

Key to conifer-infesting species of *Lepidosaphes* Shimer worldwide (Hemiptera: Coccoidea: Diaspididae), with descriptions of two new species and a redescription of *L. pallidula* (Williams)

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Abstract

Two new species of *Lepidosaphes* are described, *L. caribaeae* Williams and Miller from Trinidad and Jamaica and *L. murreeana* Williams and Miller from Pakistan. *Lepidosaphes pallidula* (Williams), a non-conifer infesting species, is redescribed so that it can be distinguished from *L. pallida* (Maskell), a species commonly detected on conifers. A dichotomus key is presented for the identification of the adult females of the 25 species of *Lepidosaphes* that occur on conifers worldwide and a matrix is provided containing 23 characters considered important in distinguishing the 25 conifer-infesting species.

Key words: *Lepidosaphes*, conifer, armored scale, Trinidad, Jamaica, Pakistan, worldwide

Introduction

While writing a manuscript on the economic armored scales of the United States (Miller & Davidson 2005), considerable effort was spent sorting out the identity of *Lepidosaphes* species that occur on conifers, especially *Lepidosaphes pallida* Maskell and *L. pallidula* (Williams) (the latter does not occur on conifers but has been confused with *Lepidosaphes pallida*). In the United States *L. pallida* has gone under the names Maskell scale, *L. maskelli* Cockerell; Newstead scale, *L. newsteadi* Šulc; and Maskell scale, *L. pallida*. The purpose of this paper is 1) to redescribe *L. pallidula* so that it can be compared with *L. pallida*, 2) to describe two new conifer-infesting species of *Lepidosaphes*, 3) to provide a key to the conifer-infesting *Lepidosaphes* species world wide, and 4) to provide a matrix

of characters that can be used to distinguish the 25 conifer-infesting species of *Lepidosaphes*.

Maskell (1895) first used the name *Mytilaspis pallida* and stated, “*Mytilaspis pallida*, Green (var.?). I have received from Mr. Koebele a *Mytilaspis* on *Podocarpus* sp., imported into Honolulu from Japan, which seems to me to be so close to a species in Ceylon to which Mr. Green proposes to give the name of *M. pallida*. Mr. Green has not yet published a description of his insect.” Although Maskell did not intend to publish the name, he included a description sufficient to validate it. Green (1896a) described the species mentioned by Maskell from Ceylon (=Sri Lanka) as *Mytilaspis pallida*. Cockerell (1897) realized that the two species were different and gave a replacement for the older name (*Mytilaspis pallida* Maskell, 1895) calling it *Mytilaspis pallida maskelli*. Unfortunately, the Maskell species did not require a replacement, so Cockerell’s name was unnecessary. Even though this name is invalid, it was used as the correct species epithet for many years in several major publications (Balachowsky 1954; McKenzie 1956; Borchsenius 1966). Ferris (1938) treated the species from the U. S. as *L. newsteadi* but McKenzie (1956) realized that it was not the same and considered Ferris’ treatment to be a misidentification. Williams (1969a & b) designated the species epithet *pallidula* as a replacement name for the junior homonym *Mytilaspis pallida* Green, 1896 but no illustration or description was included. Takagi and Moghaddam (2005) provided an illustration and short description of *L. pallidula* from material collected in Iran but were unable to see the type series because they were on loan to the first author.

One of the new species, *L. caribaeae* Williams and Miller, has been collected on *Pinus caribaea* in Jamaica and Trinidad. This pine species is native to the Caribbean area and to parts of Central America. It grows best in frost-free areas and since 1950–1960 it has been planted in many countries throughout the world. The tree is widely used for general-purpose pulpwood, and industries have been established to manufacture resins, turpentine, and other products. It is possible that *L. caribaeae* may become important as an invasive pest if accidentally introduced to new locations.

Materials and methods

Morphological terms used in the descriptions and key are based on those given by Miller and Davidson (2005). The 3 digit gland-spine formula is the number of gland spines between the median lobes and second lobes, the number of gland spines between the second lobes and the setae marking the position of the third lobes if they were present, and the number of gland spines between the dorsal setae marking the positions of the third and fourth lobes. Thus, a gland-spine formula of 2-1-3 signifies that there are 2 gland spines in the space between the median lobes and second lobes (i.e., the first space), 1 gland spine between the second lobe and the setae marking the position of the third lobes (i.e., the second space), and 3 gland spines between the dorsal setae marking the position of the

third and fourth lobes (i.e., the third space). Measurements and counts are recorded as a range followed by an average in parentheses.

Determination of the presence of spurs is sometimes complicated because in many instances there is a small area of sclerotization and swelling associated with the openings of some marginal macroducts. In many instances it appears that large heavily sclerotized spurs are homologous with macroduct swellings on all segments except the spur that occurs either on the posterior edge of segment I or the anterior edge of segment II. In this position the sclerotization and swelling do not seem to be associated with a macroduct (*Lepidosaphes caribaeae* is the exception by having a sclerotized swelling associated with a duct on segment II). Therefore, to determine if spurs are present, check the posterolateral area of segment I or anterolateral area of segment II to determine if there is a sclerotized area that may have one or more small projections. The occurrence of this structure meets the criteria for the presence of spurs.

Each figure represents an enlargement of the pygidium and a generalized specimen of the adult female showing the dorsum on the left and the venter on the right. Enlargements of important characters are shown around the main drawing; they are not drawn to scale.

Abbreviations for depositories are **BMNH**: The Natural History Museum, London, U.K.; **NZAC**: New Zealand Arthropod Collection, Landcare Research, Auckland, N.Z.; **BME**: Bohart Museum, University of California, Davis, U.S.A; **USNM**: The National Entomological Collection of the National Museum of Natural History, Beltsville, Maryland, U.S.A.

Information for the character matrix was compiled from the literature and from specimens deposited in BMNH, BME, and USNM as follows: *L. araucariae* Beardsley, (Beardsley 1965:51) (studied type material); *L. caribaeae* Williams and Miller, **n. sp.** (studied type material); *L. chamaecyparidis* Takagi and Kawai (Takagi & Kawai 1966:98) (studied identified material from Japan); *L. cupressi* Borchsenius (Borchsenius 1958:169, description of Takagi (1962) may not be this species, not enough gland spines, wrong host) (no specimens examined); *L. japonica* (Kuwana) (Ferris 1921:217; Kuwana 1925:80; Takagi 1970:3) (studied identified specimens from Japan); *L. juniperi* Lindinger, (Balachowsky 1954:86; Danzig 1993:267) (studied identified material from Europe); *L. junipericola* (Tang), (Tang 1986:69) (no specimens examined); *L. keteleeriae* Ferris, (Ferris 1953:70) (studied type material); *L. murreeana* Williams and Miller, **n. sp.** (studied type material); *L. newsteadi* (Šulc), (Balachowsky 1954; Danzig 1993:266; Schmutterer 1959) (studied identified material from Europe); *L. nivalis* Takagi (Takagi 1970:4) (studied type material); *L. okitsuensis* Kuwana (Kuwana 1925:33) (studied identified material from Japan); *L. pallida* (Maskell) (Danzig 1993:268; Ferris 1938:146 as *newsteadi*; Miller & Davidson 2005:256; Takagi 1970:4 as *maskelli*) (studied type material); *L. piceae* (Tang) (Tang 1986: 73) (no specimens examined); *L. pinea* (Borchsenius) (Borchsenius 1964:164; Williams 1971:448) (studied identified material from Hong Kong); *L. pineti* Borchsenius (Borchsenius 1958:170; Tang 1977:214) (studied

identified material from China); *L. pini* (Maskell) (Kosztarab 1996:523; Miller & Davidson 2005:261; Tang 1977:212) (studied identified material from many localities); *L. pinicolous* Chen (Tang 1986:24) (studied identified material from China) (based on comments by S. Takagi (personal communication September 2006) we decided to continue usage of the rather unusual original spelling and consider it a random combination of letters); *L. pinifolii* (Borchsenius) (Borchsenius 1964:160; Danzig 1980:308; Danzig 1993:263) (no specimens examined); *L. piniphila* (Borchsenius) (Borchsenius 1958:171; Takagi 1960:84; Tang 1977:206) (studied identified material from Japan and China); *L. piniroxburghii* Takagi (Takagi 1975:13) (no specimens examined); *L. pitysophila* (Takagi) (Takagi 1970:17) (no specimens examined); *L. pseudotsugae* Takahashi (Borchsenius 1963:1172; Danzig 1980:308; Danzig 1993: 262; Takagi 1975:17) (studied identified material from Japan); *L. sciadopitysi* McKenzie (Kosztarab 1996:525; McKenzie 1955:187; McKenzie 1956:128) (studied type material); *L. tsugaedumosa* (Takagi 1977:21) (studied identified material from Nepal); *L. yoshimotoi* Takagi 1970:12 (studied type material).

Results

Description

Lepidosaphes caribaeae Williams and Miller, n. sp.

(Fig. 1)

Type material. Holotype adult female in BMNH, on slide labelled as follows: left label 'TRINIDAD, Valencia, *Pinus caribaea*, 24.v.1975/ F.D. Bennett. Right label HOLOTYPE / BMNH *Lepidosaphes caribaeae*'. In addition there are 8 paratype adult female specimens with same data (1 specimen in USNM, others in BMNH) and 9 paratype adult females labelled JAMAICA, Mt Airy Nursery, on *Pinus caribaea*, S.K. Kazimi, 2.vi.1975 (1 specimen in USNM, others in BMNH).

Description. Adult female on microscope slide elongate-oval, membranous except for pygidium, 0.54–1.00 (0.77) mm long, 0.25–0.35 (0.30) mm wide, head margin only gently rounded anteriorly, projecting and angled laterally, almost truncate, often forming rounded tubercle with 1 or 2 membranous protrusions, anterior portion of head with numerous minute spinules; sides of prothorax and mesothorax often sub-parallel, lateral margins of posterior segments moderately lobed on fully expanded specimens. Pygidium with 2 definite pairs of lobes, third and fourth lobes represented by slightly sclerotized areas with several small projections. Paraphyses present on medial and outer margins of median lobes, each a little longer than lobes and almost touching anteriorly; smaller paraphyses present on inner and outer margins of medial lobules of second lobes. Median lobes each 8–13 (10) μ m long, 9–11 (10) μ m wide, separated by a space 9–10 (10) μ m wide (0.8–1.0

(0.9) times width of a median lobe), inner and outer basal margins straight, very slightly diverging, each inner margin with 1–2 (2) minute notches, outer margin with 1 notch, apex rounded. Second lobes bilobed, inner lobule usually with 1 outer notch. Gland spines each with single microduct. Gland spines between median lobes with inner and outer notches, slightly longer or equal to median lobes; gland-spine formula 1-1-2 or 2-1-2, gland spines between median and second lobes projecting beyond apex of each median lobe, and gland spine between second and third lobes longest, with apex about on same level as apices of inner gland spines. Smaller gland spines paired on lateral margins of abdominal segments forward to segments II or III, usually with 2 on each margin of segments IV and V, 3 gland spines on each margin of abdominal segment III; with tubercle-like gland spines as follows: 2 or 3 on segment II, 6–11 (9) on segment I and; 3–5 (3) on metathorax and 1 rarely on mesothorax. Macroducts of 3 main sizes, largest size present on pygidial margin, 1 duct in first space, 2 in second space, 3 on segments IV and V. Smaller paired ducts sometimes placed wide apart submarginally and submedially on segment VI (some specimens with 2 ducts submarginally only) and 2 on submargin of abdominal segment V. Other dorsal ducts present in marginal groups as far forward as metathorax or abdominal segment I and in submedial groups of 2 or 3 on abdominal segments II or III to V. Ventrally, ducts present on lateral margins of mesothorax, metathorax and abdominal segment I. An intermediate-size submarginal dorsal duct, narrower than small ducts but wider than microducts, present medially anterior to medial pair of gland spines, and a similar submarginal duct present anterior to inner lobule of each second lobe. Microducts present on venter singly or in pairs in submedial areas of abdominal segment VI and forward to metathorax and laterally on metathorax. Perivulvar pores in 5 groups, 3–6 (4) present in medial group, 4–8 (6) in each anterolateral group, and 2–5 (4) in each posterolateral group, total of 21–25 (24). Perispiracular pores, each with 3 loculi, usually present singly next to each anterior spiracle, or occasionally absent entirely. Anal opening 10–15 (12) μm in diameter, situated at base of pygidium, 100–130 (115) μm from base of median lobes. Lateral tubercle-like swellings present on anterior marginal lobes of abdominal segments II–IV, sometimes terminating in a sclerotized point, on abdominal segments II and III always with associated apical macroduct. Eye present on lateral protrusion on head. Antennae each with 2 enlarged setae. Without microducts near base of antennae.

Notes. This species is similar to *L. pallida* in many respects in the general distribution of dorsal ducts but, whereas *L. pallida* possesses only a single slender dorsal duct anterior to each second lobe, *L. caribaeae* also has a similar duct medially anterior to the gland spines between the median lobes. The widely-spaced dorsal submarginal ducts on abdominal segment VI in *L. caribaeae* are similar in position to those of *L. murreeana* and differ in position to the paired submedial ducts on abdominal segment VI in *L. pallida*. Furthermore, there are lateral swellings or tubercles on the margins of abdominal segments II–IV in *L. caribaeae* but only on abdominal segments III and IV in *L. pallida*. Sometimes

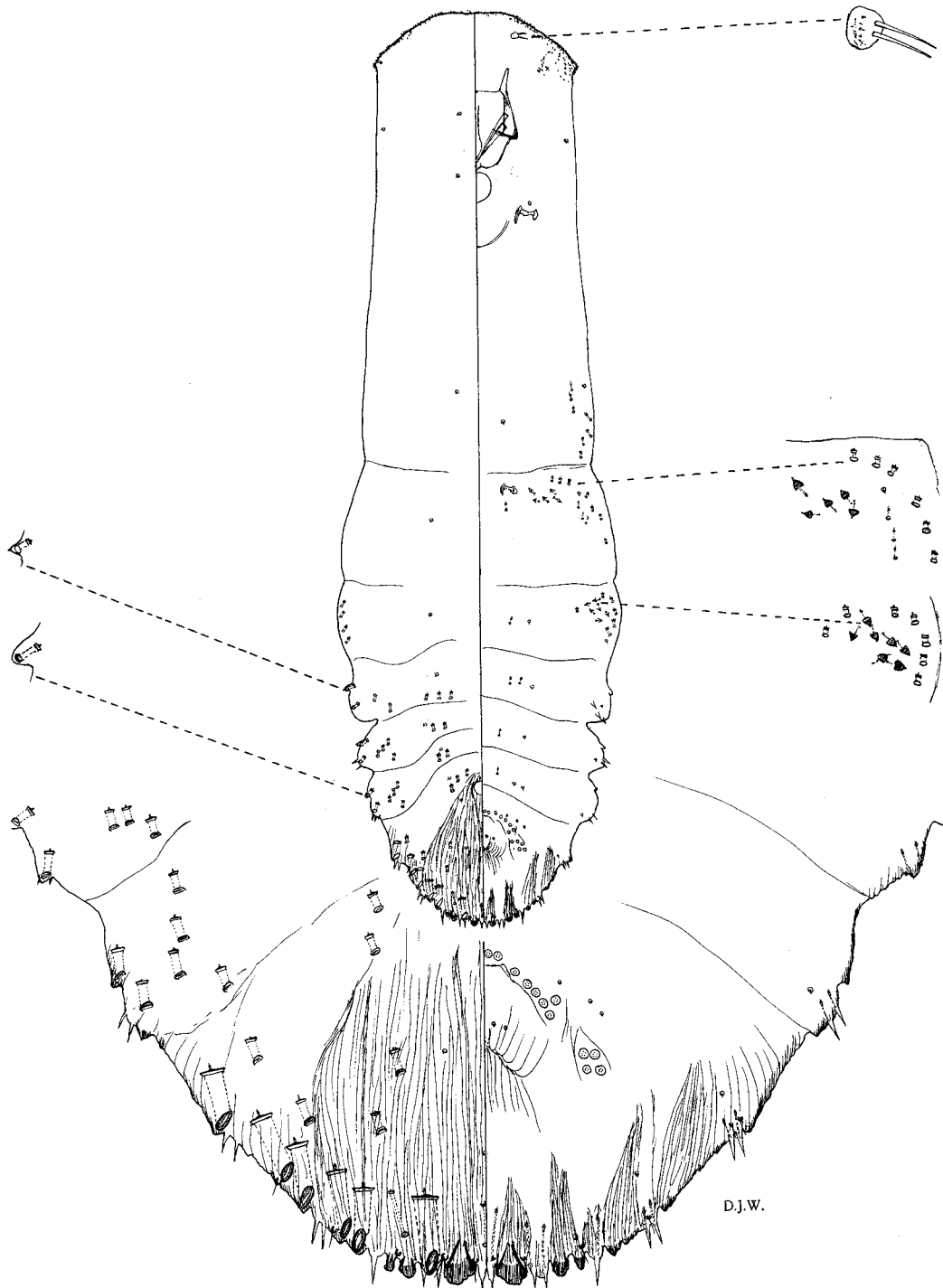


FIGURE 1. *Lepidosaphes caribaeae* Williams and Miller **n. sp.** Valencia, Trinidad, on *Pinus caribaea*, May 24, 1975, F. D. Bennett.

these swellings in *L. caribaeae* have a minute sclerotized point at the apex, which is always absent in *L. pallida*. Although *L. pallidula* possesses lateral abdominal spurs on segments II and sometimes III, the submedial ducts on abdominal segment VI are at the base of the pygidium, near the anal opening, whereas in *L. caribaeae* the ducts are often widely spaced and submarginal in position. A striking character of *L. caribaeae* is the anterior head margin with numerous minute spinules similar to several other conifer-infesting species (*L. okitsuensis*, *L. piniphila*, and *L. pitysophila*).

Etymology. The name is based on the Latin genitive of the botanical plant epithet *caribaea*.

***Lepidosaphes murreeana* Williams and Miller, n. sp.**

(Fig. 2)

Type material. Holotype adult female in BMNH, on slide labelled as follows: left label 'HOLOTYPE/ BMNH, *Lepidosaphes murreeana*. Right label PAKISTAN, Murree, on *Abies pindrow*, 22.v.70'. In addition there are 2 paratype adult female specimens with same data also in BMNH.

Description. Adult female on microscope slide elongate-oval, membranous except for pygidium, 0.88–1.04 (0.98) mm long, 0.30–0.41 (0.36) mm wide, head rounded, with smooth margin, without minute spinules and tubercles; margins of mesothorax, metathorax and prepygidial abdominal segments strongly lobed. Pygidium with 2 definite pairs of lobes, third and fourth lobes represented by slightly sclerotized areas anterior of marginal macroduct swellings. Paraphyses present on medial and outer margins of median lobes, each about same length as lobes, and smaller paraphyses present on inner and outer margins of medial and lateral lobules of second lobes. Median lobes each about 10–14 (11) μm long, 10–15 (13) μm wide, separated by space 9–13 (10) μm wide (0.6–1.0 (0.8) times width of median lobes), lateral margin of each lobe straight, diverging slightly with 1 notch, medial margin at first straight then diverging with 1–2 (2) small notches, apex rounded. Second lobes bilobed, inner lobule larger, with 0–1 (1) notches on outer margin, without notches on inner margin, apex about on same level as apex of median lobes, inner lobule usually without notches. Gland spines each with single microduct. Gland spines between median lobes with inner and outer notches, shorter than lobes, gland-spine formula 2-2-1, gland spines between median and second lobes shorter than median lobes, gland spines between second and third lobes longer than median lobes. Small gland spines paired on each lateral margin of abdominal segments III–V, segment III sometimes with 3; 3–4 (3) tubercle-like gland spines on each lateral margin of abdominal segment II, 5–7 (6) tubercle-like gland spines on each lateral margin of abdominal segment I, and 3–7 (5) posterior to each second spiracle. Macroducts of 2 main sizes, larger size present on pygidial margin only; 1 duct in first space, 2 in second space (occasionally only 1 on each side), 3 on margin of segments IV and V. Smaller single ducts present immediately

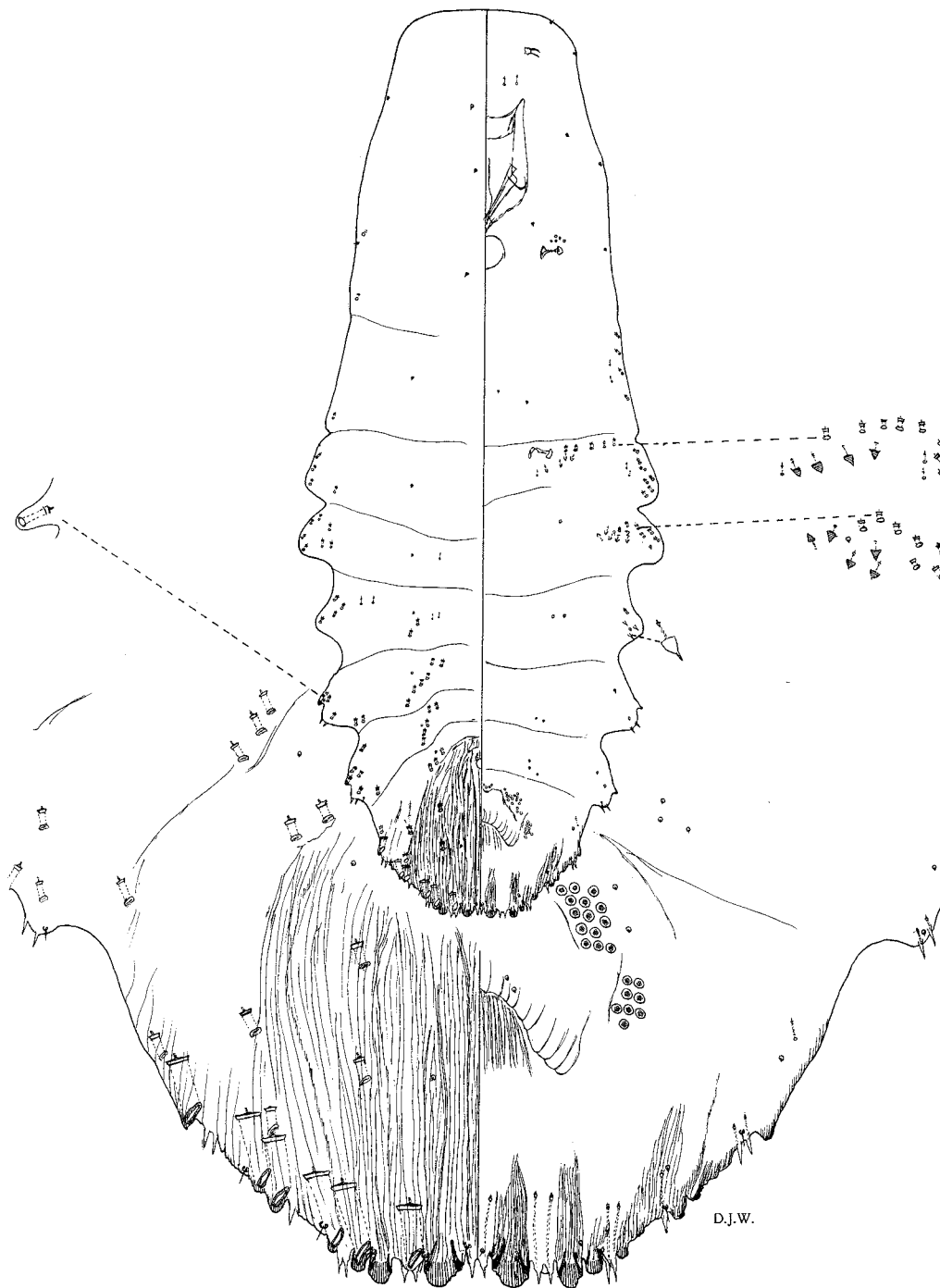


FIGURE 2. *Lepidosaphes murreeana* Williams and Miller **n. sp.** Murree, Pakistan, on *Abies pindrow*, May 22, 1970.

anterior to inner large duct on segment VI and to large duct on segment V; 1 submarginal and 1 submedial duct on each side of pygidium on segment VI (1 specimen lacks submedial duct on 1 side), 1–3 (1) submarginal and 2–4 (3) submedial ducts on segment V, submedial small ducts present to segment II or III, a series of small marginal ducts present as far forward as mesothorax or prothorax and ventrally on mesothorax to segment II. Ventral microducts present submedially on any of segments I–IV, on pygidial margin of segment V, on prepygidial submarginal areas of mesothorax to segments 1 or 2. Dorsal microducts present submedially on segments 1 and 2. Perivulvar pores in 5 groups, 5–8 (6) pores in medial group, 12–14 (13) in each anterolateral group, and 7–10 in each posterolateral group, total 49–50 (49). Perispiracular pores each with 3 loculi, next to each anterior spiracle in a group of 3–7 (5). Anal opening 12–15 (14) μm in diameter, located 140–162 (152) μm from base of median lobes. Lateral rounded or tubercle-like swellings present on anterior marginal lobe of abdominal segments III and IV, each swelling associated with a macroduct. Eyes evident on only 1 specimen, represented by small, weakly sclerotized dome. Antennae each with 2 large setae. With several microducts near base of antennae.

Notes. This species has similar dorsal submarginal ducts, placed well apart on abdominal segment VI, to those of *L. caribaeae* but differs in lacking the lateral swellings on abdominal segment II, lacking minute spinules on the head, and in possessing a smooth anterior head margin. The widely-spaced dorsal submarginal ducts on abdominal segment VI and the lack of a slender duct anterior of second lobes also separate *L. murreeana* from *L. pallida*.

Etymology. The epithet is based on the type locality Murree, in NE Pakistan, and the Latin suffix ‘-ana’ meaning ‘belonging to’ or ‘pertaining to’.

Lepidosaphes pallidula (Williams)

Figure 3

Mytilaspis pallida Green, 1896a:5. Homonym of *Mytilaspis pallida* Maskell, 1895.

Mytilaspis gloverii pallida; Green, 1896b:85.

Lepidosaphes pallida; Fernald, 1903:312.

Lepidosaphes pallidus; Green, 1919:446.

Lepidosaphes gloverii pallida; MacGillivray, 1921:283.

Mytilaspis (Lepidosaphes) pallida; Ramakrishna Ayyar, 1930:31.

Mytilococcus pallidus; Lindinger, 1936:159.

Insulaspis pallida; Borchsenius, 1963:1173.

Insulaspis pallidula Williams, 1969b:114. Replacement name for *Mytilaspis pallida* Green, 1896a.

Lepidosaphes pallidula; Kawai, 1980:240.

Type material. Although Green marked 1 specimen as “type,” there is no indication of a primary type in the original description, so the type series must be considered syntypes. A lectotype is here designated to clarify the status of the species. It is selected from material

deposited in BMNH labeled as follows: right label in Green's handwriting "**Mytilaspis gloverii** Packard/ var **pallida** Green/ Punduloya, Ceylon"; left label, circular, printed "CO-TYPE." A label has been placed to the right of the circular label giving the location of the lectotype and stating "LECTOTYPE/ Paralectotypes/ desig. by Miller/ Williams &/ Davidson." There are 3 adult females on the slide, the right specimen is here selected as the lectotype (BMNH). There are 2 other slides in BMNH, 1 contains 1 adult female and is labeled "TYPE" and a second slide contains 4 adult females and has the same data as the lectotype. We had difficulty selecting a lectotype from BMNH syntypes because of their poor condition; none showed all diagnostic characteristics. The lectotype has the following primary diagnostic characters: a lateral sclerotized spine on the lateral margin of segment I, 2 inner notches on the median lobes, and a gland-spine formula of 2-2-2. However, the specimen is unusual in that it has only 3 perivulvar pores in each posterolateral cluster, 1 or 2 submarginal macroducts on segment V, and antennae with 2 obvious setae. We also have seen a slide labeled "Lepidosaphes/ pallidula/ (Williams)/ Pundaluoya, Ceylon/ E. E. Green/ #6865/ Balsam" (USNM) that may be part of the type series. In addition, there are specimens that apparently were sent to Maskell by Green, probably in 1894. There are 9 slides containing slide-mounted specimens and dry-mounted scale covers. These specimens were prepared from dry material from the Maskell collection and were incorporated in the USNM collection as part of an agreement with New Zealand. For details see Morrison and Morrison (1922) and Miller *et al.* (1998). One additional slide contains 1 adult female and may be part of the same series of specimens sent by Green to Maskell in 1894; it probably was mounted by Maskell (NZAC).

Field Characters Adult female cover oystershell shaped, straight, pale yellow or brown; shed skins marginal, yellow. Male cover shorter and narrower than female cover, same color and texture; shed skins marginal, yellow. Body of adult female white; eggs and crawlers white. On foliage.

Description. Adult female on microscope slide elongate oval, membranous except for pygidium, 0.73–1.37 (1.11) mm long, 0.36–0.49 (0.42) mm wide, head margin rounded anteriorly, without lateral tubercles and minute spinules; sides of prothorax and mesothorax diverging, sides of metathorax to apex of abdomen converging, lateral margins of prepygidial segments weakly lobed. Pygidium with 2 definite pairs of lobes, third and fourth pairs of lobes represented by series of small points. Paraphyses present on inner and outer margins of median lobes, each a little longer than lobes and almost touching anteriorly; smaller paraphyses normally present on inner lobule of second lobes, occasionally with 1 or 2 paraphyses on outer lobule. Median lobes each 10–16 (14) μm long, 15–17 (16) μm wide, separated by space 10–12 (10) μm wide (0.5–1.0 (0.7) times width of median lobe), inner and outer basal margins straight, inner margin usually longer than outer margin, each inner margin with 1–5 (3) notches, outer margin with 1–3(2) notches, apex rounded. Second lobes bilobed, inner lobule largest, with 0–1 (1) outer notches, 0–1 (1) inner notches, outer lobule with outer margin with 0–1(1) notches, inner

margin with 0–1(0) notches; third lobes single, represented by swelling surrounding marginal macroduct and series of small teeth; fourth lobes represented by 2 macroduct swellings, 1 swelling often with a series of teeth, anterior swelling in front of seta marking lobe 5. Gland spines each with single microduct. Gland spines between median lobes with inner and outer notches, slightly longer or equal to median lobes; gland-spine formula 2-2-2, gland spines between median and second lobes projecting about same length as median lobes and gland spines between second and third lobes longest. Additional smaller gland spines present from segment II or III to segment V, each with 2 to 5 gland spines, metathorax with 4–7 (6) tubercle-like gland spines near each spiracle, segment I with 12–16 (14). Macroducts of 2 sizes, larger size on margin only, 1 duct in first space, 2 in second, and 3 on segments IV and V. Smaller ducts in submedial areas of segments V and VI, with 1–3 (2) submarginal on segment V. Other dorsal ducts on marginal areas of mesothorax to segment IV; submedial ducts on segments II–IV. Ventral ducts on meso- and metathorax and segment I. With 1 small dorsal duct anterior of second lobe. Pygidial microducts on venter in submarginal areas of segments V to VI or VII; prepygidial ducts in submedial areas of segments I–IV, submarginal on segments III and sometimes IV; dorsal pygidial and prepygidial microducts absent. Perivulvar pores in 5 indistinct groups, 3–6 (4) present in medial group, 4–12 (8) in anterolateral group, 4–6 (4) in posterolateral group, total of 27–32 (29). Perispiracular pores with 3 loculi, anterior spiracular pores each with 1–4 (2) pores. Anal opening 10–15 (12) μm in diameter, situated at base of pygidium, located 125–170 (140) μm from base of median lobes. Lateral spurs usually present on segment I or between segments I and II, usually with sclerotized point, without associated macroduct, sometimes also present between segments II and III, with associated macroduct. Eyes difficult to see, usually represented by small membranous dome with central sclerotized area near body margin at level of antenna. Antennae each with 1 or 2 (1) large setae, single seta occasionally with bifurcate base. With 1–4 (2) microducts near each antenna.

Notes. *Lepidosaphes pallidula* is very similar to *L. pallida* by having the gland-spine formula of 2-2-2, no dermal sclerotization on mature females, no cicatrices, and macroducts present from mesothorax to abdomen apex. *Lepidosaphes pallidula* can be separated by having a spur on the lateral margin of abdominal segment 1 or between segments I and II, and sometimes with a second spur between segment II and III (*L. pallida* without), usually 2 or more notches on inner margin of median lobes (*L. pallida* normally with 1), inner margin of median lobes sometimes longer than outer margin (normally equal in *L. pallida*), median lobes 15–18 (16) μm wide (9–13 (11) μm in *L. pallida*), 1–3 (2) submarginal macroducts on segment V (1–2 (1) in *L. pallida*), and by not occurring on coniferous hosts (*L. pallida* is almost exclusively on conifers). *Lepidosaphes pallidula* also is similar to *L. newsteadi* by having no dermal sclerotization on mature females, no cicatrices, usually more than 1 submarginal macroduct on each side of

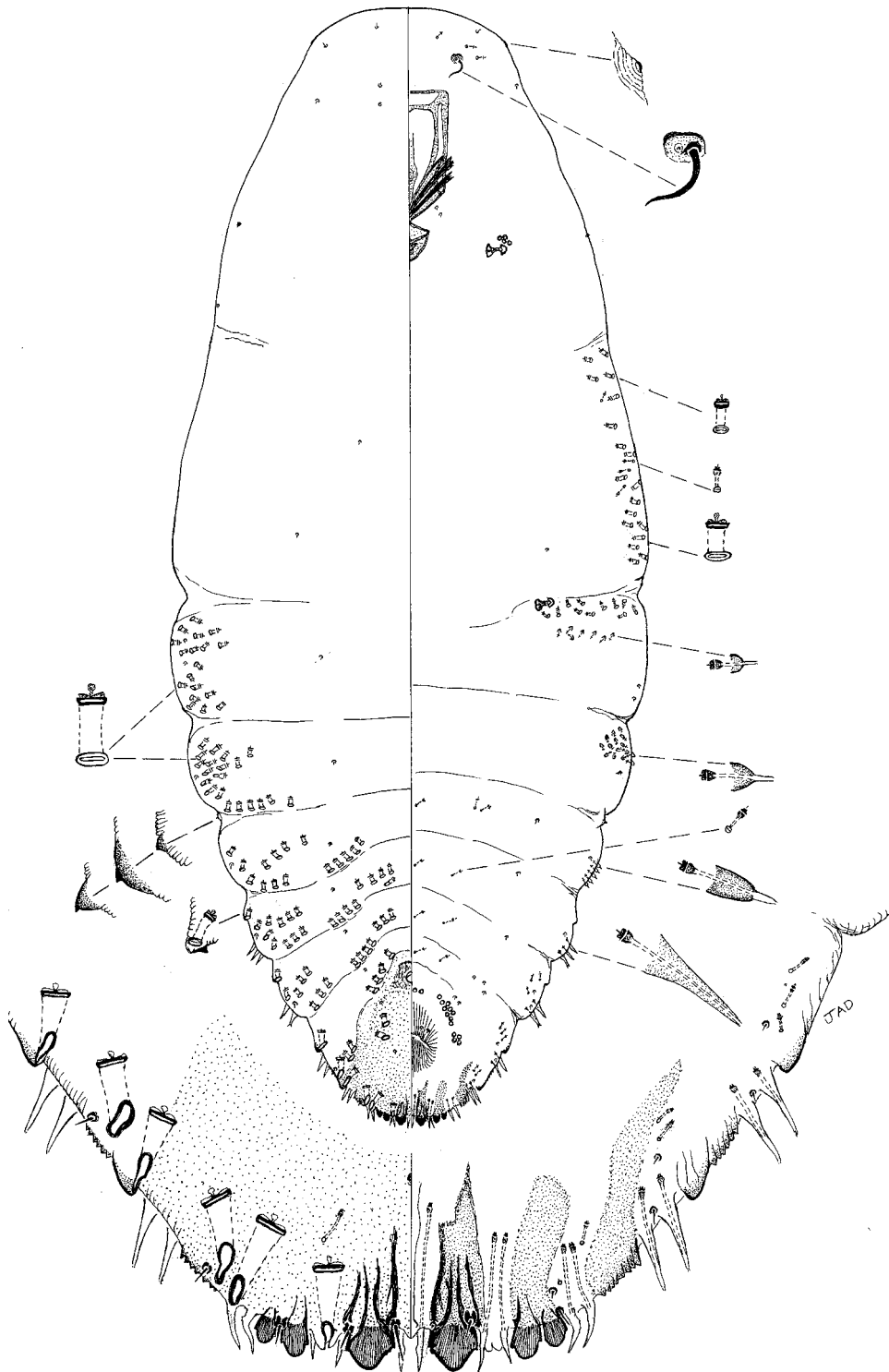


FIGURE 3. *Lepidosaphes pallidula* (Williams). Punduloya, Sri Lanka, on unknown host, E. E. Green.

abdominal segment V. *Lepidosaphes pallidula* differs by having a spur on the lateral margin of abdominal segment I or between segments I and II, and sometimes with a second spur between segment II and III (*L. newsteadi* without), gland spine formula 2-2-2 (2-2-0 or 2-2-1 in *L. newsteadi*), usually 2 or more notches on inner margin of median lobes (*L. newsteadi* normally with 1), space between median lobes narrower than width of median lobe (usually wider in *L. newsteadi*), posterolateral cluster of perivulvar pores with 3–6 (4) pores (7–12 (9) pores in *L. newsteadi*), and macroducts absent from prothorax (present on prothorax on *L. newsteadi*).

Hosts and Distribution. Miller and Gimpel (2006) recorded this species from 4 host genera in 4 families and from the following countries: Australia, Egypt, India, Mauritius, Pakistan, and Sri Lanka. We have examined specimens from: Japan on *Rhizophora*; Malaysia on *Hibiscus*, *Murraya*, and *Passiflora*; Philippines on *Mangifera*, *Psidium*, and *Scolopia*; Sri Lanka on undetermined host.

Identification tools

A table is presented that provides a synopsis of the character states considered important in distinguishing adult females of conifer-infesting species of *Lepidosaphes* (see Table 1). In addition, a dichotomous key is presented below.

Key to conifer infesting species of *Lepidosaphes*

- 1 Dorsal ducts absent from submedial areas of segment VII..... 2
- Dorsal ducts present in submedial areas of segment VII 21
- 2 Without lateral spurs on abdomen between segments I and II or on segment II..... 3
- With lateral spurs on abdomen between segments I and II or on segment II..... 14
- 3 Third space with 2 gland spines 4
- Third space with fewer than 2 gland spines 10
- 4 Small or medium macroduct present on dorsum anterior of second lobe 5
- Small or medium macroduct absent from dorsum anterior of second lobe 7
- 5 Second space with 1 gland spine 6
- Second space with 2 gland spines *L. pallida* (Maskell)
- 6 Lateral margins of prepygidial segments not long and finger like; submedial ducts about same size on pygidium and prepygidium *L. pinea* Borchsenius (in part)
- Lateral margins of prepygidial segments long, finger like; submedial ducts conspicuously larger on pygidium than on prepygidium *L. pinicolous* Chen
- 7 Without supernumerary perivulvar pores 8
- With supernumerary perivulvar pores *L. pini* (Maskell)
- 8 Inner lobule of second lobe about 2 times as wide as width of outer lobule; 2 gland

- spines in second space 9
- Inner lobule of second lobe more than 2 times as wide as width of outer lobule; 1 gland spine in second space *L. chamaecyparidis* Takagi and Kawai
- 9 Dorsal submarginal/submedial ducts on segment VI widely spaced
..... *L. murreeana* Williams and Miller (in part)
- Dorsal submarginal/submedial ducts on segment VI in cluster *L. nivalis* Takagi
- 10 With 2 gland spines in second space 11
- With 1 gland spine in second space 13
- 11 Without supernumerary perivulvar pores 12
- With supernumerary perivulvar pores *L. pineti* Borchsenius
- 12 Dorsal submarginal and submedial ducts on segment 6 widely spaced
..... *L. murreeana* Williams and Miller (in part)
- Dorsal submarginal and submedial ducts on segment 6 in cluster *L. newsteadi* Šulc
- 13 With 1 gland spine in first space; without small dorsal macroduct anterior of second lobe *L. juniperi* Lindinger
- With 2 gland spines in first space; with small dorsal macroduct anterior of second lobe *L. pinea* (Borchsenius) (in part)
- 14 Eye not spine like 15
- Eye spine like 19
- 15 Cicatrices absent 17
- Cicatrices present 16
- 16 Gland-spine formula 1-1-2 *L. yoshimotoi* Takagi
- Gland-spine formula 2-2-3 *L. cupressi* Borchsenius
- 17 Head without spinules; without dorsomedial duct between median lobes 18
- Head with minute spinules; thin dorsomedial duct between median lobes
..... *L. caribaeae* Williams and Miller
- 18 With 0–5 ducts near base of antennae *L. sciadopitysi* McKenzie
- With 8–20 ducts near base of antennae *L. japonica* (Kuwana)
- 19 With 6 enlarged marginal macroducts on each side of pygidium 20
- With 7 enlarged marginal macroducts on each side of pygidium *piceae* (Tang)
- 20 Tubular ducts abundant on head and prothorax; antennae with 3 or 4 enlarged setae ...
..... *L. junipericola* (Tang)
- Tubular ducts absent or rare on head and prothorax; antennae with 1 or 2 enlarged setae *L. pinifolii* (Borchsenius)
- 21 Without minute spinules on head 22
- With minute spinules on head 26
- 22 Eye not spine like, usually small dome or absent 23
- Eye spine like 24
- 23 With 6 enlarged marginal macroducts on each side of pygidium ... *L. keteleeriae* Ferris
- With 4 or 5 enlarged marginal macroducts on each side of pygidium

- *L. araucariae* Beardsley
- 24 Tubular ducts on head restricted to ventral interantennal areas or absent 25
- Tubular ducts scattered on head on dorsum and venter *L. piniroxburghii* Takagi
- 25 Submedial macroducts absent from segments I and II; usually with 3 or more submedial macroducts on each side of segment VII *L. pseudotsugae* Takahashi
- Submedial macroducts present on segments I and II; usually with 1 or 2 submedial macroducts on each side of segment VII *L. tsugaedumosae* Takagi
- 26 Lateral spurs plate like, relatively inconspicuous, with small projection 27
- Lateral spurs cone shaped, conspicuous, without basal plate *L. okitsuensis* Kuwana
- 27 Ventrolateral area of segment I with cluster of 20 or more tubercle-like gland spines on each side of body.....*L. pitysophila* (Takagi)
- Ventrolateral area of segment I with cluster of 10 or fewer tubercle-like gland spines on each side of body.....*L. piniphila* Borchsenius

Conclusion

Characters important in distinguishing species of *Lepidosaphes* include gland-spine distribution, lateral spurs, distribution of macroducts, relative sizes of macroducts, presence of a small dorsal duct between median lobes and anterior of second lobe, and shape of the eye. We examined the perispiracular pores on all species available to us (*Lepidosaphes araucariae*, *L. caribaeae*, *L. chamaecyparidis*, *L. japonica*, *L. juniperi*, *L. keteleeriae*, *L. murreeana*, *L. newsteadi*, *L. nivalis*, *L. okitsuensis*, *L. pallida*, *L. pinea*, *L. pineti*, *L. pinicola*, *L. pini*, *L. piniphila*, *L. pseudotsugae*, *L. sciadopitysi*, *L. tsugaedumosae*, *L. yoshimotoi*) and found that all have predominantly 3-ocular pores even though some have been described as having 5.

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Appendix

TABLE 1. Character matrix for 25 species of conifer-infesting *Lepidosaphes*.

	Number large marginal macroducts	Spurs on segs. 1 or 2	Segs. with spurs	Segs. with sub-medial ducts	Anterior most segment with madroducts	Eye shape	Number spiracular pores	Minute spinule on head
<i>araucariae</i>	4–5	no	5, 4	7, 6, 5	pro	star or round	2–3	no
<i>caribaeae</i>	6	yes	2, 3	6, 5	pro	round or absent	1	yes
<i>chamaeey</i>	6	no	none	6, 5	meso	absent?	1	no
<i>cupressi</i>	6	yes	1–6	6, 5	meso	absent?	4–5	no
<i>japonica</i>	6	yes	1, 2	6, 5	pro, meso	sclerotized spots	2–3	no
<i>juniperi</i>	6	no	none	6, 5	head, pro	absent ?	1	no
<i>juniperico</i>	6	yes	2–4	6, 5	head	spine like	7–10	no
<i>keteleeria</i>	6	no	none	7, 6, 5	head, pro	small unsclerotized	3–4	no
<i>murreeana</i>	6	no	3	6, 5	meso	small unsclerotized	5	no
<i>newsteadi</i>	6	no	none	6, 5	pro	small	1–4	no
<i>nivalis</i>	6	no	none	6, 5	pro	small unsclerotized	1–3	no
<i>okitsuensis</i>	6	yes	meta, 2, 3, 4	7, 6, 5	head, pro	small unsclerotized	8–18	yes
<i>pallida</i>	6	no	none	6, 5	meso	small	2–4	no
<i>piceae</i>	7	?	2, 3	6, 5	head	spine like	3	no
<i>pineae</i>	6	no	2, 3	6, 5	pro	small or absent	1–2	no
<i>pineti</i>	6	no	4 or absent	6, 5	meso	small or absent	1–5	no
<i>pini</i>	6	no	4, 3	6, 5	pro	small or absent	3–6	no
<i>pinicolous</i>	6	no	none	6, 5	meso	small dome	1	no
<i>pinifolii</i>	6	yes	2, 3	6, 5	meso	spine like	2–4	no
<i>piniphila</i>	6	yes	1, 3, 4	7, 6, 5	pro	absent or unsclerotized	3–5	yes
<i>piniroxbur</i>	6	yes	2, 3, 4	7, 6, 5	pro, head	spine like	3–7	no
<i>pitysophila</i>	6	yes	2–4	7, 6, 5	head	absent	5–8	yes
<i>pseudotsug</i>	6 or 7	yes	1, 3–5	7, 6, 5	meso	spine like	8–27	no
<i>sciadoptys</i>	6	yes	1, 3, 4	6, 5	meso?, pro	absent	4–5	no
<i>tsugaedumo</i>	6	yes	1, 3, 4	7, 6, 5	meso	spine like	2–10	no
<i>yoshimotoi</i>	6	yes	1, 3 or 4	6, 5	pro	absent	5–7	no

TABLE 1 (continued).

	Total number perivulvars	Number postlateral perivulvars (each cluster)	Super-numerary perivulvars	Gland tubercles nr. spiracles	Submedial macroduct shape	Micro-ducts nr antennae	Cicatrices	Medial notches median lobes
<i>araucariae</i>	26–35	6–10	no	no	narrow	13	no	1
<i>caribaeae</i>	24	4–5	no	yes	broad	0	no	2–3
<i>chamecyp</i>	14–28	2–4	no	yes	broad	0	no	0
<i>cupressi</i>	36–58	9–14	no	0, 1	broad	?	yes	1–2
<i>japonica</i>	20–47	3–11	no	4	very broad	8–19	no	0–1
<i>juniperi</i>	14–26	3–6	no	yes	broad	1	no	1–3
<i>juniperico</i>	54–68	14–16	no	yes	narrow	10	no	0?
<i>keteleeriae</i>	53–63	11–16	no	0–2(1)	very narrow	0–3	no	0
<i>murreeana</i>	56	8–9	no	yes	broad	4	no	2–3
<i>newsteadi</i>	30–44	7–12 (9)	no	yes	broad	6–10	no	0–2(1)
<i>nivalis</i>	26–40	6–8	no	yes	very broad	6–8	no	0–1
<i>okitsuensis</i>	41–70	8–17	no	no	very narrow	8–10	no	1–2
<i>pallida</i>	24–30	4–7(4)	no	yes	broad	0–3	no	0–2(1)
<i>piceae</i>	42–68	8–16	no	yes	narrow	12	no	0
<i>pineae</i>	17–28	2–5	no	5–8	broad	0	no	1
<i>pineti</i>	23–46	5–10	yes	7–9	broad	0–2	no	0–3
<i>pini</i>	44–78	8–15	yes	yes	very broad	1–8	no	0–2
<i>pinicolous</i>	17–20	3–4	no	no	very broad and narrow	0	no	1
<i>pinifolii</i>	47–76	9–16	no	yes	broad	0	no	2
<i>piniphila</i>	16–38	4–8	no	no	very narrow	0–7	no	0–1
<i>piniroxbur</i>	22–51	4–13	no	yes	broad	20	no	1
<i>pitysophila</i>	25–42	5–8	no	no	very narrow	0	no	0
<i>pseudotsug</i>	84–98	14–27	no	few or absent	broad	3–7	no	0
<i>sciadopitys</i>	21–47	4–9	no	yes	broad	2–3	no	1–2
<i>tsugaedum</i>	54–82	5–20	No	yes	broad	8–10	no	0–1
<i>yoshimotoi</i>	29–42	6–9	no	yes	narrow	6–11	yes	0–1

TABLE 1 (continued).

	Number large antennal setae	Number submedial ducts on 6	Number submarginal ducts on 5	Submarginal ducts on 6	Dorsal duct anterior 2 nd lobe	Dorsal duct between median lobes	Gland-spine formula
<i>araucariae</i>	1, 2	5–7	2–4	yes	no	no	1-1-2
<i>caribaeae</i>	2	1	2	no	yes thin	yes	2-1-2
<i>chamecyp</i>	2	1, 2	2	no	no	no	2-1-2
<i>cupressi</i>	2, 3	7	13	yes	no	no	2-2-3
<i>japonica</i>	1, 2	2–4	2–4	no	no	no	2-2-2
<i>juniperi</i>	2	2	2, 3	no	no	no	1-1-0
<i>juniperico</i>	3, 4	6	12	yes	no ?	no	2-1-2
<i>keteleeriae</i>	3	3, 4	0	no	no	no	2-2-2 2-3-2
<i>murreeana</i>	2	1	2	no	no	no	2-2-1 2-2-2
<i>newsteadi</i>	2	2	1–4	no	no	no	2-2-0 2-2-1
<i>nivalis</i>	1, 2	2–4	2–4	no	no	no	2-2-2
<i>okitsuensis</i>	1, 2	5–7	4–5	yes	cluster ?	no	2-2-2
<i>pallida</i>	1, 2	2	1	no	yes thin	no	2-2-2
<i>piceae</i>	4	4	9	yes	yes thin	no	2-1-2
<i>pineae</i>	2	2, 3	2–4	no	yes thin	no	2-1-2 2-1-1
<i>pineti</i>	2, 3	2	4–6	yes	no	no	2-2-0
<i>pini</i>	2–4	2–6	2–4	yes, no	no	no	2-2-2
<i>pinicolous</i>	2	2–4	2–4	yes	yes broad	no	1-1-2
<i>pinifolii</i>	2	3	6	yes	yes broad	no	2-1-2
<i>piniphila</i>	2	5–10	6–10	yes	yes	yes	1-2-2 2-2-2
<i>piniroxbur</i>	3, 4	2, 3	2–4	yes	yes broad	no	2-2-2
<i>pitysophila</i>	3	5	4	no	yes	yes	2-2-1
<i>pseudotsug</i>	3, 4	3–8	7–14	yes	yes broad	no	2-2-2 2-1-1
<i>sciadopitys</i>	1, 2	2	1–3	no	no	no	2-2-2
<i>tsugaedmos</i>	4	1, 2	4–7	no	yes broad	no	2-2-2 2-1-2
<i>yoshimotoi</i>	1, 2	4–6	6–10	yes	yes broad	no	1-1-2