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NEW OR NOTEWORTHY ARMOURED SCALE INSECTS OCCURRING IN IRAN (HOMOPTERA: COCCOIDEA: DIASPIDIDAE)

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Abstract

TAKAGI, S. and MOGHADDAM, M., 2005. New or noteworthy armoured scale insects occurring in Iran (Homoptera: Coccoidea: Diaspididae). *Ins. matsum. n. s.* 61: 43–74, 16 figs.

Twelve species of armoured scale insects occurring in Iran are dealt with, including two new species, *Rungaspis avicenniae* and *Diaspidiotus platychaetae*, and three newly recorded species, *Lepidosaphes pallidula* (Williams), *Mongrovaspis quadrispinosa* (Green), and *Oceanaspidiotus spinosus* (Comstock). Two undetermined forms are described and illustrated: they may belong to *Contigaspis zillae* and *Balachowskiella salvadorae*, respectively, unless they represent new species. *Mercetaspis isis* (Hall) inhabits a branch gall probably induced by a mite. *Fiorinia phoenicis* Balachowsky, *Lepidosaphes belutchistana* Balachowsky, *Suturaspis archangelskyae* (Archangelskaya), and *Suturaspis crataegi* (Bodenheimer) (=*Leucaspidopsis crataegi* Bodenheimer) are remarkably variable in some pygidial features of the adult or second-instar females, and the significance of these varying features is mentioned in an extended discussion.

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Contents. Introduction — Enumeration (*Fiorinia phoenicis* — *Contigaspis* sp. — *Balachowskiella* sp. — *Lepidosaphes pallidula* — *Lepidosaphes belutchistana* — *Mercetaspis isis* — *Mongrovaspis quadrispinosa* — *Suturaspis archangelskyae* — *Suturaspis crataegi* — *Oceanaspidiotus spinosus* — *Rungaspis avicenniae*, sp. nov. — *Diaspidiotus platychaetae*, sp. nov.) — Discussion: Phenotypic variation —Acknowledgements — References.

Introduction

The study of armoured scale insects occurring in Iran was started by M. Kaussari in the 1940's, and was promoted especially with the co-operation of A. S. Balachowsky mainly in the 1950's. In 1977, Seghatoleslâmi published a list of the Diaspidoidea (Phoenicococcidae and Diaspididae) which had been described or recorded from Iran, and enumerated 93 species in 53 genera with collection data. The junior author (Moghaddam, 2004) has revised and supplemented the list, enumerating 107 species and arranging them in 41 genera.

In recent years, the junior author has been engaged in collecting and studying Coccoidea in Iran. Based on her collection, 12 species of Diaspididae are dealt with in this paper. Two of them, *Rungaspis avicenniae* and *Diaspidiotus platychaetae*, are new to science and three, *Lepidosaphes pallidula*, *Mongrovaspis quadrispinosa*, and *Oceanaspidiotus spinosus*, are new to Iran. Two undetermined forms are described and illustrated: they may belong to *Contigaspis zillae* and *Balachowskiella salvadorae*, respectively, unless they represent new species. The other five species have been known to occur in Iran. One of them, *Mercetaspis isis*, is newly recorded as a gall-inhabitant, but the circumstance suggests that a mite is responsible for the gall and that *M. isis* is an inquiline in the gall. The remaining four, *Fiorinia phoenicis*, *Lepidosaphes belutchistana*, *Suturaspis archangelskyae*, and *Suturaspis crataegi*, are remarkably variable in some pygidial features of the adult or second-instar females, and the significance of these varying features is mentioned in an extended discussion.

The holotypes of the two new species are deposited in the collection of the Hayk Mirzayans Insect Museum, Plant Pests and Diseases Research Institute, Tehran.

Enumeration

In this paper, the terms 'trullae' and 'pectinae' are used in place of 'lobes' and 'plates' of other authors. The abbreviations 'abd I–IX' stand for the first to ninth abdominal segments.

Fiorinia phoenicis Balachowsky (Fig. 2)

Material examined. Collected in Fars Province, on the leaves of *Phoenix* sp. (Arecaceae).

This species was originally described by Balachowsky (1967) from Iran on the basis of material collected on date palm, *Phoenix dactylifera*, and recorded by Matile-Ferrero (1984) from Saudi Arabia on the same plant species. The specimens examined in the present study nearly agree with the original description except that a pair of marginal setae is definitely present on the ninth abdominal segment (between the median trullae) in the second-instar female (Fig. 2A) as usual in *Fiorinia* species. In the adult female the marginal setae of the ninth segment are usually present, but are not stable in position in accordance with variation in the shape of the median trullae (Fig. 2B–E: see below).

The following characters have also been observed in the adult female (the numbers of the secretory organs are based on 15 specimens). Anterior spiracles each with 2–6 disc pores, which are tri- or sometimes quadrilocular. Posterior spiracles without disc pores, with 6–12 microducts in a loose transverse row just caudad of them; 3–9 microducts scattered around the posterior margin of the rostrum. Perivulvar disc pores: 1–5 in the median group, 8–15 in each anterolateral group, and 10–18 in each posterolateral group.

Marginal macroducts of the pygidium single, usually 4 on each side, occurring on abd IV –VII, all of them well developed or the lateralmost (on abd IV) much reduced often to the size of a microduct and sometimes even obsolete, at times the one on abd V also very small. Marginal gland spines, if present, much reduced and not easily recognizable on the pygidium, their microducts usually occurring on abd V–VII or at times even on VIII; usually gland spines on abd III and IV also reduced to microducts.

The adult female is provided with well-sclerotized median trullae, but has no lateral ones. In the examined specimens, the median trullae are variable in shape. Usually these trullae are represented by a pair of roundish lobes connected basally by a robust zygosis, with a pair of marginal setae between them (these setae belong to the ninth abdominal segment) (Fig. 2B). In several specimens, the lobes themselves are connected together, with their apices still separated from each other; the setae of the ninth segment are removed from the margin onto the ventral surface of the pygidium (Fig. 2C, in which these setae are situated on the anterior end of the zygosis). In one specimen, the lobes and zygosis are expanded laterally, depressed, and scarcely produced beyond the pygidial margin, which is smoothly rounded and partly sclerotized; in this specimen, too, the setae of the ninth segment are removed onto the ventral surface of the pygidium just in front of the zygosis (Fig. 2E). In another specimen, the lobes are completely fused to form a round prominence at the apex of the pygidium; this specimen is also unusual in having only one pair (instead of two pairs) of dorsal setae on the outer bases of the trullae and a single dorsal seta in front of the fused trullae (Fig. 2D) (this single seta may be the remnant of the other pair of setae originally occurring on the outer bases of the trullae or of the marginal setae of the ninth abdominal segment removed onto the ventral surface). (See also Discussion: Phenotypic variation.)

Contigaspis sp. (Fig. 3)

Material examined. Collected at Larak, Hormozgan Province, on an undetermined plant with succulent leaves, 20 Feb., 2000. Tests of both sexes occurring on the branches and the leaves.

The examined adult females have rudimentary median trullae, which are represented at most by a pair of minute prominences at the apex of the pygidium and, thus, nearly merged into the pygidial margin. This state is quite unusual in the genus *Contigaspis*. They are also characterized in the dorsal macroducts occurring along the pygidial margin and other ducts much fewer than in many species of the genus described and illustrated by Balachowsky (1954), Borchsenius and Williams (1963), Bazarov and Shmelev (1971), and Danzig (1993). They, therefore, may represent an undescribed species. According to Danzig (1993), however, *Contigaspis zillae* (Hall) is a variable species and includes *C. kochiae* Borchsenius, *C. monticola* Borchsenius (=*Pinnaspis acantholimoni* Bodenheimer), and *C. borchsenii* Bazarov as infraspecific forms. The last of these forms possesses very small median trullae (Bazarov and Shmelev, 1971), and suggests that the median trullae in *C. zillae* as understood by Danzig has a tendency towards reduction. In Iran, *C. zillae* has been recorded from some localities on *Kochia* and *Heliotropium* (Seghatoleslâmi, 1977; Moghaddam, 2004). A greater range of material from Iran and other areas may be helpful for determining whether the present specimens represent a distinct species or an extreme form in the variation of *C. zillae*.

The following characters have also been observed in the adult female (the numbers of the secretory organs are based on about 25 specimens). Anterior spiracles each with 1

–3 disc pores, which are mostly trilocular; posterior spiracles usually without disc pores, sometimes with 1. Perivulvar disc pores in 5 groups, 5–11 (usually 7 or 8) in the median group, 6–14 (often 11 or 12) in each anterolateral group, and 7–13 (usually 8 –10) in each posterolateral group. Robust gland spines on prepygidial segments, their numbers on each side: 3–10 laterally to anterior spiracle, 1–5 laterally to posterior spiracle, 1 –3 submarginally on each of abd I–IV (usually 1 or 2 on IV); 1 marginal gland spine on each of abd V–VIII, small and slender on VII and VIII. Dorsal macroducts on the pygidial margin variable in number, but not numerous, their numbers on each side: 1 or 2 on abd VII, 2–5 on VI, and 1–4 on V; a few dorsal macroducts also present on the margin on IV and often also on III. Other dorsal ducts much smaller; submedian ducts occurring on abd III–VI, few on III and VI.

Contigaspis davatchii Kaussari was described from Iran but, so far as based on the description (Kaussari, 1959), it is rather aberrant for a *Contigaspis* species, having some resemblance to *Pinnaspis* species.

Balachowskiella sp. (Fig. 4)

Material examined. Collected in Gheshm–Hormoz, Hormozgan Province, on *Avicennia* sp. (Avicenniaceae), 3 Oct., 2002. Four mounted specimens of the adult female have been examined, but they are not in good condition.

Kaussari (1955) erected the genus *Balachowskiella*, and described *Balachowskiella salvadorae* on the basis of material collected in Iran on *Salvadora persica* (Salvadoraceae). The present form collected on *Avicennia*, a mangrove plant, agrees well with Kaussari's description and figures of *B. salvadorae* in the median and second trullae, which are considerably characteristic in shape as described below, but disagrees in all or most of the submedian dorsal ducts and some of the submarginal dorsal ducts being replaced by microducts. However, such a difference is found between infraspecific forms in certain Diaspidini. In the limited specimens at hand, it is impossible to determine whether the present form represents a variation in *B. salvadorae* or another distinct species.

One of the examined specimens is remarkably swollen in the metathorax and the base of the abdomen (Fig. 4A), but the other three are fusiform. Median trullae small, elongate, appressed together, confluent along their basal halves, nearly parallel, with the apices separated from each other; no distinct median zygosis. Second trullae with the inner lobule relatively large, stout, with the apical margin flat or slightly roundish (Fig. 4B–D); outer lobule very small, conical. Third trullae with the inner lobule alone represented by a small conical process. Marginal dorsal macroducts as follows on each side: 1 between the median and second trullae (on abd VII), with the orifice not sclerotized on the rim and, therefore, not easily recognizable; 2 on each of abd VI and V, 1 or 2 on IV, and 1 on III. Three or so macroducts occurring along the lateral margin on each of abd II and III. Submarginal dorsal macroducts present on abd III–V, 2 or 3 on each side of each segment. Submarginal dorsal microducts occurring on abd II–IV mesally to the lateral or submarginal macroducts, few on each segment. Submedian dorsal ducts occurring on the metathorax and abd I–V in 1 specimen, on I (or II)–V in the other specimens, few on each segment, replaced by microducts except for 1 on V occasionally larger. Marginal gland spines short, their numbers on each side are as follows: 1 or 2 (at times absent?) on abd II, 3–6 on III, 5 or 6 on IV, 1–3 on V, and 1 on each of VI–VIII. Anterior spiracles each with 3 (or 2?) trilocular disc pores. The numbers of the perivulvar disc pores in the 4 specimens are as follows: 6 (9–9) 6–7; 8 (10–11) 8–7;

6 (8–11) 7–4; 8 (12–14) 8–7.

Balachowskiella salvadorae also occurs in Saudi Arabia (Matile-Ferrero, 1984). *Pinnaspis dracaenae* (Cooley) (originally *Hemichionaspis dracaenae*) is very similar to *B. salvadorae* and the present form in the median trullae, which are elongate and parallel unusually for a *Pinnaspis* species, and possibly belongs to *Balachowskiella*. It was originally described as from 'Socotia Island' and from *Dracaena cinnibari*. According to Ferris (1947), the locality should be Socotra Island, which lies south of Arabia and not very far from Iran and Saudi Arabia. Furthermore, *P. dracaenae* was recorded from Sri Lanka on *Hevea brasiliensis* and from South India on areca palm (Green, 1922; Ramakrishna Ayyar, 1930), but these records were accompanied with no description and no figure.

Lepidosaphes pallidula (Williams) (Figs 5, 6)

Material examined. Collected at Chabahar, Systan & Baluchestan Province, on the stem of eggplant, *Solanum melongena* (Solanaceae), 28 April, 2003, together with *Aonidiella orientalis* (Newstead) and *Oceanaspidiotus spinosus* (Comstock). Five specimens of the adult female have been mounted, not all of them being in good condition. This species is newly recorded from Iran.

In the present study, the genus *Lepidosaphes* is understood in a broad sense, including *Mytilaspis*, *Insulaspis*, and others, which may be recognized as species groups.

Mytilaspis pallida Green, 1896 (preoccupied by *Mytilaspis pallida*, Green (var.?): Maskell, 1895) was renamed *Insulaspis pallidula* by Williams (1969, 1969b). No recent redescription, however, has been available for this species. The identification of the present material is based on Green's (1896) redescription and illustration (*Mytilaspis gloverii*, Packard, var. *pallida* Green, which was collected at Punduloya, Kandy, Sri Lanka, on leaves of various unidentified shrubs) and some slides labelled '*Lepidosaphes ?pallida* Green, W. J. Hall det.' and made available for study by Dr Jon H. Martin, the Natural History Museum, London. These slides contain four specimens of the adult female collected in Egypt on mango and three in Malaya on *Passiflora laurifolia*. Other slides labelled as of this species and deposited in the collection of that museum were also examined, but the specimens mounted on these slides belong to three species, of which none is identical with *L. pallidula* as understood in the present study.

Dr Douglass R. Miller, USDA, has recently examined ten syntype slides of *Mytilaspis pallida* Green. Information from him (his letter dated September 7, 2004, with a figure of the adult female and data on some characters in ten adult females) strongly supports the identification in the present study. Thus, *Lepidosaphes pallidula* definitely occurs in Iran, Egypt, and Malaya in addition to Sri Lanka. The localities and host plants of the examined specimens suggest that this species occurs widely in the tropics of the Old World on various plants.

The 12 adult female specimens referred to *Lepidosaphes pallidula* in the present study (five from Iran, four from Egypt, and three from Malaya) closely agree in main characters. Median trullae separated from each other by a space a little narrower than one of them. A small, but strongly sclerotized lateral spur present on each side of the body on the posterior border of abd I (or between I and II), spiniform, sometimes bicuspid. Dorsal ducts not particularly reduced in size. Submedian dorsal ducts occurring on abd II–VI, their numbers on each side: 2–5 (at times absent) on II, 3–9 on III, 4–8 on IV, 2 –5 on V, and 1–4 (usually 2) on VI. Submarginal dorsal ducts few on abd IV and V,

rather abundant on the preceding abdominal segments. Small tubercular gland spines on metathorax and abd I, their numbers on each side: 4–7 just caudad of posterior spiracle, 9–15 in an oblique row on the lateral lobe of abd I; 2 or 3 conical gland spines on the lateral lobe of abd II, 2 elongate gland spines on the lateral lobe of III; 2 marginal gland spines on each of abd IV–VIII on each side, and 2 on IX (between the median trullae). Anterior spiracles each with 1–3 trilocular disc pores. Perivulvar disc pores: 2–4 in the median group, 6 or 7 in each anterolateral group, and 3 or 4 (usually 4) in each posterolateral group. Antennae each with 2 setae, which are united together except for a short basal length in some specimens.

Lepidosaphes belutchistana Balachowsky (Figs 7, 8)

Material examined. Collected in Systan & Baluchestan Province, 25–27 April, 2003: in Chabahar–Kahir, on *Prosopis spicigera* (Fabaceae), and at Ooraki, on *Acacia* sp. (Fabaceae). Tests were found on the twigs of *Prosopis spicigera* and on the twigs and leaves of *Acacia* sp. Five specimens of the adult female of the twig-associated form (four from *Prosopis spicigera* and one from *Acacia* sp.) and seven specimens of the leaf-associated form from *Acacia* sp. have been mounted and examined.

This species was described by Balachowsky (1954) on the basis of material collected in Iran on lignified parts of *Prosopis spicigera*, one of the host plants of the present material. Seghatoleslâmi (1977) recorded it (under the name *Mytilaspis belutchistana*) from *Periploca aphylla* (Asclepiadaceae) as well as from *Prosopis spicigera*.

The twig-associated form examined in the present study nearly agrees with the original description and the accompanying illustration. This form is especially characterized by having membranous second trullae (Fig. 8A), a character quite unusual for a member of *Lepidosaphes*. The leaf-associated form, however, differs in the second trullae remarkably developed and sclerotized, with both lobules elongated, the apex of the inner lobule nearly attaining the level of the apex of the median trulla (Fig. 8B). In other features, these forms are very similar as described below. (See also Discussion: Phenotypic variation.)

Median trullae separated from each other by a space about half as wide as one of them. Dorsal ducts not particularly reduced in size; occurring across the metathorax and abd I–III, submedially and submarginally on IV and V, and only submedially on VI; numbers of dorsal ducts on IV–VI on each side: 3–6 submedians and 5–10 submarginals on IV, 2–5 submedians and 2–5 submarginals (2–4 along the posterior border, and often 1 in the anterolateral corner, of the segment) on V, and 1–3 on VI. Conical gland spines on the metathorax and abd I, their numbers on each side: 1–4 just caudad of the posterior spiracle and 3–6 in a submarginal row or group on abd I. Smaller gland spines within the lateral margin of abd II, 2 or 3 on each side. Very small, slender gland spines within or on the lateral margin on III and IV, 1–3 on each side of each segment. Marginal gland spines well developed and tending to be elongated on the pygidium, absent or occasionally 1 present on V, 1 or usually 2 on VI, 2 or occasionally 3 on VII, and 2 on VIII on each side, and 2 on IX (between the median trullae). Perivulvar disc pores: 2–4 in the median group, 5 or 6 in each anterolateral group, and 3 or 4 (usually 4) in each posterolateral group. Anterior spiracles each with 1 or 2 (often 1) trilocular disc pores.

Mercetaspis isis (Hall)

Material examined. Collected at Poshtkooh, Borazjan, Booshehr Province, on *Tamarix* sp. (Tamaricaceae), 23 October, 2001. Most of the specimens mounted were obtained from within galls formed on the branches. The gall is conical, attaining about 3mm across, with a small, round opening at the apex (Fig. 1). *Parlagena mckenziei* Balachowsky was also found in the material, occurring on the bark or in old, broken galls.

This species occurs on *Tamarix* in Egypt, Israel, Iraq, Iran, southern Turkmenistan, Tajikistan, and Pakistan (Danzig, 1993). It is also known as *Nilotaspis isis* (Hall). Danzig (1993) synonymized *Nilotaspis* with *Mercetaspis*, and her interpretation is followed here.

Mercetaspis isis is mentioned here on account of its association with a branch gall (see Material examined). So far as we are aware, it has not been known as a gall-inhabitant. In fact, in the present material this scale insect was not found in every gall opened for examination, and a few adult females were collected on the bark outside the galls. On the other hand, every examined gall contained abundant individuals of a mite. An individual of a thrips was also obtained from within a gall, and no doubt it had invaded the gall. The circumstance suggests that the mite was responsible for the gall and that *M. isis* was an inquiline in the gall.

Dr Yutaka Saito, Laboratory of Animal Ecology, Graduate School of Agriculture, Hokkaidô University, examined the mite. According to him, this mite belongs to the family Tydeidae, Prostigmata, while no mite, whether of the Tydeidae or any other family, has been known to induce a gall on the lignified part of a plant.

Mongrovaspis quadrispinosa (Green)

Material examined. Collected at Goater, Systan & Baluchestan Province, on the branch of *Avicennia officinalis* (Avicenniaceae), 24 April, 2003. Three adult females and their second-instar exuvial casts were mounted, but all these specimens are in poor condition. This species is newly recorded from Iran.

This species is a mangrove-inhabiting scale insect and associated with *Avicennia officinalis* and *A. marina*. It was originally described from Mersa Halaib, Egypt, and recorded by Ben-Dov (1980) from Ras Muhammad, the Sinai Peninsula, both these localities being situated on the coast of the Red Sea. Takagi (2002) redescribed the species on the basis of material collected in Mindoro and Luzón, the Philippines, and Lombok, Indonesia. The material from Iran favours the view that this species is widely distributed in the Indian Ocean between the Red Sea and eastern Asia.

Takagi (2002) compared the eastern Asian specimens with the published descriptions of the Red Sea form, and discussed agreements and disagreements of characters between them. The three adult females from Iran do not differ from the eastern Asian specimens except that some of the microducts occurring laterally to the anterior spiracles are associated each with a tubercle. They agree with the eastern Asian specimens in possessing minute ducts on the bases of the long pygidial processes. Although this character has not been stated in the descriptions of the Red Sea form, the close agreement between the Iranian and eastern Asian forms suggests that there is no substantial difference between the Red Sea form and the eastern Asian form, too. *Mongrovaspis quadrispinosa* may be considerably uniform through the supposed wide range of distribution.

Suturaspis archangelskyae (Archangelskaya) (Fig. 9)

Material examined. Fars Province, on the branches of *Fraxinus* sp. (Oleaceae).

Balachowsky (1953) and Danzig (1993) united *Salicicola*, *Suturaspis*, and *Leucaspidopsis* in one and the same genus. Indeed, there is no good basis for the generic separation in the adult females, which are, however, much simplified in association with the pupillarial mode of life. In the second-instar females of the type species, which were studied by Balachowsky (1953), *Suturaspis* is quite distinct from *Salicicola* and *Leucaspidopsis* in the pattern of the pygidial appendages. In *Suturaspis* the pygidial appendages are trullae and pectinae, both of the usual types, whereas in the other two genera the appendages are strong trullae followed by a series of sclerotized, conical processes. In diaspidids, in general, congeneric species and even species of closely related genera are very similar in the second-instar females, especially in the pygidial fringe. When this generalization is applied to the three nominal genera, *Salicicola* and *Leucaspidopsis* could be united in one genus and *Suturaspis* should not be so closely related to them as suggested by the similar adult females. In this paper, *Suturaspis* is recognized as a distinct genus, and species with the pygidial appendages in the second-instar female much reduced or almost obsolete are also referred to the genus.

Two forms of *Suturaspis* have been available for the present study, and are regarded as distinct species. One of them is identified with *S. archangelskyae*. The specific name of this species was attributed to Lindinger by authors but, according to Danzig (1993), Archangelskaya should be responsible for it. It seems that the other form is identical with *Leucaspidopsis crataegi* Bodenheimer. Balachowsky (1953) treated these two forms under the name *Salicicola Archangelskaiae* on the view that they represent polymorphism in the same species. Other authors, too, may have treated these two forms under *Suturaspis* (or *Salicicola*) *archangelskyae*. It is noteworthy that Seghatoleslâmi (1977) recorded *S. archangelskyae* in Iran from diverse plants including *Daphne angustifolia*, from which *S. crataegi* is recorded in the present study (see under *S. crataegi*).

Suturaspis archangelskyae as understood in the present study is distinguishable from *Suturaspis crataegi* in the following characters: in the adult female, the pygidium is nearly conical, and the median and second trullae are usually represented by low prominences, which are broadly rounded and sclerotized along the margin; in the second-instar female, both trullae and pectinae are well represented, occupying a broad apical margin of the pygidium (for the alternatives to these characters, see under *Suturaspis crataegi*). The trullae are sometimes very low and almost obsolete in the adult female but, even in that case, the pygidium is nearly conical, not conforming to the broadly rounded pygidium of *S. crataegi*. In the examined specimens of the adult female each anterior spiracle is provided with one to three quinquelocular disc pores, and there are no microducts laterally to the mouth-parts except for a few ducts occasionally present on one or either side. In the specimens of the second-instar female, each anterior spiracle is provided with one or two quinquelocular disc pores.

A broad variation has been observed in the development of the trullae in the second-instar female as shown in Fig. 9. The trullae are sclerotized, but tend to be frayed apically. They are sometimes similar to the neighbouring pectinae in size and shape, thus being not easily distinguishable from the latter (Fig. 9B). Usually the trullae are elongated in various degrees (Fig. 9A, 9C), and sometimes form extraordinary, narrowly oblong processes (Fig. 9D). (See also Discussion: Phenotypic variation.)

Suturaspis crataegi (Bodenheimer) (Figs 10–13)

Material examined. Collected in Asaluyeh–Haftchah, Booshehr Province, on *Daphne angustifolia* (Thymelaeaceae), 19 May, 2001. Female and male tests were found on the sepals and the bases of the leaves.

Bodenheimer (1943) described *Leucaspidopsis crataegi* on the basis of material collected at Shaklawa, Iraq, on the twigs of *Crataegus monogyna* (Rosaceae). His description of the adult female is fairly detailed, and has afforded a basis for the identification of the present form with his species. The specimens from Iran nearly agree with his description and figures except that the median dermal spicules ('rows of very small tooth-like processes') occur not on the dorsal surface (as described and illustrated by him) but on the ventral surface of the thorax and prepygidial abdomen (as usual in diaspidids). Apparently, this disagreement is not real, being attributable to some technical reason (the condition of the specimens, the power of the microscope, and so on).

This species is referable to *Suturaspis*, and the adult female is very similar to that of *Suturaspis archangelskyae*, from which it is distinguishable in the pygidium broadly rounded along the apical margin and crenulated on the entire margin; in all the examined specimens there is no trace of trullae (Figs 10, 11). Each anterior spiracle is provided with one to three (or four?) quinquelocular disc pores. There are no microducts laterally to the mouth-parts.

Bodenheimer did not examine the second-instar female. In this stage, the median and second trullae are rudimentary and represented by low, roundish, somewhat sclerotized prominences, and there are no distinct pectinae (Figs 12, 13). This species, therefore, is easily distinguishable from *Suturaspis archangelskyae* in the second-instar female. Each anterior spiracle is provided with one or two quinquelocular disc pores as in *S. archangelskyae*.

Moreover, this species is unique and peculiar in having a pair of large fan-like processes on the ventral surface of the pygidium in the second-instar female (Fig. 13C –F). These processes, which are called 'flabella' in the following lines, belong to the seventh abdominal segment, arising from the submedian areas on the posterior border of the sternum and expanding over the posterior surface of the pygidium. Each flabellum is composed of four to eight sticks, which are slender, pointed apically, often broadened subbasally and then gradually attenuated, and often curved. Neighbouring sticks are usually connected together by one or more slender spokes near their bases or on their basal halves. The occurrence of flabella, however, is not stable: sometimes they are lacking (Figs 12, 13A) or rudimentary (Fig. 13B). (See also Discussion: Phenotypic variation.)

Balachowsky (1953) was the first to notice the occurrence of flabella. As stated by him, such a conformation is unknown in any other species of the family. However, he supposed the occurrence of flabella to be an infraspecific variation in *Salicicola Archangelskaiae*. He synonymized *Leucaspidopsis crataegi* and *L. crataegi* forma *fraxinicola*, both described by Bodenheimer (1943), with that species. According to Bodenheimer, forma *fraxinicola* possesses well-developed median and second trullae in the adult female. It seems certain, therefore, that this form is identical with *Suturaspis archangelskyae*. However, *Suturaspis crataegi* and *S. archangelskyae* as represented by the specimens examined in the present study are distinguishable in both the adult female and the second-instar female by the differences mentioned above. Thus, the presence or absence of flabella should be an infraspecific variation in *Suturaspis crataegi*.

Balachowsky found this conformation in colonies from Iran and Central Asia, so that *S. crataegi* must be widely distributed over these areas.

In describing *Salicicola Archangelskaiae*, Balachowsky (1953) did not clearly discriminate the two forms. However, most of the figures on Planche CXLIX in his monograph represent *Suturaspis archangelskyae*, and Figs 1 and 2 on Planche CL show the pygidia of the adult and second-instar females of *Suturaspis crataegi* (Fig. 3 on this plate has no explanation, and it is not certain which part of the body is depicted in the figure).

It seems that *Suturaspis crataegi* and *Suturaspis archangelskyae* overlap in geographical distribution. Though the recorded host plants are still few, *S. crataegi* is probably polyphagous. *S. archangelskyae* is polyphagous, having been recorded from many plants (which, however, must include host plants of *S. crataegi* confused with *S. archangelskyae*). The possibility that *S. crataegi* and *S. archangelskyae* are geographical or host–associated races of the same species, therefore, should be excluded. However, further studies based on material from various localities and diverse host plants and including *Suturaspis pistaciae* (Lindinger) and *Suturaspis davatchi* (Balachowsky and Kaussari), which also occur in Iran and are associated with *Pistacia*, may be necessary to clear up the relationships among these *Suturaspis* forms. *S. crataegi* is probably closely related to *S. davatchi*.

Oceanaspidiotus spinosus (Comstock) (Fig. 14)

Material examined. Collected at Chabahar, Systan & Baluchestan Province, on the stem of eggplant, *Solanum melongena* (Solanaceae), 28 April, 2003, together with *Aonidiella orientalis* (Newstead) and *Lepidosaphes pallidula* (Williams). More than 30 specimens of the adult female were mounted. This species is newly recorded from Iran.

This species is widely distributed in the tropics and warm areas of the world, occurring on a long list of plants. In the adult female, it is variable in the development of the trullae, the thickness of the marginal setae occurring on the sixth and seventh abdominal segments, and the numbers of the perivulvar disc pores and dorsal macroducts. One extreme of the variation in the pygidial fringe was described as *Aspidiotus persearum* Cockerell and the other extreme as *Acanthaspidiotus borchsenii* Takagi and Kawai. In a comparison of specimens from various parts of the world, these forms merged into an indivisible series through intermediate individuals, and the species thus recomposed was referred to the newly proposed genus *Oceanaspidiotus*. It was called *O. spinosus*, because the earlier named *Aspidiotus spinosus* was included as an infraspecific form (Takagi, 1984).

The present specimens from Iran are similar to the *borchsenii* form especially in having robust median trullae, tubercular second trullae, and membranous and spiniform third trullae. The dorsal and ventral marginal setae of the seventh abdominal segment and the dorsal marginal seta of the sixth are more or less thickened. The specimens do not differ from the *borchsenii* form in the total number of the dorsal macroducts on the pygidium. However, they usually possess, in addition, a few or several submarginal dorsal macroducts on the third abdominal segment. They remarkably differ from the *borchsenii* form and the other specimens examined by Takagi (1984) in having much more perivulvar disc pores as follows: 0–3 in the median group (0 in 20 out of 30 specimens), 9–16 in each anterolateral group (sample size=60, mean=12.0), and 5–11 in each posterolateral group (sample size=60, mean=7.9); total 33–46.

The present specimens suggest that the variation in *Oceanaspidiotus spinosus* is not yet fully known.

Rungaspis avicenniae, sp. nov. (Fig. 15)

Material examined. Collected at Goater, Systan & Baluchestan Province, on the branches of *Avicennia officinalis* (Avicenniaceae), 30 March, 2001 and 24 April, 2003. Female and male tests white, burrowing under a thin upper epidermal layer of the bark. The description below is based on about 20 adult females mounted from the material. Two specimens of the adult female collected in Gheshm–Tabl, Hormozgan Province, on *A. officinalis*, 8 March, 2001, were also examined. A specimen of the adult female collected at Goater, 2001, is designated as holotype.

Adult female. Body circular, with the pygidium broad, triangular, and a little rounded along the margin; attaining about 1mm in length when fully grown. Prepygidial region becoming oblong, strongly sclerotized broadly along the margin at maturity. Dorsal surface of the pygidium somewhat sclerotized on a broad median area, subbasally with a slender median sclerosis curved to form an inverted U-shape, sometimes interrupted medially, and with an oblique lateral sclerosis on each side divided into several pieces. Ventral surface of the pygidium with two pairs of strong, longitudinal paravulvar scleroses, one pair anteriorly to the level of the vulva and the other laterally to the vulva; perivulvar disc pores absent. Antennae situated between the head margin and the mouth-parts, separated from each other by a space nearly as broad as the mouth-parts, tubercular, each with a rather short, robust seta. Median trullae robust, set parallel, separated from each other by a space much narrower than one of them; each median trulla conical, with the outer margin sloping and the apex rounded, deeply notched once on the outer side, and also notched once on the inner side but less deeply and more apically; each median trulla with a robust, clavate basal sclerosis about as long as the trulla. No trace of lateral trullae. A pair of pectinae occurring between the median trullae, usually reduced to very small, spinous processes; 1 or 2 similar spinous processes present just laterally to each median trulla; no further pectinae. Marginal seta on the dorsal surface of abd VII thickened. Anus round or oblong, subapical, separated from the apex of the pygidium by a space 2 or 3 times as long as its longitudinal diameter. Dorsal ducts filiform; their segmental pattern of arrangement is not obvious on the pygidium probably because they are few: 1 or 2 marginally between the median trullae; 1 between the marginal setae of abd VII and VIII, and 1 or 2 on each of the succeeding spaces between the marginal setae of abd IV–VII; some ducts scattered submarginally over abd IV–VII and a few submedially towards the anterolateral corner of the pygidium; 1 or a few ducts submarginally and also submedially on each prepygidial abdominal segment. Ventral microducts occurring within the margin on the segments comprised in the pygidium and anteriorly as far as the metathorax; scattered submarginally on the mesothorax, in front of each anterior spiracle, and around the eye.

Remarks. This species is similar to *Rungaspis capparidis* (Bodenheimer) (=*R. trabuti* Balachowsky) in the median trullae of the adult female distinctly separated from each other, but is easily distinguishable from the latter in the anus situated much closer to the median trullae, in lacking spiniform pectinae on the seventh abdominal segment, in having fewer dorsal ducts towards the apex of the pygidium, in having some submarginal dorsal ducts towards the lateral corner of the pygidium, and in the dorsal marginal seta on the seventh abdominal segment thicker than the setae on the other segments. Three

adult females of *R. capparidis*, collected at Zahedan, Daman, on *Calotropis procera*, have been examined for comparison. In these specimens, the anus is separated from the apex of the pygidium by a space four or five times as long as its diameter; there are as many as 20 dorsal ducts towards the apex of the pygidium on each side, forming an ill-defined broad row extending anteriorly beyond the level of the anus. The second and third trullae are absent, but there are slight marginal prominences on the seventh and sixth abdominal segments; no paraphyses or distinct scleroses, however, are associated with these prominences. Short spiniform pectinae occur in pairs on the seventh to ninth abdominal segments.

Specimens of *Rungaspis macrolobis* Kaussari, collected at Iranshahr on *Haloxylon*, have also been examined. This species is distinct in having the median trullae closely appressed together and deeply notched on the outer side. However, it is similar to the new species in the anus situated close to the apex of the pygidium and in the dorsal ducts of the pygidium fewer than in *R. capparidis*.

Rungaspis arcuata Munting was described from South Africa. So far as based on the original description and accompanying figure (Munting, 1967), it is not easily distinguishable from *R. capparidis*.

Diaspidiotus platychaetae, sp. nov. (Fig. 16)

Material examined. Collected at Bagmalek, altitude 759m, Khuzestan Province, on *Platychaeta mucronifolia* (Asteraceae), 30 April, 2001. Female and male tests occurring on both surfaces of the leaves. Female test circular, white, with the exuvial casts yellowish to brownish; male test also white. More than 30 specimens of the adult female were mounted, but many of them are fully aged, with the median trullae more or less worn out apically. The other specimens keep the shape of the median trullae, which is quite characteristic as described below, and one of them has been selected as holotype.

Adult female. Body broadly obpyriform, with the pygidium broad and triangular; attaining 1mm or more in length when fully grown. Prepygidial region rounded, broadly sclerotized along the margin at maturity. Dorsal surface of the pygidium sclerotized, largely covered with irregular longitudinal stripes, subbasally with a pair of transverse submedian scleroses and a pair of oblique lateral scleroses. Ventral surface of the pygidium with a pair of broad, longitudinal paravulvar scleroses; perivulvar disc pores lacking. Antennae situated between the frontal margin and the mouth-parts, separated from each other by the width of the mouth-parts, each consisting of a flat tubercle and a short seta. Median trullae separated from each other by a space nearly half as wide as one of them, parallel, little narrowing apicad, with the apex slanting outwards and broadly and shallowly concave. No trace of lateral trullae. No trace of pectinae. A pair of short, robust scleroses on the pygidial margin between abd VI and VII, and also between VII and VIII, each pair embracing the orifice of a duct. Anus nearly rounded, separated from the apex of the pygidium by a space 2.4–3.7 times as long as its longitudinal diameter. Dorsal ducts small and slender, little larger than the ventral microducts, mostly arranged segmentally on the pygidium; 2 marginally between the median trullae; 3–5 ducts (including the one between the marginal scleroses) in a short row between abd VII and VIII, sometimes with another duct submarginally on VII; 8–13 ducts (including the one between the marginal scleroses) in a much longer, oblique row between abd VI and VII, with 2–6 ducts forming a parallel row on VI; many ducts on abd V submarginally, and some on the lateral subbasal sclerosis, all these ducts often forming a continuous row; 1

–3 ducts often present medially on the base of the pygidium. Prepygidial dorsal ducts abundant on abd II–IV submdially and submarginally; ducts scattered within the margin on abd I, a few ducts on the margin of the metathorax and on the posterior corner of the mesothorax; no ducts in the preceding region of the body. Submarginal rows of ventral microducts on abd IV–VI.

Remarks. *Diaspidiotus* and *Quadraspidiotus* had long been recognized as distinct genera until Danzig (1980, 1993) united them in one and the same genus. They had been separated by the presence or absence of lateral trullae, but the development of lateral trullae varies in a continuous manner and there are no distinct differences in other features. Moreover, in diaspidids in general, the development of lateral trullae may greatly change between closely related forms, even within the same species. Danzig's decision has afforded a broader scope for investigating relationships among species once referred to the different genera. Her view has recently been adopted by Ben-Dov and German (2003) in their catalogue.

The new species is unique in the median trullae with the apex obliquely truncated and broadly concave. *Diaspidiotus slavonicus* (Green) (=*Quadraspidiotus slavonicus*) is variable in the shape of the median trullae; in one form the median trullae (and the second, too) are subrectangular, with the apex truncated and slightly concave (Balachowsky, 1950), thus resembling the median trullae in *D. platychaetae*. These two species differ in many other features, and there seems to be no possibility that they are closely related. *Aspidaspis dentilobis* Kaussari and Balachowsky also possesses rectangular median trullae. All these species occur in Iran, but are associated with quite different plants.

Discussion: Phenotypic variation

Phenotypic variation in association with different feeding sites on the host plant is now known in some species of the Diaspididae, and the leaf-associated forms have been supposed to be atavistic and, thus, to suggest more about ancestral phenotypes than the branch-associated forms (for a summary, see Takagi, 1990). *Lepidosaphes belutchistana* presents another example of site-caused variation, the second trullae in the adult female being low and membranous in the twig-associated form and remarkably elongated and sclerotized in the leaf-associated form (Fig. 8). Generally in *Lepidosaphes* species, the second trullae are sclerotized and yet much smaller than the median trullae. The second trullae probably play a subsidiary role as compared with the median trullae and are shaped accordingly (apart from the question what their role is). On this generalization it seems that *L. belutchistana* has lost the function of the second trullae, which are too weak in the twig-associated form and extraordinarily developed and too elongated in the leaf-associated form. This state of the second trullae in the leaf-associated form may basically be atavistic, but apparently does not faithfully reflect the ancestral phenotype.

Unusually elongated trullae have also been observed in the second-instar female of *Suturaspis archangelskyae*. This stage shows a broad variation of the trullae (Fig. 9), which fact is sufficient to arouse doubt that the trullae, though well represented, still retain their functions. In the second-instar females of other congeneric species (*Suturaspis crataegi*; *S. davatchi*), the pygidial appendages are rudimentary and apparently of no use.

In pupillarial diaspidids, the adult female is entirely enclosed within the sclerotized exuvial cast of the second instar. Under this condition, the pygidial appendages in the

adult female are apparently useless, and in many species they are much reduced or even obsolete. In some other species, however, appendages grow extraordinary in size and strange in shape. Thus, overgrowth and monstrosity are also evidence of functionless appendages, which are liberated from adaptive constraints. The cases of *Lepidosaphes belutchistana* and *Suturaspis archangelskyae* suggest that in the pygidial appendages of non-pupillarial forms and even second-instar females, too, loss of function at times results in overgrowth.

Fiorinia phoenicis is pupillarial, and shows a great variation in the median trullae of the adult female, the only distinct pygidial appendages in this stage. These trullae should be functionless, but appear to vary in an orderly manner, with no overgrowth involved. In *normal* specimens, the median trullae conform to the fioriniine pattern (Fig. 2B). In the other specimens, these trullae take *abnormal* shapes, which, however, are not strange to us. Three types of the median trullae have been observed on them. In one type, the median trullae are fused together but still retain their apices (Fig. 2C). In another type, the trullae are completely fused to form a round process (Fig. 2D). These two types find analogues in other various non-pupillarial diaspidids, in which such fused median trullae are normal features and undoubtedly perform their functions in the adult females. In the third type, the median trullae are depressed and expanded along the pygidial margin, thus nearly merged into the latter, which is smoothly rounded, with no particular prominences (Fig. 2E). This type approaches the rugaspidiotine pattern, which is found in some unrelated taxa.

Quite strange processes, called flabella in this paper, occur on the ventral surface of the pygidium in the second-instar female of *Suturaspis crataegi* (Fig. 13). This stage has rudimentary trullae and no pectinae. The flabella may occur as a substitute for these rudimentary or obsolete appendages. However, the ordinary pygidial appendages are formed on the lateral margins of the pygidial segments, whereas the flabella are situated on the posterior border of the seventh abdominal segment. The flabella may be homologous with the spicules occurring on the ventral surface of the preceding abdominal segments and thorax, but these spicules are arranged across a broad median region and do not occur on the posterior borders of the segments (Fig. 12). It seems that the flabella are a novel conformation that has abruptly appeared in *S. crataegi*. As a feature, however, the flabella are still unstable, their full development and complete absence having been observed in the same colony.

In all the observed flabella, the neighbouring sticks are usually connected by one or more spokes near their bases or on their basal halves (Fig. 13C–F). The development of this pattern may be explained by the following alternative suppositions.

1) Each flabellum is formed by a pack of growing sticks, of which most neighbouring ones are fused together at one or more points during an early stage in their growth. The points, then, are stretched to form spokes as the sticks grow and expand. In one observed case, the paired flabella are fused together at the apices of their mesalmost sticks (Fig. 8F), and this example suggests that pointwise fusions are possible also between neighbouring sticks.

2) Each flabellum originates from a lobe-like extension of the ventral derm, and the sticks are formed by the occurrence of apoptosis in the regions where the spaces between the sticks are to appear. In general, programmed cell death (PCD), of which the process is known as apoptosis, is a prominent phenomenon in development and metamorphosis. Apoptosis itself has a broader biological significance, playing a critical role also in

tissue homeostasis and a wide variety of diseases, including cancer. PCD is involved, for example, in digit formation in quadrupeds, and partial apoptosis results in webbing. In an analogous manner, punctuated apoptosis in the subbasal region of the flabella may form spokes.

A rudimentary flabellum has been observed (Fig. 13B). It may be a growing stick, but it also appears to be an incipient lobe. Various rudimentary flabella (including developing flabella within the body of the first instar) may show which supposition is correct.

It is doubtful that the flabella have any important function in the life of *Suturaspis crataegi*, because they are not stable in occurrence. Moreover, it is not easy to imagine their function from their structure. The specimens examined in the present study are not sufficiently numerous to estimate the frequency of flabellum-bearing individuals in the colony from which they were collected, but it seems that the frequency was considerably high. Half a century ago, the flabella occurred widely in Iran and Central Asia (Balachowsky, 1953). In 2001, they arose with considerable frequency in Booshehr Province, Iran. They probably have continued to appear for a long time and in a vast area. What factor, then, has maintained their appearance, if they have no function?

Phenotypic plasticity refers to the production of different phenotypes in response to different external conditions and in adaptation to those environments. In the interpretations attempted above, the phenomena in the four diaspidids are concerned not immediately with adaptation but with phenotypic potential, which is fundamental to phenotypic evolution and adaptation.

Acknowledgements

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Fig. 1. Branch galls on *Tamarix* sp., inhabited by *Mercetaspis isis*. Scales in millimetres.

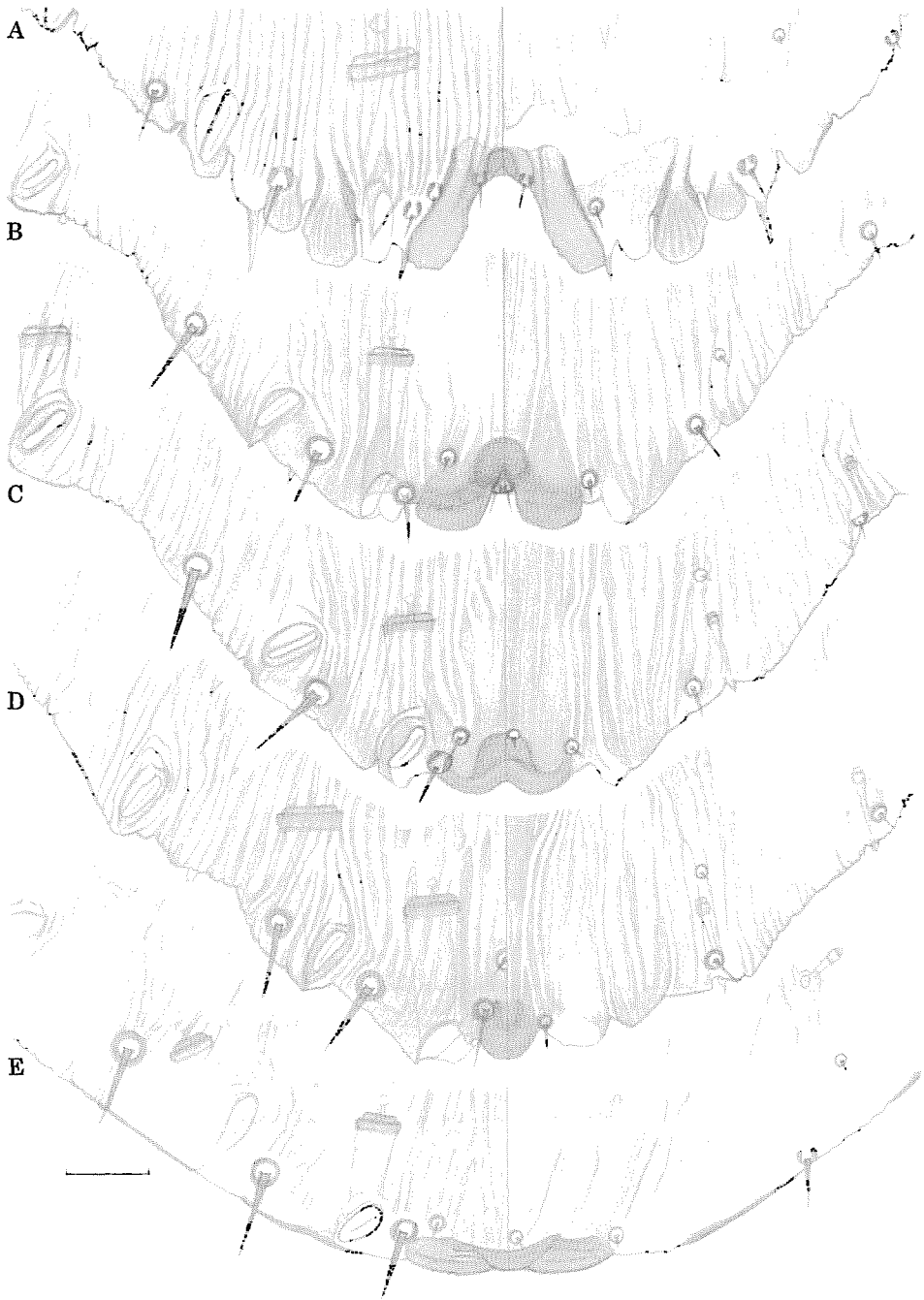

Fig. 2. *Fiorinia phoenicis*, second-instar female exuvial cast (A) and adult females (B–E): pygidial margins. Scale bar: E, 10μm (A–D magnified at the same rate as E).

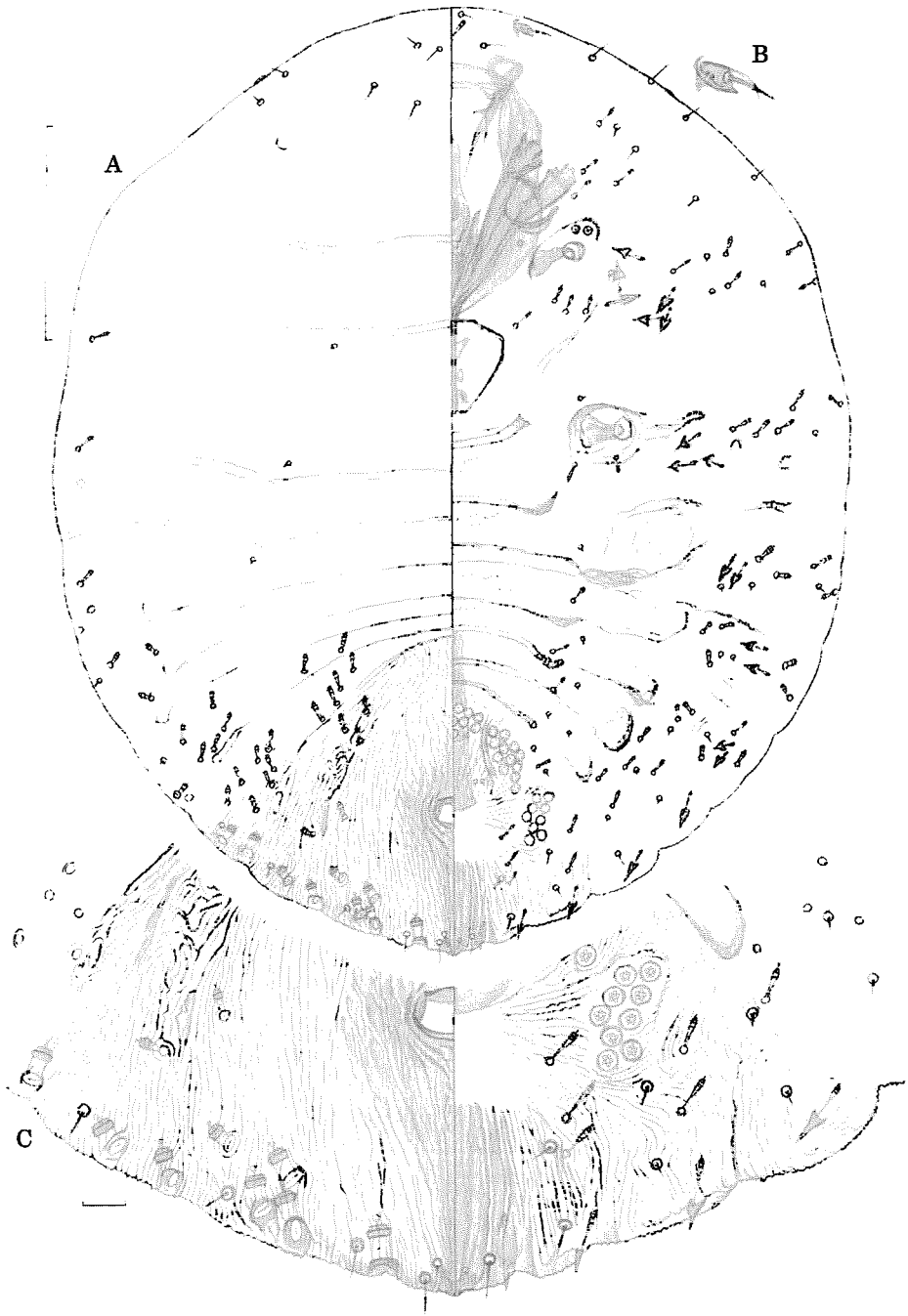

Fig. 3. *Contigaspis* sp., adult female. B, antenna; C, pygidial margin. Scale bars: A, 100μm; C, 10 μm (B magnified at the same rate as C).

Fig. 4. *Balachowskiella* sp., adult female. B, pygidial margin; C and D, trullae in dorsal and ventral view, respectively. Scale bars: A, 100μm; C, 10μm (B and D magnified at the same rate as C).

Fig. 5. *Lepidosaphes pallidula*, adult female. B, antenna; C, posterior spiracle, with ducts and tubercular gland spines; D, ducts, tubercular gland spines, and spur on the lateral lobe of abd I. Scale bars: A, 100μm; D, 10μm (B and C magnified at the same rate as D).

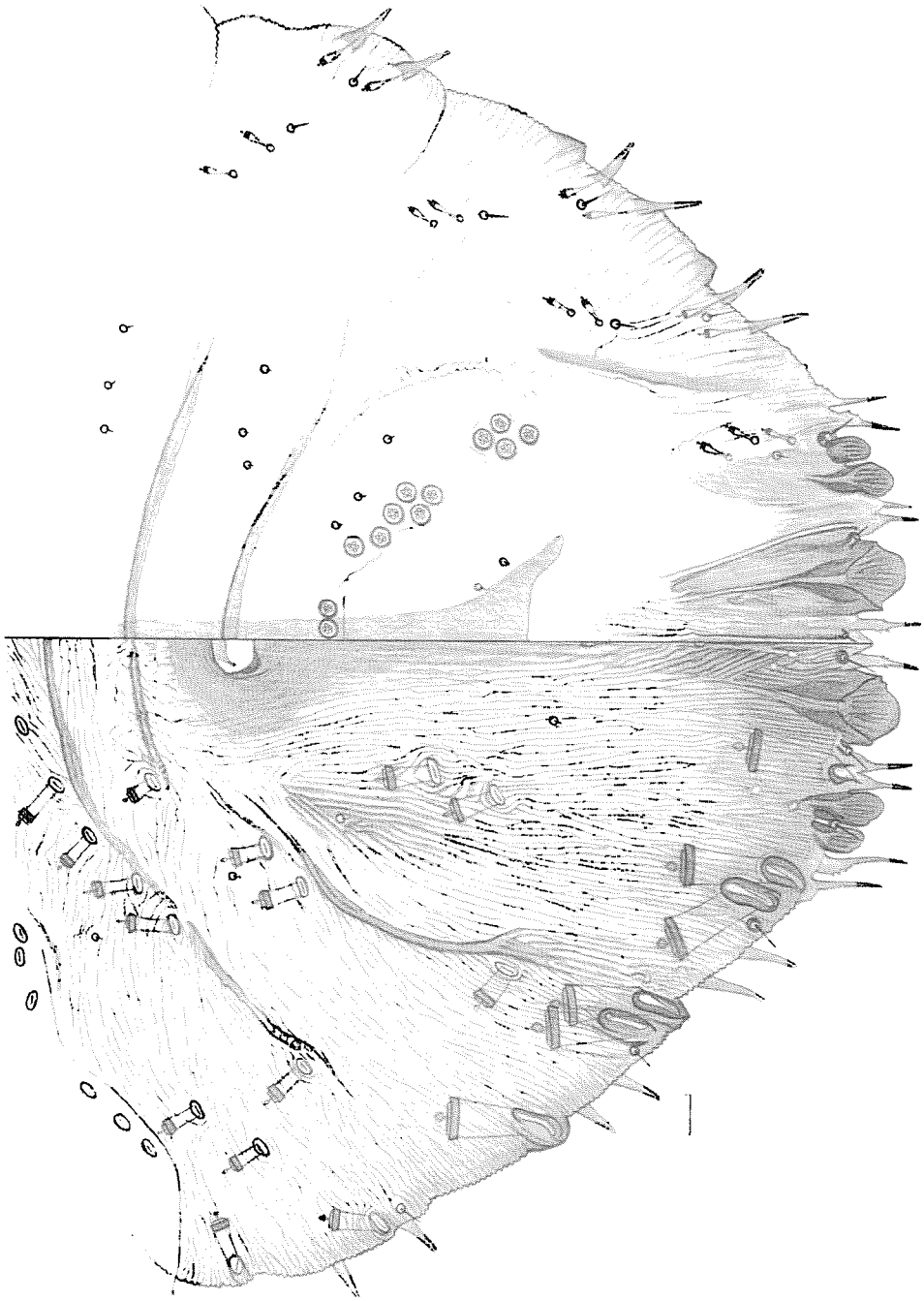

Fig. 6. *Lepidosaphes pallidula*, adult female: pygidium. Scale bar: 10μm.

Fig. 7. *Lepidosaphes belutchistana*, twig-associated form, adult female. B, antennae with microducts between; C, posterior spiracle with ducts and gland spines; D, ducts and gland spines on the lateral lobe of abd I. Scale bars: A, 100μm; D, 10μm (B and C magnified at the same rate as D).

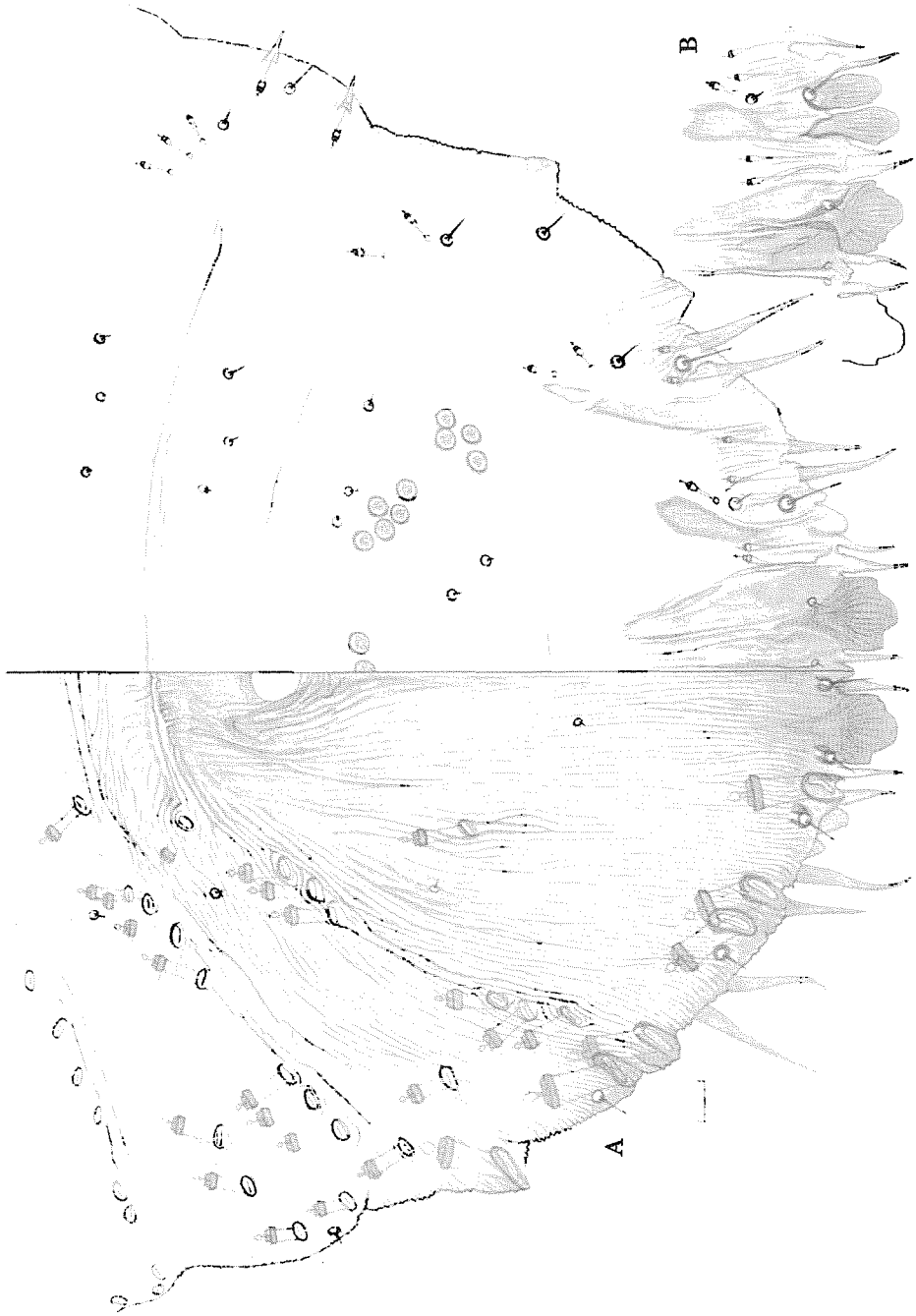

Fig. 8. *Lepidosaphes belutchistana*, adult female. A, twig-associated form, pygidium; B, leaf-associated form, median and second trullae in ventral view. Scale bar: A, 10μm (B magnified at the same rate as A).

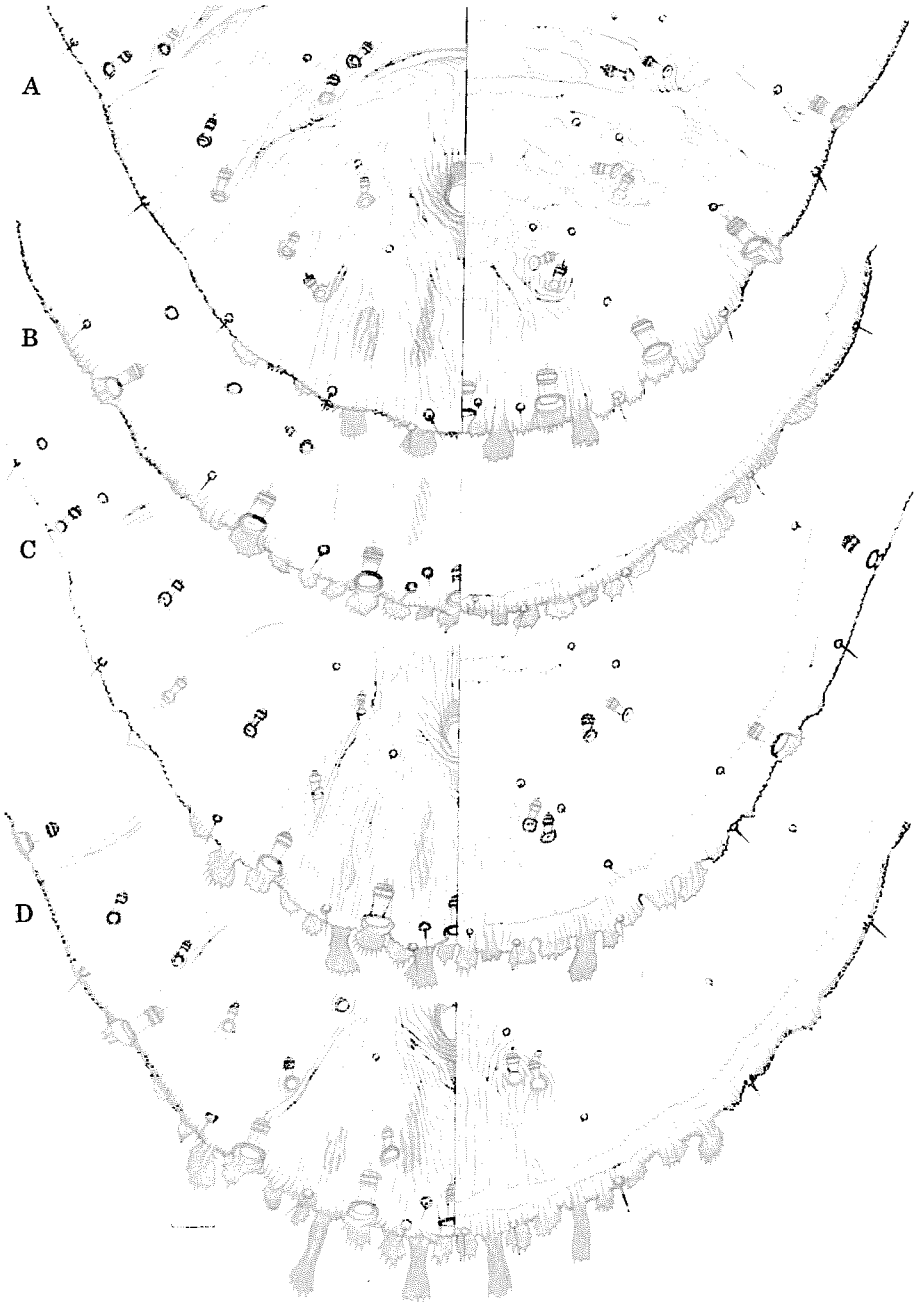

Fig. 9. *Suturaspis archangelskyae*, second-instar females: pygidial appendages. B–D, exuvial casts. Scale bar: D, 10μm (A–C magnified at the same rate as D).

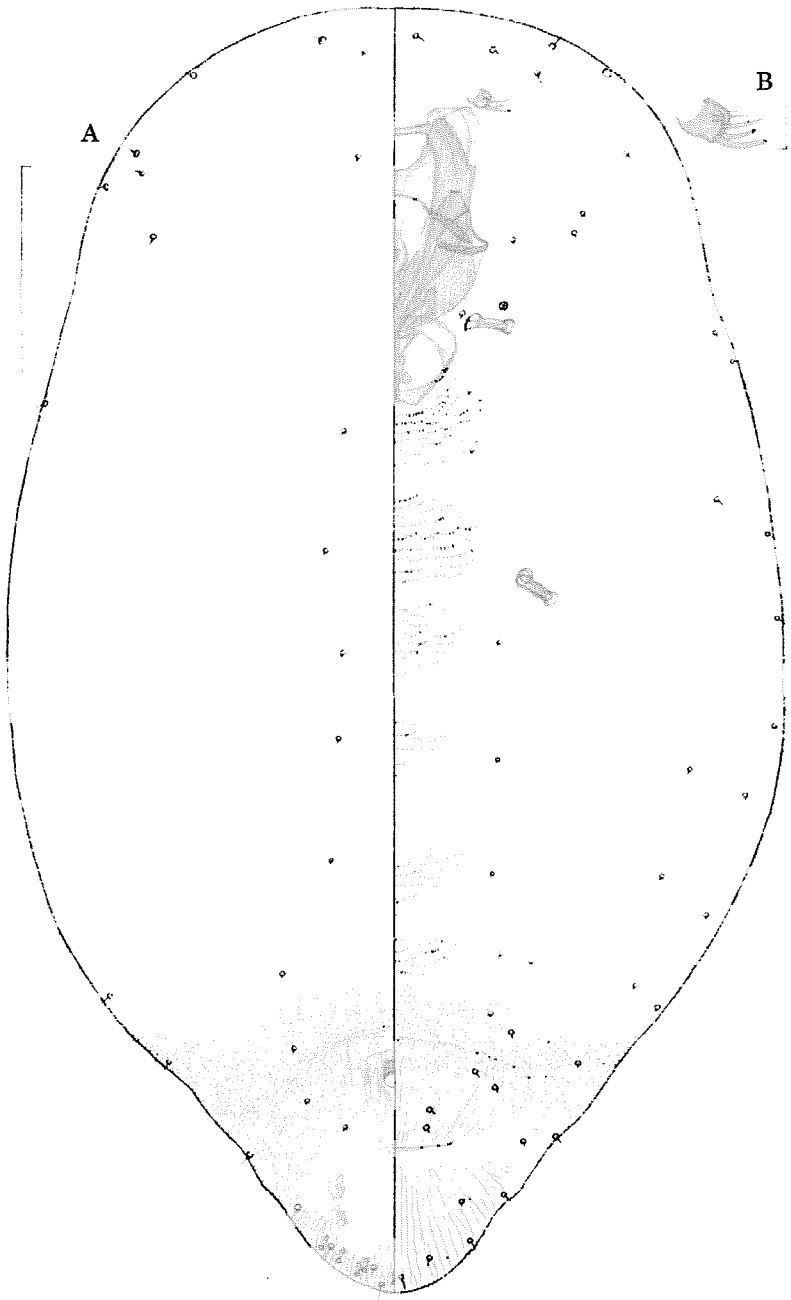

Fig. 10. *Suturaspis crataegi*, adult female. B, antenna. Scale bars: A, 100μm; B, 10μm.

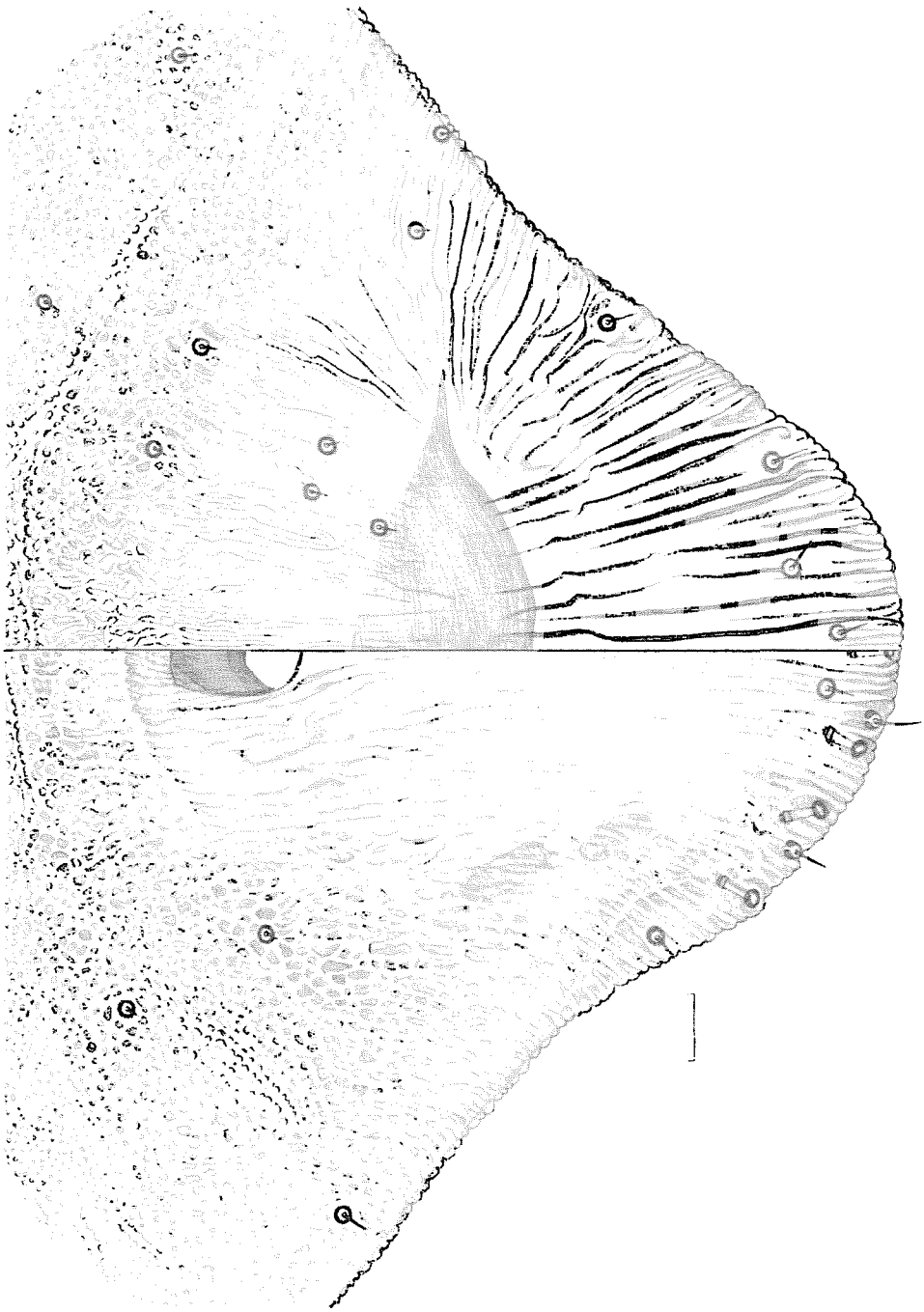

Fig. 11. *Suturaspis crataegi*, adult female: pygidium. Scale bar: 10μm.

Fig. 12. *Suturaspis crataegi*, second-instar female. B, antenna. Scale bars: A, 100μm; B, 10μm.

Fig. 13. *Suturaspis crataegi*, second-instar females: pygidia and flabella. D–F, exuvial casts. Scale bar: C, 10μm (A, B, and D–F magnified at the same rate as C).

Fig. 14. *Oceanaspidiotus spinosus*, 'Chabahar form' (near the *borchsenii* form), adult female: pygidium. Scale bar: 10μm.

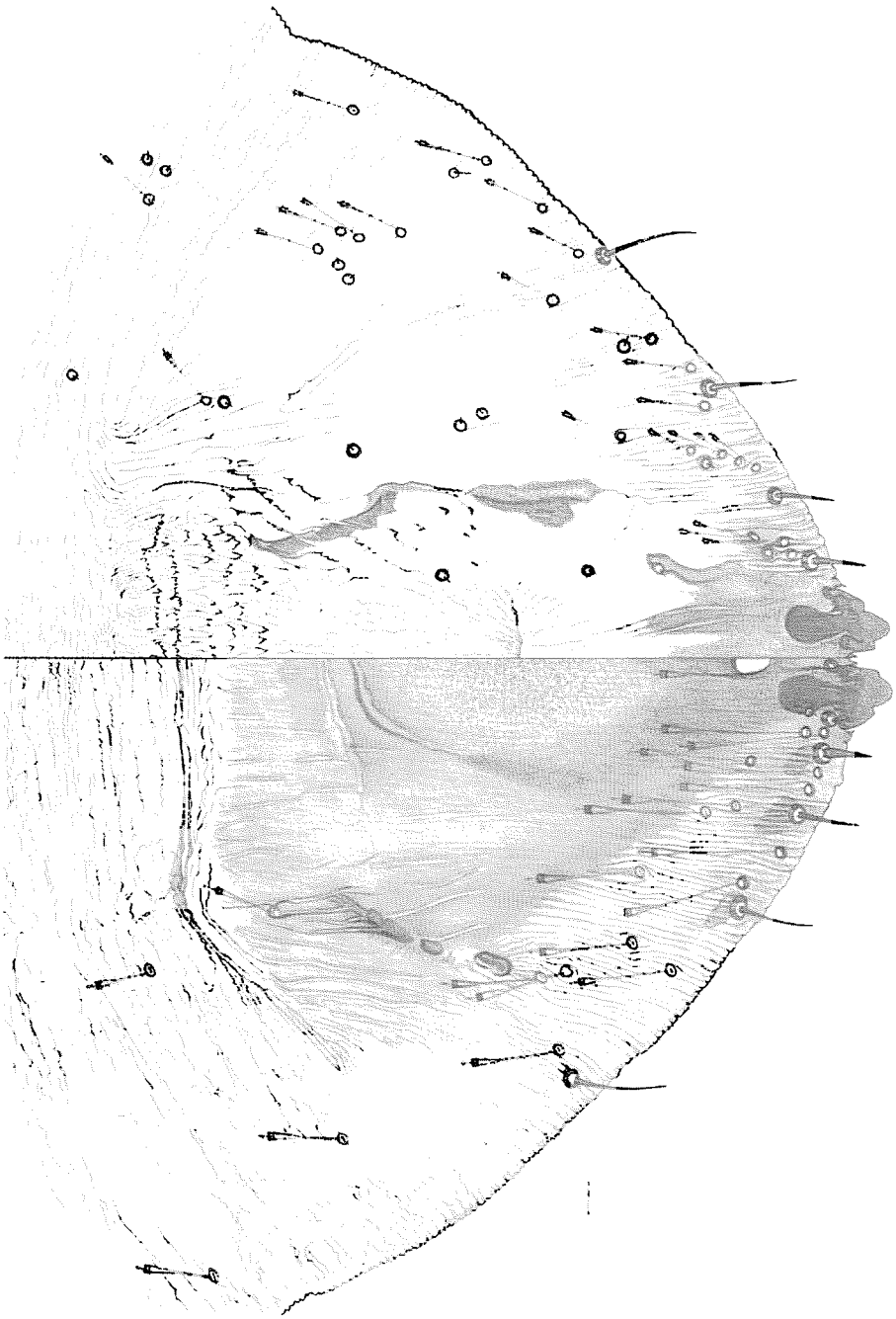

Fig. 15. *Rungaspis avicenniae*, adult female: pygidium. Scale bar: 10μm.

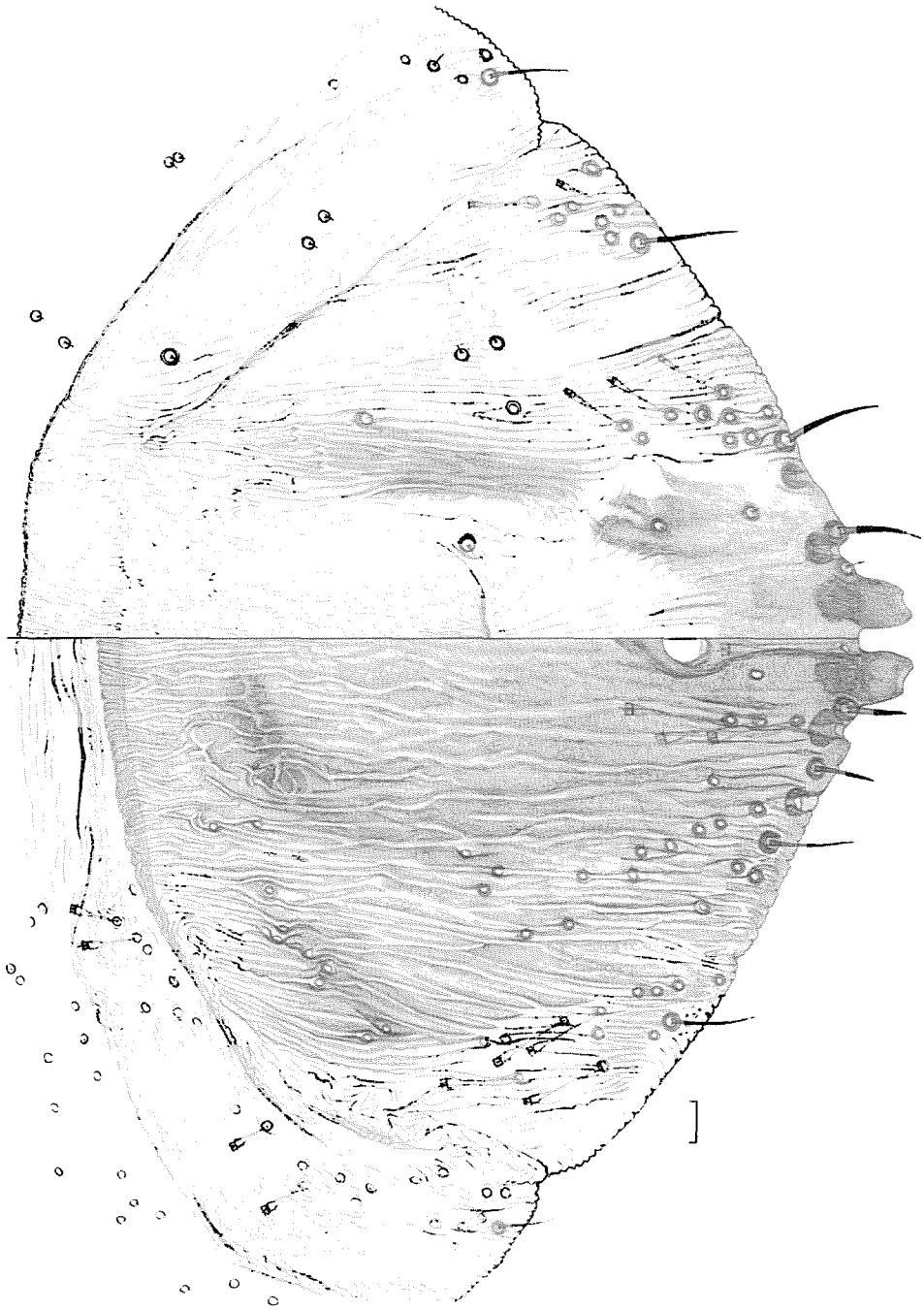

Fig. 16. *Diaspidiotus platychaetae*, adult female: pygidium. Scale bar: 10μm.