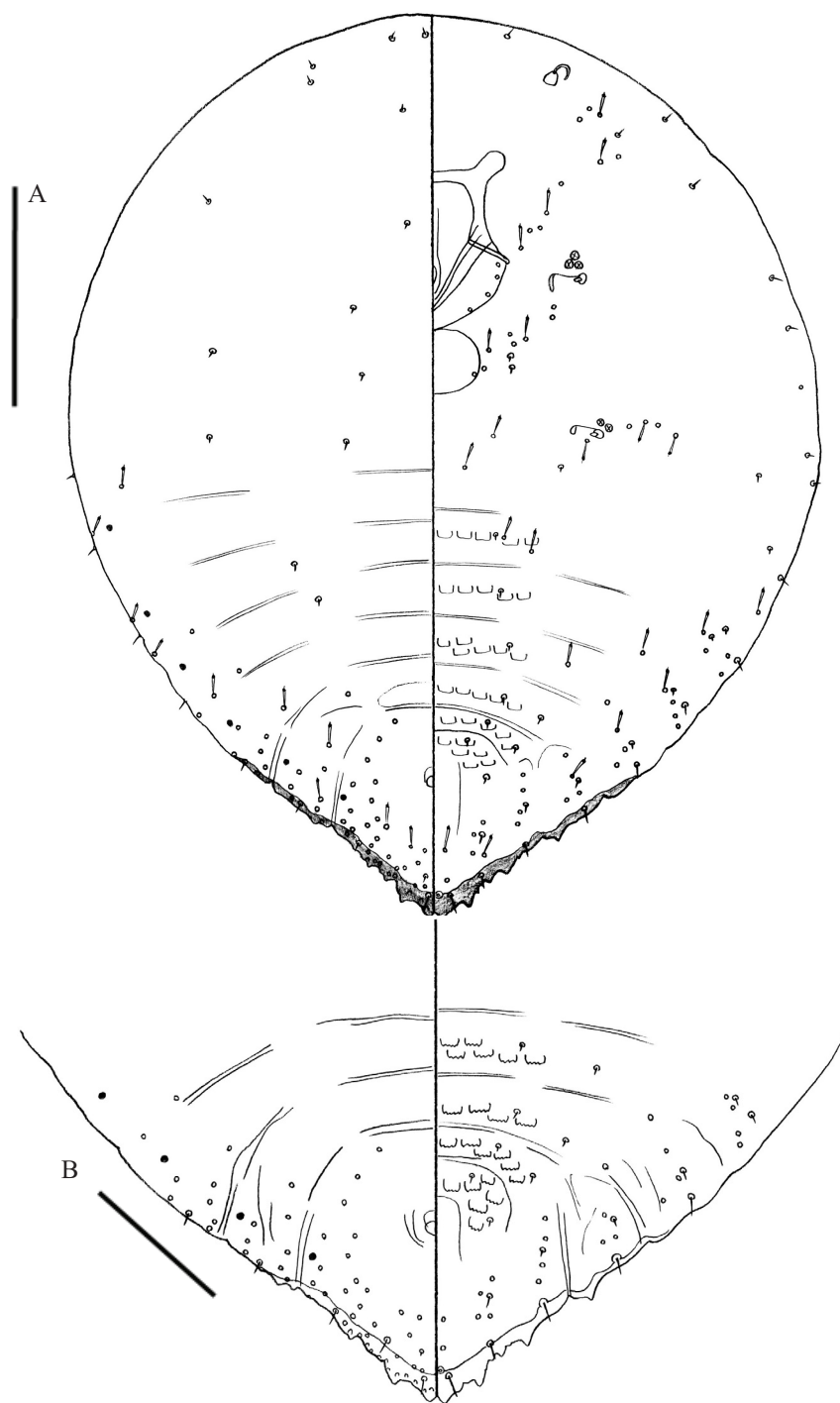


Fig. 43. *Odonaspis rugosa*, sp. nov., second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

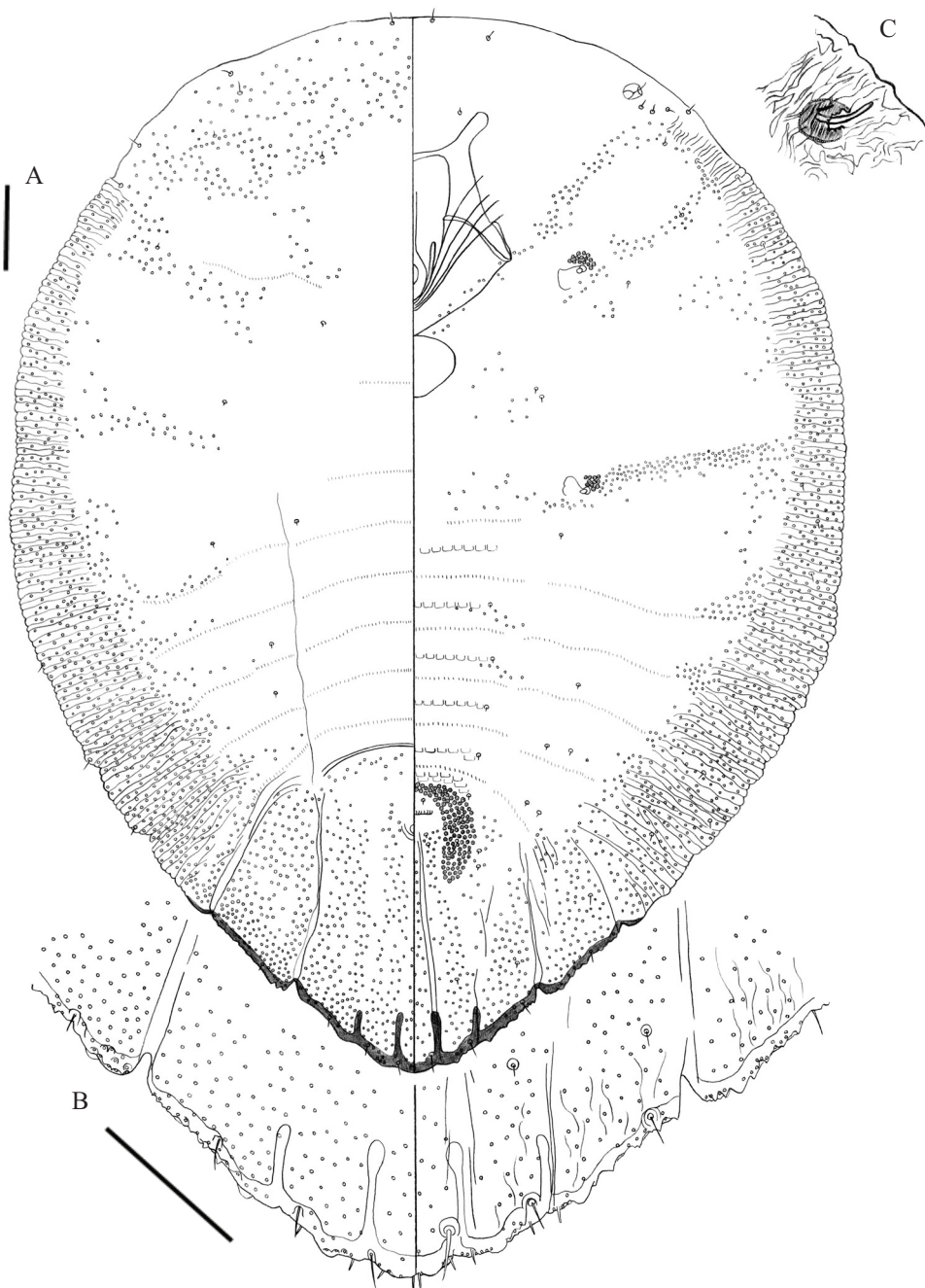


Fig. 44. *Odonaspis spinulata*, sp. nov., adult female. B, pygidial margin; C, antenna. Scale bars: A & B, 100 μ m.

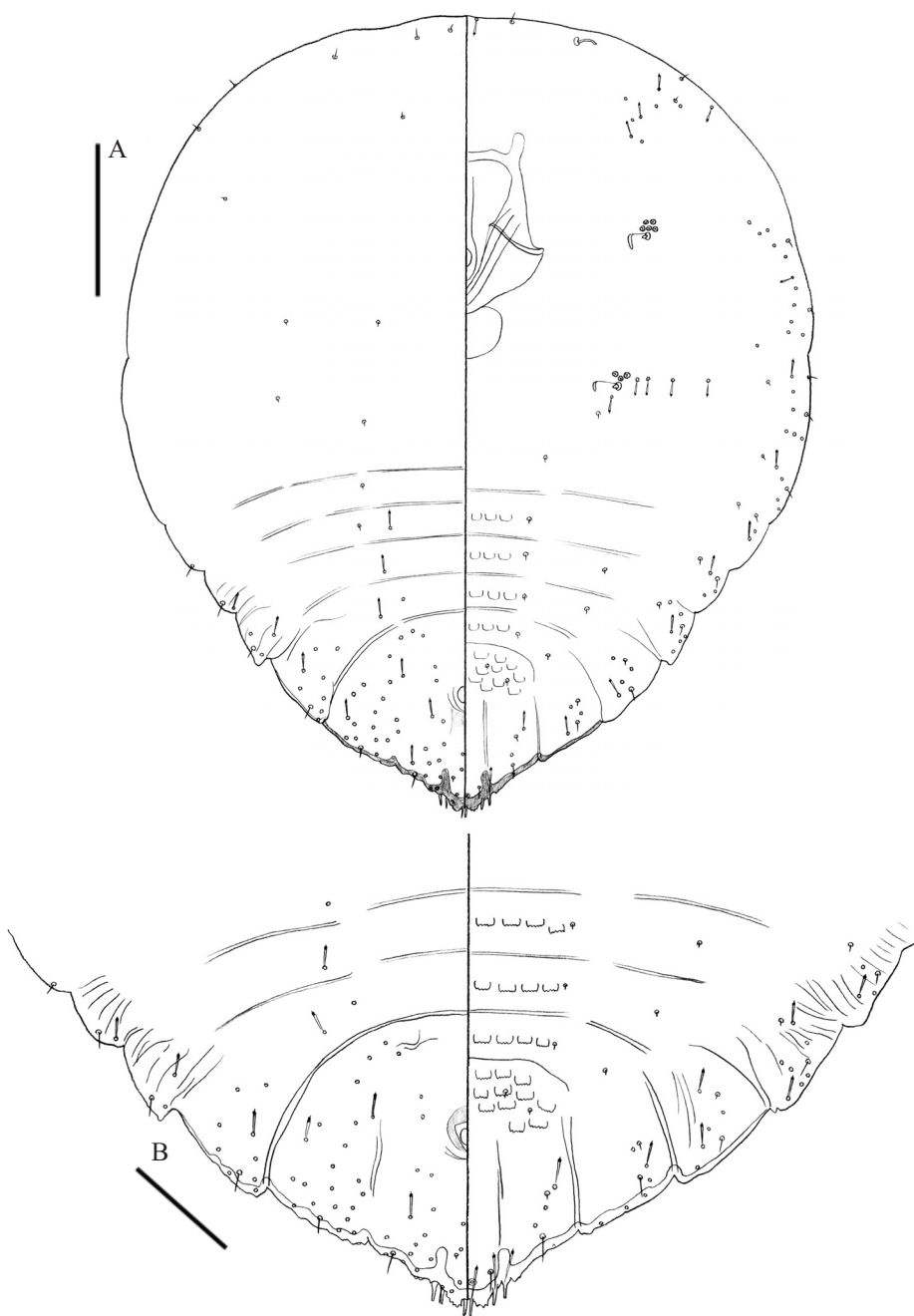


Fig. 45. *Odonaspis spinulata*, sp. nov., second-instar female. B, pygidium. Scale bars: A, 100 μ m; B, 50 μ m.

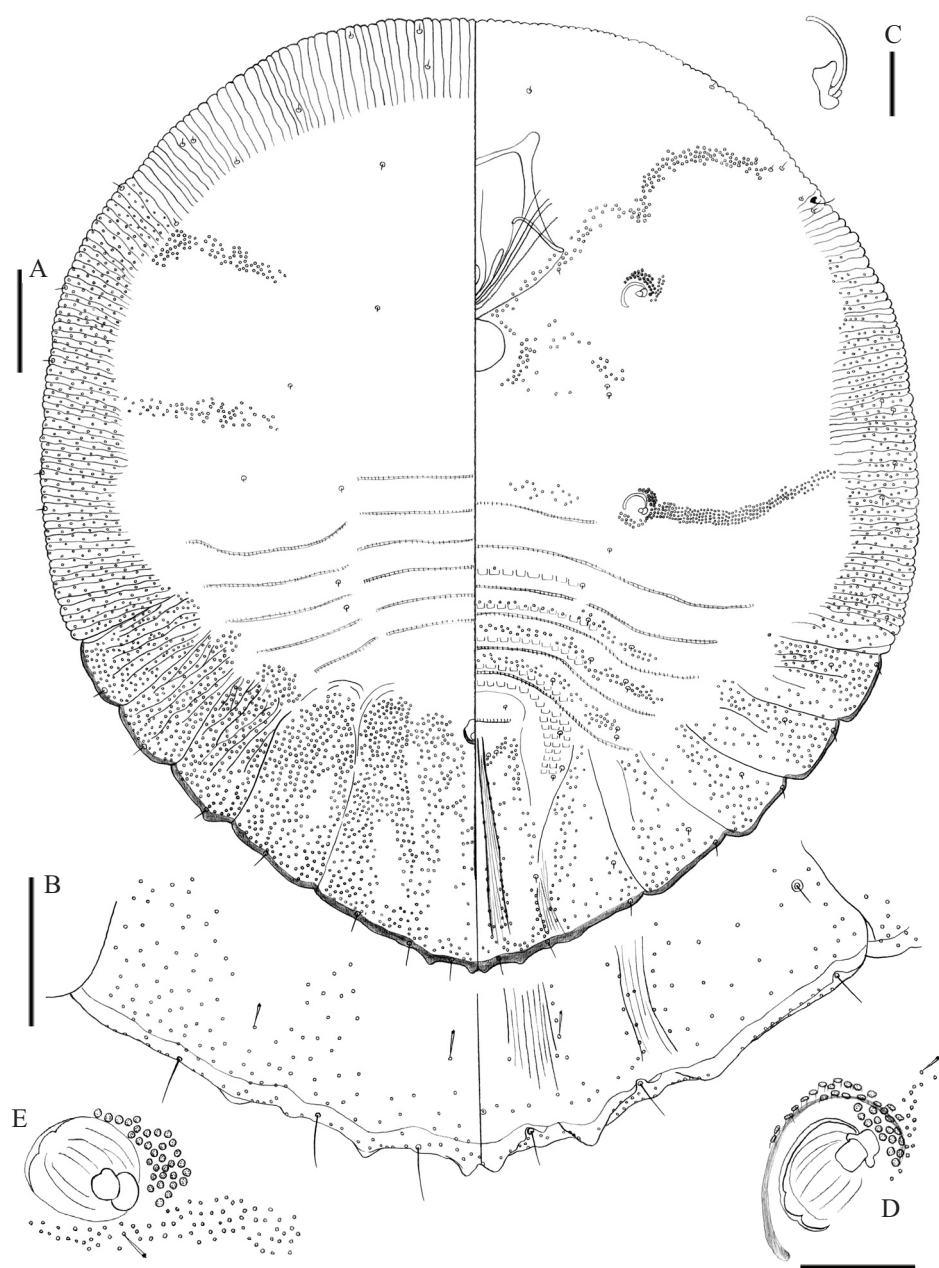


Fig. 46. *Odonaspis tapahensis*, sp. nov., adult female. B, pygidial margin; C, antenna; D, anterior spiracle; E, posterior spiracle. Scale bars: A & B, 100 μ m; C, 20 μ m; D, 50 μ m (D & E, the same scale).

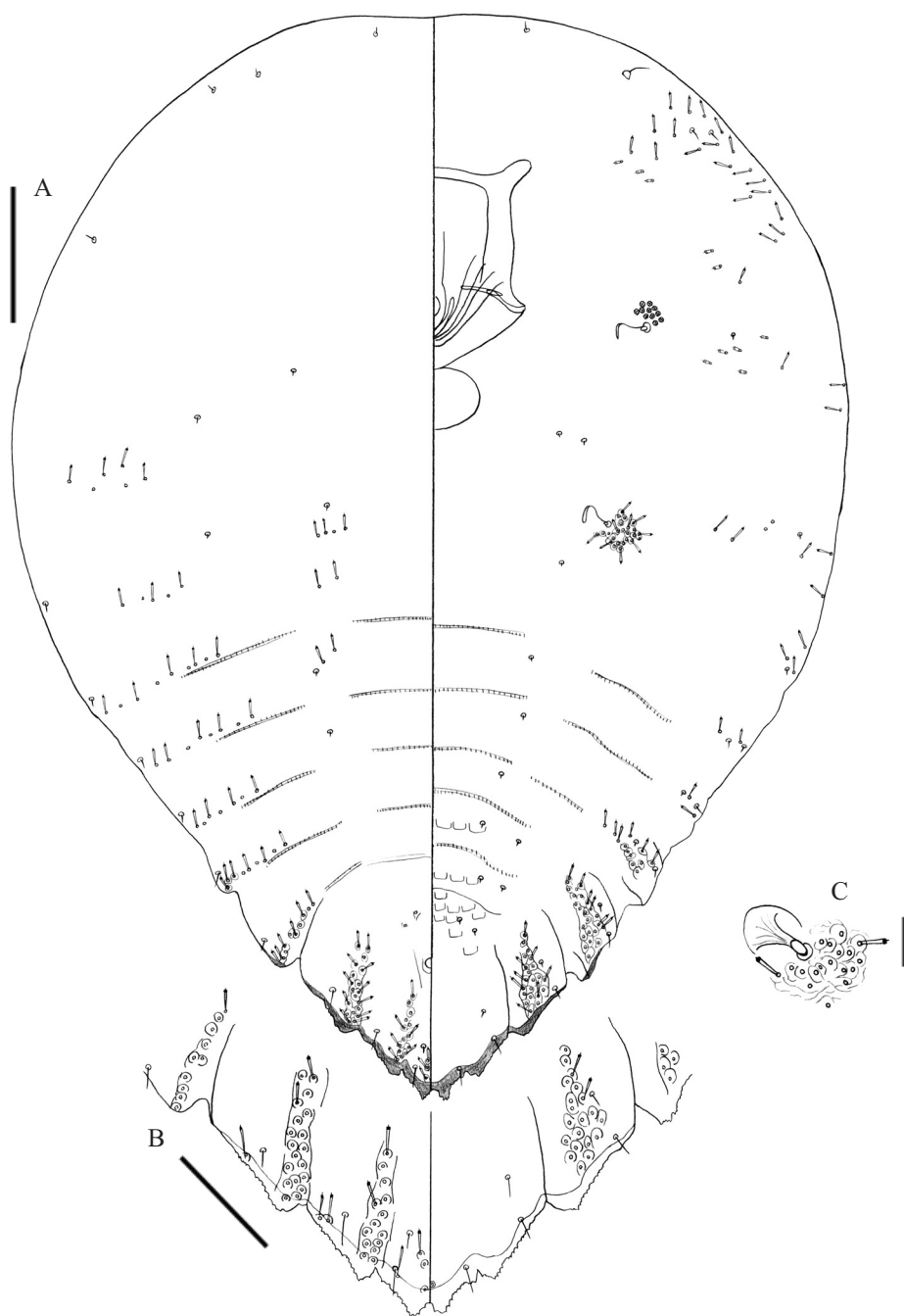


Fig. 47. *Odonaspis tapahensis*, sp. nov., second-instar female. B, pygidium; C, posterior spiracle. Scale bars: A, 100µm; B, 50µm; C, 20µm.



Fig. 48. *Odonaspis trispatulata*, sp. nov., adult female. B, pygidial margin. Scale bars: A & B, 100 μ m.

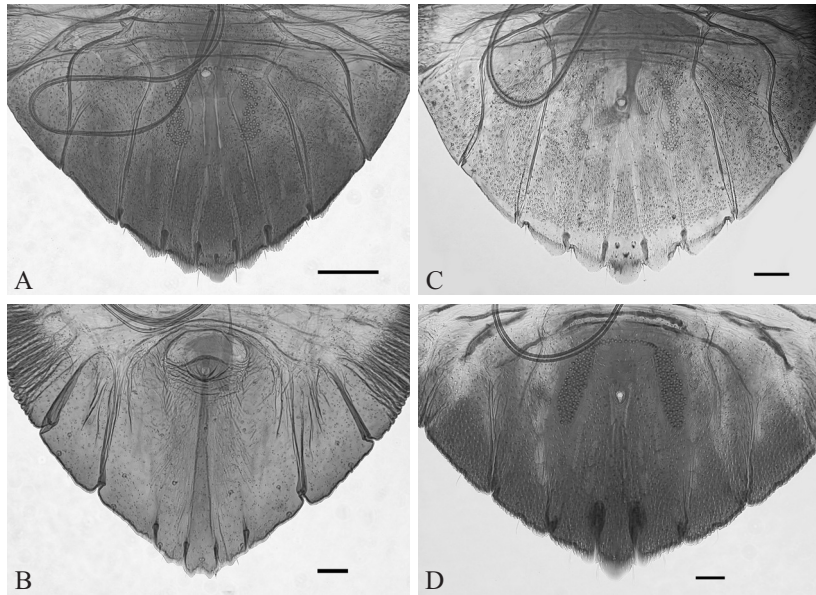


Fig. 49. A-D, adult female (pygidium). A, *Odonaspis batarazaensis*, sp. nov.; B, *O. densipora*, sp. nov.; C, *O. maasinensis*, sp. nov.; D, *O. miyakoensis*, sp. nov. Scale bars: A, 100 μ m; B-D, 50 μ m

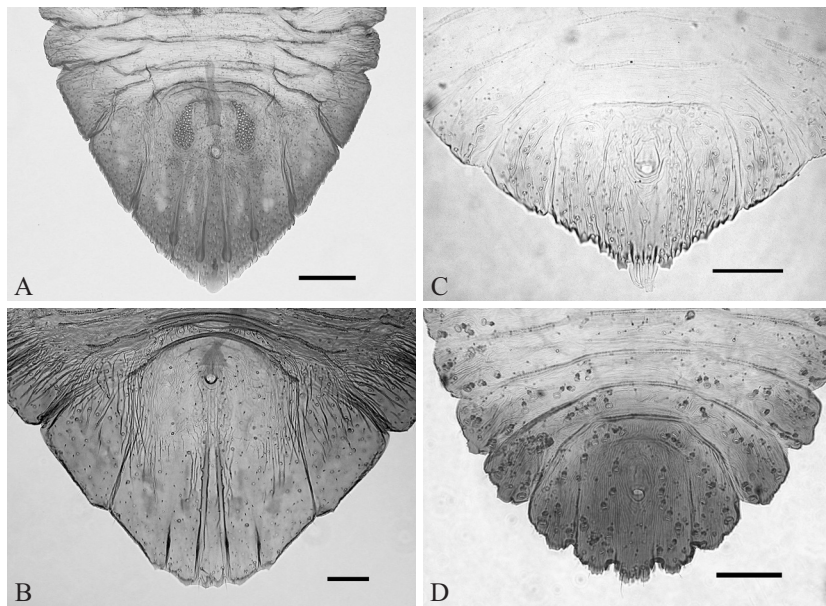


Fig. 50. A & B, adult female. A, *Odonaspis procera*, sp. nov.; B, *O. sparsa*, sp. nov. C & D, second instar (pygidium). C, *Froggattiella penicillata* (female); D, *F. penicillata* (male). Scale bars: A, 100 μ m; B-D, 50 μ m

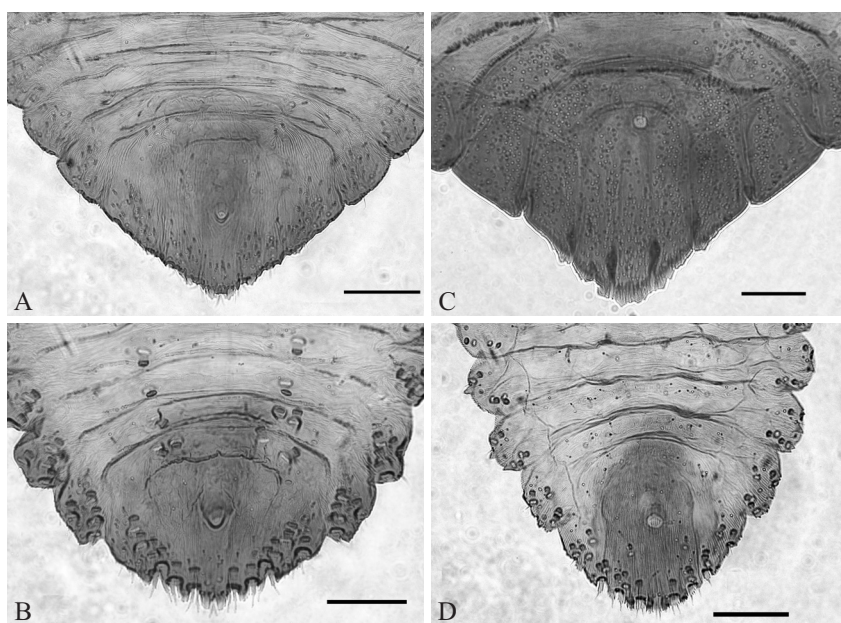


Fig. 51. A-D, second instar (pygidium). A, *Odonaspis arcusnotata* (female); B, *O. arcusnotata* (male); C, *O. bambusarum* (female); D, *O. bambusarum* (male). Scale bars: A-D, 50 μ m.

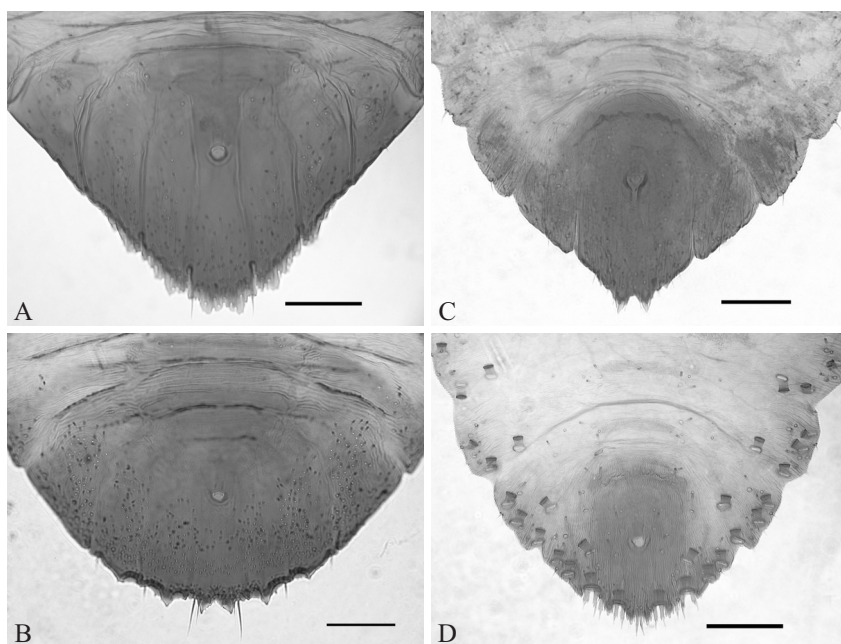


Fig. 52. A-D, second instar (pygidium). A, *Odonaspis batarazaensis* (female); B, *O. batarazaensis* (male); C, *O. densipora* (female); D, *O. densipora* (male). Scale bars: A-D, 50 μ m.

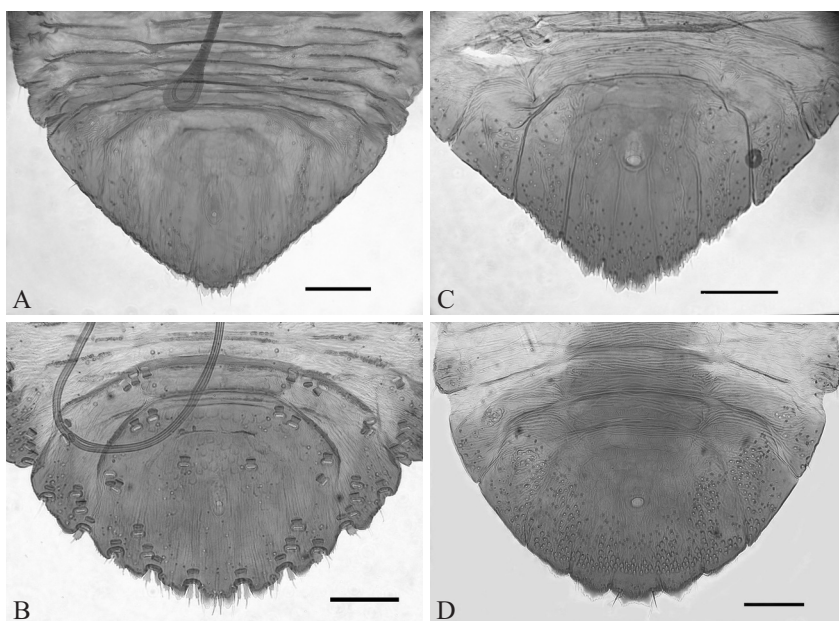


Fig. 53. A-D, second instar (pygidium). A, *Odonaspis greeni* (female); B, *O. greeni* (male); C, *O. maasinensis* (female); D, *O. maasinensis* (male). Scale bars: A-D, 50 μ m.

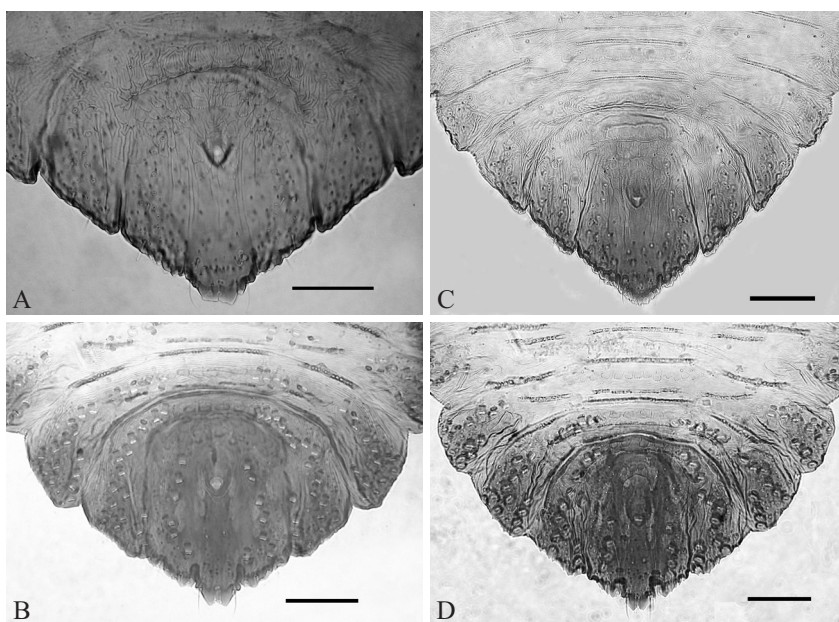


Fig. 54. A-D, second instar (pygidium). A, *Odonaspis miyakoensis* (female); B, *O. miyakoensis* (male); C, *O. morrisoni* (female); D, *O. morrisoni* (male). Scale bars: A-D, 50 μ m.

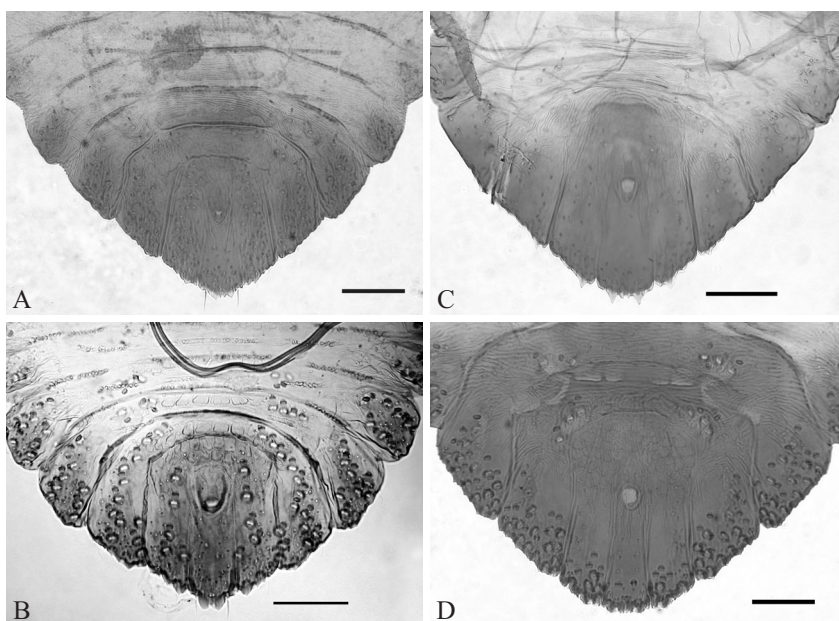


Fig. 55. A-D, second instar. A, *Odonaspis oshimaensis* (female); B, *O. oshimaensis* (male); C, *O. procera* (female); D, *O. procera* (male). Scale bars: A-D, 50µm.

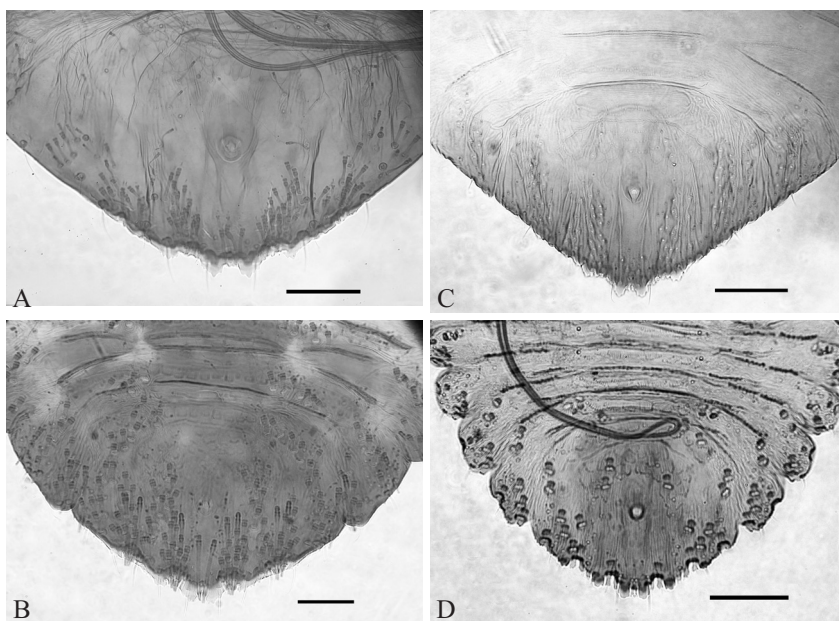


Fig. 56. A-D, second instar (pygidium). A, *Odonaspis schizostachyi* (female); B, *O. schizostachyi* (male); C, *O. secreta* (female); D, *O. secreta* (male). Scale bars: A-D, 50µm.

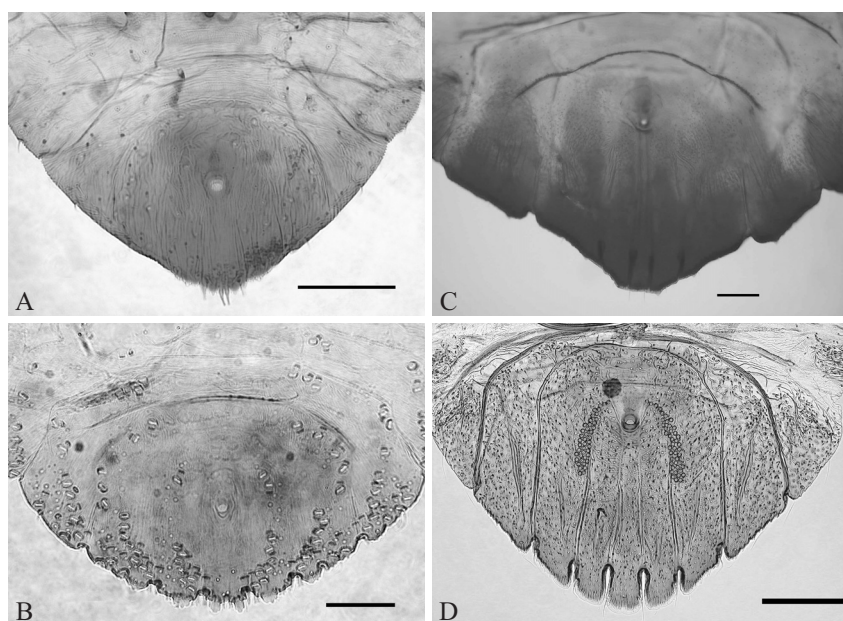


Fig. 57. A & B, second instar (pygidium). A, *Odonaspis sparsa* (female); B, *O. sparsa* (male). C & D, adult female (pygidium). C, *Froggattiella gigantochloae*, sp. nov.; D, *O. trispatulata*, sp. nov. (adult female). Scale bars: A & B, 50µm; C & D, 100µm.

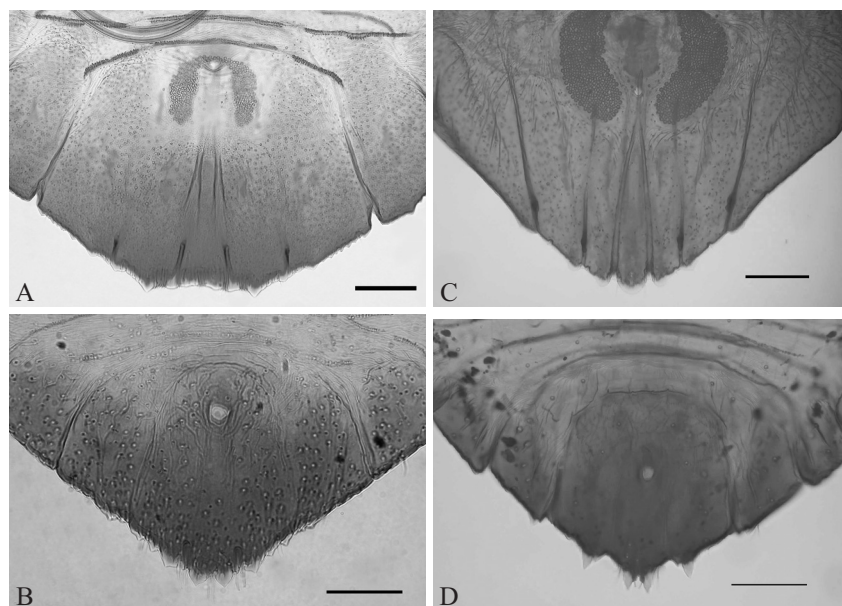


Fig. 58. A-D, pygidium. A, *Froggattiella pentapeniculata*, sp. nov. (adult female); B, *F. pentapeniculata*, sp. nov. (second-instar female); C, *Odonaspis collarifera*, sp. nov. (adult female); D, *O. collarifera*, sp. nov. (second-instar female). Scale bars: A & C, 100µm; B & D, 50µm.

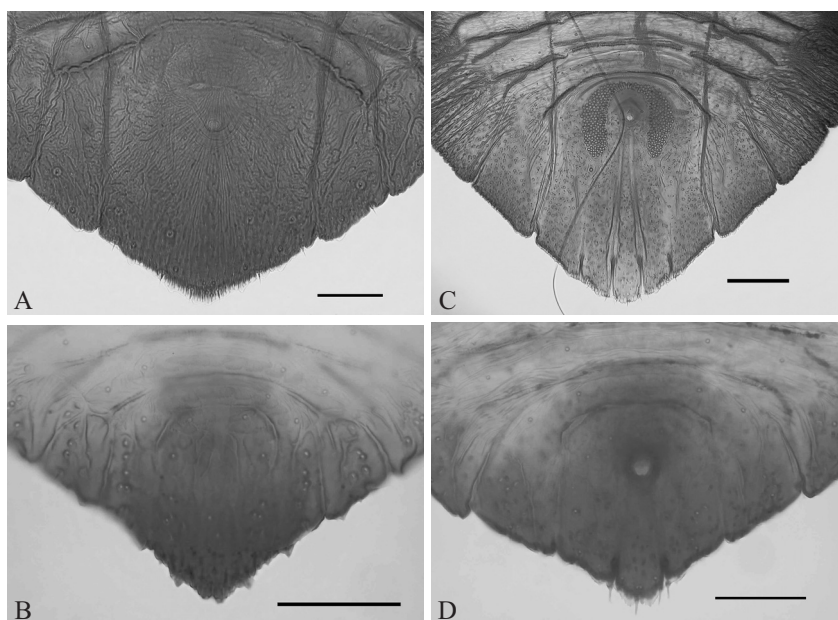


Fig. 59. A-D, pygidium. A, *Odonaspis rugosa*, sp. nov. (adult female); B, *O. rugosa*, sp. nov. (second-instar female); C, *O. spinulata*, sp. nov. (adult female); D, *O. spinulata*, sp. nov. (second-instar female). Scale bars: A & C, 100µm; B & D, 50µm

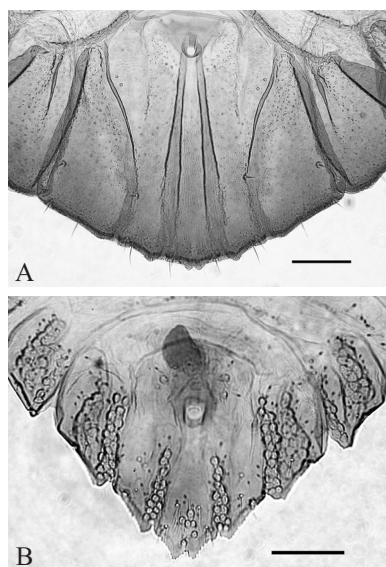


Fig. 60. A & B, pygidium. A, *Odonaspis tapahensis*, sp. nov. (adult female); B, *O. tapahensis*, sp. nov. (second-instar female). Scale bars: A & B, 100µm.