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Scale insects (Hemiptera: Sternorrhyncha: Coccoidea) of the Krakatau Islands including species from adjacent Java

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Abstract

In this paper we provide a list of all species of scale insects that have been collected in the Krakatau Islands since the catastrophic eruption of 1883. Included in the list are species collected during the La Trobe University Expedition in 1984 from the islands and from the adjacent mainland in Java and also species collected in earlier expeditions, including those during 1919–1933, discussed by Dammerman (1948). In addition, we describe two new species of armoured scales, *Aulacaspis thorntoni* Williams & Miller and *Greeniella calophylli* Williams & Miller and provide a key to the species of *Greeniella* Cockerell.

Key words: Krakatau, introduced species, *Aulacaspis thorntoni* **sp. n.**, *Greeniella calophylli* **sp. n.**, key to *Greeniella*

Introduction

The purpose of this paper is to list the scale insects that have been collected in the Krakatau Islands since the catastrophic volcanic eruptions of 1883 which sterilised the islands. The islands are situated in the Sunda Strait and lie almost midway between the southern tip of Sumatra and the north-east corner of Java. Prior to these eruptions, the Krakatau Islands comprised five main islands, Rakata, Panjang, and Sertung, forming a ring about 12 km in diameter around two central islands, Daman and Perbuatan, all formed after an earlier eruption in Prehistoric times. After the eruption in 1883, the two central islands disappeared along with much of the other islands. After a series of eruptions starting in 1927 in the centre of the islands, a new island emerged in 1930 and was named Anak Krakatau (Fig. 1). In 1952, all plant and animal life on Anak Krakatau was wiped out when it erupted again.

As a result of zoological surveys of the Krakatau Islands during 1919–1922 and 1929–1933, some scale insects were collected and these were listed by Dammermann (1948). Several of these are deposited in The Natural History Museum, London, and a few others have been added since. The present list includes these scale insects and records from the literature but the list has been largely increased by collections made during the La Trobe University Expeditions in 1984. An overview of the 1984, 1985 and 1986 expeditions was presented by Thornton (1987). The list also includes a few species collected during the expedition on the mainland of Java on the Ujung Kulang Penisula, opposite the Krakatau Islands.

Female scale insects are wingless and winged adult males do not feed. First-instar nymphs are often transported by wind, and any instar can be introduced on plant material. Phoretic methods, perhaps on birds, cannot be ruled out as mechanisms for introduction to these islands. Even so, the list includes a variety of species from seven scale insect families. One species, *Icerya jacobsoni* Green (family Monophlebidae), was observed in 1982 infesting many plant species especially *Ficus fistulosa* and *Pipturus argenteus* on Rakata (Yukawa, 1984). Most of the species are cosmopolitan but it is interesting that other species of *Icerya* are also present. *Icerya samaraia* (Morrison) has become widely distributed throughout the Krakatau Islands in recent

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years. This species is fairly common throughout the Pacific Region and parts of southern Asia (Unruh & Gullan, 2008: Ben-Dov, 2005: Ben Dov *et al.*, 2009). Since the eruption on Anak Krakatau in 1952, three scale insect species and their host plants have become established. These are *Drosicha* sp., *Icerya aegyptiaca* (Douglas) and *I. samaraia*, all in the family Monophlebidae. Anak Krakatau still suffers from volcanic activity and the scale insects there remain at risk.

We have taken the opportunity to describe two new species of armoured scales, *Aulacaspis thorntoni* sp. n. from Indonesia (Krakatau), Java and Malaysia, and *Greeniella calophylli* sp. n. from Java, and we provide a key to all species of *Greeniella* Cockerell.

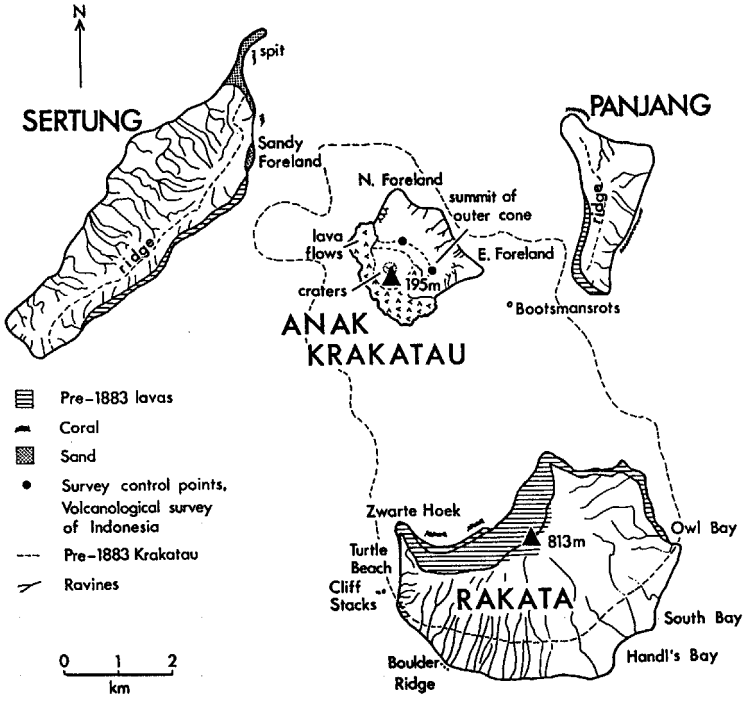

FIGURE 1. Map of Krakatau Islands.

Material and methods

All the specimens examined have been mounted in Canada balsam on microscope slides using the method discussed by Williams & Granara de Willink (1992). The illustrations of the species show the adult females divided down the middle with the dorsum on the left and the venter on the right. Enlargements of important characters are included and described in the legends to the figures. We have listed all the information from the slide labels. The initials ZEK refer to the Zoological Expedition to the Krakatau Islands and the initials GF refer to Grant Farrell. When a species has been listed in the literature under a different genus, we have indicated this after the species name. Numerical designations listed at the beginning of the specimen label data are lot numbers assigned during the ZEK.

Depositories

Abbreviations given for type depositories and voucher specimens are as follows: ANIC—Australian National Collection of Arthropods, Canberra, Australia; BMNH—The Natural History Museum, Department of Entomology, London, UK; NMV—The National Museum of Victoria, Melbourne, Australia: USNM—United States National Entomological Collection, National Museum of Natural History, Washington, D.C., U.S.A.

Scale insects of the Krakatau Islands and the Ujung Kulon Peninsula of Java

Asterolecaniidae

Asterolecanium javae Russell

147-4 Krakatau Is, Rakata, W Ridge, 100m, 6°09'S 105°25'E, on *Ficus montana* [Moraceae] (causing pit galls), 8.ix.1984, ZEK, GF. Listed also by Dammerman (1948: 474) on *Ficus ampelas*.

Coccidae

Ceroplastes ceriferus (Fabricius)

146-2 Krakatau Is, Rakata, W Ridge, 100m, 6°09'S 105°25'E, 1.ix.1984, GF, on *Ficus montana*.

146-7 Krakatau Is, Panjang, 8°05'S 105°28'E, 3.x.1984, GF, on *Neonauclea calycina* [Rubiaceae].

Listed by Dammerman (1948: 474) as *C. ceriferus* Anderson, on *Ficus hispida*.

Ceroplastes hawanus Williams and Watson

Krakatau Is, no locality or number, BMNH. There are two specimens on a single slide identified originally as *Ceroplastes* sp. in F. Laing's handwriting and they may be the specimens listed by Dammerman (1948: 474) as *Ceroplastes* spec.

Ceroplastes rubens Maskell

146-2 Krakatau Is, Rakata, W Ridge, 100m, 6°09'S 105°25'E, 1.ix.1984, GF, on *Ficus monyana*.

Milviscutulus mangiferae (Green)

147-4 Krakatau Is, Rakata, W Ridge, 100m, 6°09'S 105°25'E, 8.ix.1984, ZEK, GF, on *Ficus montana*.

146-4 do, 1.ix.1984.

BMNH Sertung (Verlaten Island), on *Morinda citrifolia* [Rubiaceae], iv.1920, K.W. Dammerman. Listed in Dammerman (1948: 474).

Parasaissetia nigra (Nietner) (*Lecanium*)

Listed by Dammerman (1948: 474) from Sertung (Verlaten Island) on *Morinda citrifolia*.

Pulvinaria psidii Maskell

145-12 Java, Ujong Kulon, Cidaon, 6°48'S 105°15'E, GF, on undetermined plant, 1984.

Diaspididae

Aspidiotus destructor Signoret

146-11 Krakatau Is, Rakata, W Ridge, 6°09'S 105°25'E, ZEK, on *Barringtonia asiatica* [Lecythidaceae], 6.ix.1984.

Aulacaspis thorntoni Williams & Miller sp. n. described as new below.

144-4 Java, Ujong Kulon, Cidaon, 6°46'S 105°15'E, ZEK, on unidentified plant, 15.ix.1984.

?number Java, Ujong Kulon, Cikalappabeurren, Ciramea track, 6°47'S 105°14'E, GF, on *Barringtonia nudica*, 20.ix.1984.

144-9 Java, Ujung Kulon, Pulay Peucan, 6°45'S 105°15'E, GF, ZEK, on *Calophyllum inophyllum* [Guttiferae], 21.ix.1984.

Also recorded from Malaysia, Kuala Lumpur, on "Tembrusu", no. 7725, 8.i.1931.

Aulacaspis tubercularis Newstead

146-1 Krakatau Is, Rakata, W Ridge, 250m, 6°09'S 105°25'E, ZEK, on leaves of unidentified plant, 1.ix.1984.

143-1 Java, Ujung Kulon, Pulau Peucang 6°45'S 105°11'E, on *Calophyllum inophyllum,* 17.ix.1984.

145-13 Java, Ujung Kulon, Cidaon, 6°46'S 105°15'E, GF, *Canarium* sp. [Burseraceae], 6.ix.1984.

Fiorinia sp.

144-2 Java, Ujung Kulon, Pilau Peucan, 6°45'S 105°15'E, ZEK, on *Calophyllum inophyllum,* 1984. These specimens are not satisfactory to describe and illustrate.

Greeniella calophylli Williams & Miller sp. n. described as new below.

143-1 Java, Ujung Kulon, Pulau Peucan, 6°45'S 105°11'E, ZEK, on *Calophyllum inophyllum,* 17.ix.1984.

Parlatoria crotonis (Douglas)

11-1 Java, Ujong Kulon, Pulay Peucang, 6°45'S 105°15'E, ZEK, on *Linoceira* [=*Chionanthus*] *lanceolata* [Oleaceae] , 13.ix.1984.

Pinnaspis buxi (Bouché)

11-4 Java, Ujung Kulon, Pulau Peucan, 6°45'S 105°15'E, GF, ZEK, on *Barringtonia* sp. , 17.ix.1984.

145-26 Java, Ujung Kulon, Pulau Peucan, 6°45'S 105°15'E, GF, ZEK, on *Dysoxylum* sp. [Meliaceae], 17.ix.1984.

Kerriidae

Tachardina aurantiaca (Cockerell)

10-6 Rakata, Zwarte Hoek, 6°09'S 105°25'E, GF, on *Desmodium umbellatum* [Papillionaceae], 8.ix.1984.

Monophlebidae

Drosicha sp.

147-5 Krakatau Is, Anak Krakatau, 6°06'S 105°26'E, GF, on *Casuarina equisetifolia* [Casuarinaceae], 2.ix.1984. Immature specimens only.

Icerya aegyptiaca (Douglas)

147-12 Krakatau Is, Panjang, 6°05'S 105°28'E, GF, on *Drymaria* sp. [Caryophyllaceae], 1984; also 147-13 on *Ficus ampelas*, 3.ix.1984.

147-6 Krakatau Is, Anak Krakatau, 6°06'S 105°26'E, GF, on *Casuarina equisetifolia*, 2.ix.1984.

Icerya jacobsoni Green

146-7 Krakatau Is, Panjang, 6°05'S 105°28'E, GF, on *Neonauclea calycina*, 3.x.1984.

147-20 Krakatau Is, Rakata, W Ridge, 250m, 6°05'S 105°25'E, GF, on *Villebrunea rubescens* [Urticaceae]. Listed by Dammerman (1948: 473) on *Macaranga tanarius*, and discussed by Yukawa (1984).

Icerya pulchra (Leonardi)

145-14 Java, Ujung Kulon, Cidaon, 6°46'S 105°15'E, on *Calopyllim inophyllum*, 15.ix.1984.

147-9 Krakatau Is, Panjang, 6°05'S 105°28'E, GF, on Euphorbiaceae, 1984.

Icerya samaraia (Morrison)

10-5 & 147-2 Krakatau Is, Rakata, Zwarte Hoek, 6°09'S 105°25'E, GF, on *Hibiscus tiliaceus* [Malvaceae], 8.ix.1984.

10-1 & 10-3 Krakatau Is, Rakata, Zwarte Hoek, 6°09'S 105°25'E, GF, on unidentified plant, and on

Macaranga sp. [Euphorbiaceae], 8.ix.1984, and 147-1, P. Vaughan, on *Ficus ampelas*, 3.viii.1984.

146-7 Krakatau Is, Panjang, 6°05'S 105°28'E, GF, on *Neonauclea calycina*, 3.x.1984.

146-9, 146-8, 147-17, 147-18 & 147-19 Krakatau Is, Sertung, Spit, 6°04'S 18°24-25'E, GF, on *Omalanthus* [=*Homolanthus*] *populneus* [Euphorbiaceae], *Casuarina equisetifolia*, an unidentified plant, and *Hibiscus tiliaceus*, 7.ix.1984.

147-9 Krakatau Is, Panjang, 6°05'S 105°28'E, GF, on Euphorbiaceae.

147-2 Krakatau Is, Rakata, Zwarte Hoek, 6°09'S 105°25'E, GF, on *Hibiscus tiliaceus*, 3.viii.1984.

147-8 & 147-15 Krakatau Is, Anak Krakatau, 6°06'S 105°26'E, GF, on *Mikania cordata* [Asteraceae] and *Casuarina equisetifolia*, 2.ix.1984.

Icerya zimmermanni Green

147-3 Krakatau Is, Rakata, W Ridge, 250m, 6°09'S 105°25'E, GF, on *Macaranga ranarius*, 1984.

Ortheziidae

Nipponortheziella guadalcanalia (Morrison)

40-10 Krakatau Is, Rakata, W Ridge, 250m, 6°09'S 105°25'E, in yew litter, 19.ix.1984.

Pseudococcidae

Exallomochlus hispidus (Morrison)

146-4 Krakatau Is, Rakata, W Rudge, 100m, 6°09'S 105°25'E, on *Ficus Montana*, 1.ix.1984.

Ferrisia virgata (Cockerell) (*Pseudococcus*)

Listed by Dammerman (1948: 474) on *Guettatda speciosa* [Rubiaceae] and *Canavalia lineata* (*maritima*) [Papilionaceae].

Maconellicoccus hirsutus (Green) (*Pseudococcus*)

146-10 Krakatau Is, Sertung, 6°04'S 105°24-25'E, ZEK, on *Hibiscus tiliaceus*, 7.ix.1984. Also listed by Dammerman (1948: 474).

Planococcus citri (Risso) (*Pseudococcus*)

Listed by Dammerman (1948: 474) on *Macaranga tanarius*.

Planococcus lilacinus (Cockerell)

146-2 Krakatau Is, Rakata, W. Ridge, 100m, 6°09'S 105°15'E, GF, on *Ficus montana*, 1.ix.1984.

Pseudococcus ? viburni (Signoret)

Green (1913) recorded a single specimen of *Pseudococcus maritimus* (Ehrhorn) from Krakatau, collected on the sea shore. This mealybug is New World in origin and most records elsewhere have proved to be based on misidentifications. We believe that the species could have been *Pseudococcus viburni*, often misidentified as *P. maritimus* in the past.

Pseudococcus sp.

Listed by Dammerman (1948: 474) on *Ipomoea pescaprae* [Convolvulaceae].

Xenococcus acropygae Williams

Indonesia, Krakatau Is, Rakata. No date available. Recorded by Williams (1998) from the mandibles of the ant *Acropyga acutiventris* Roger.

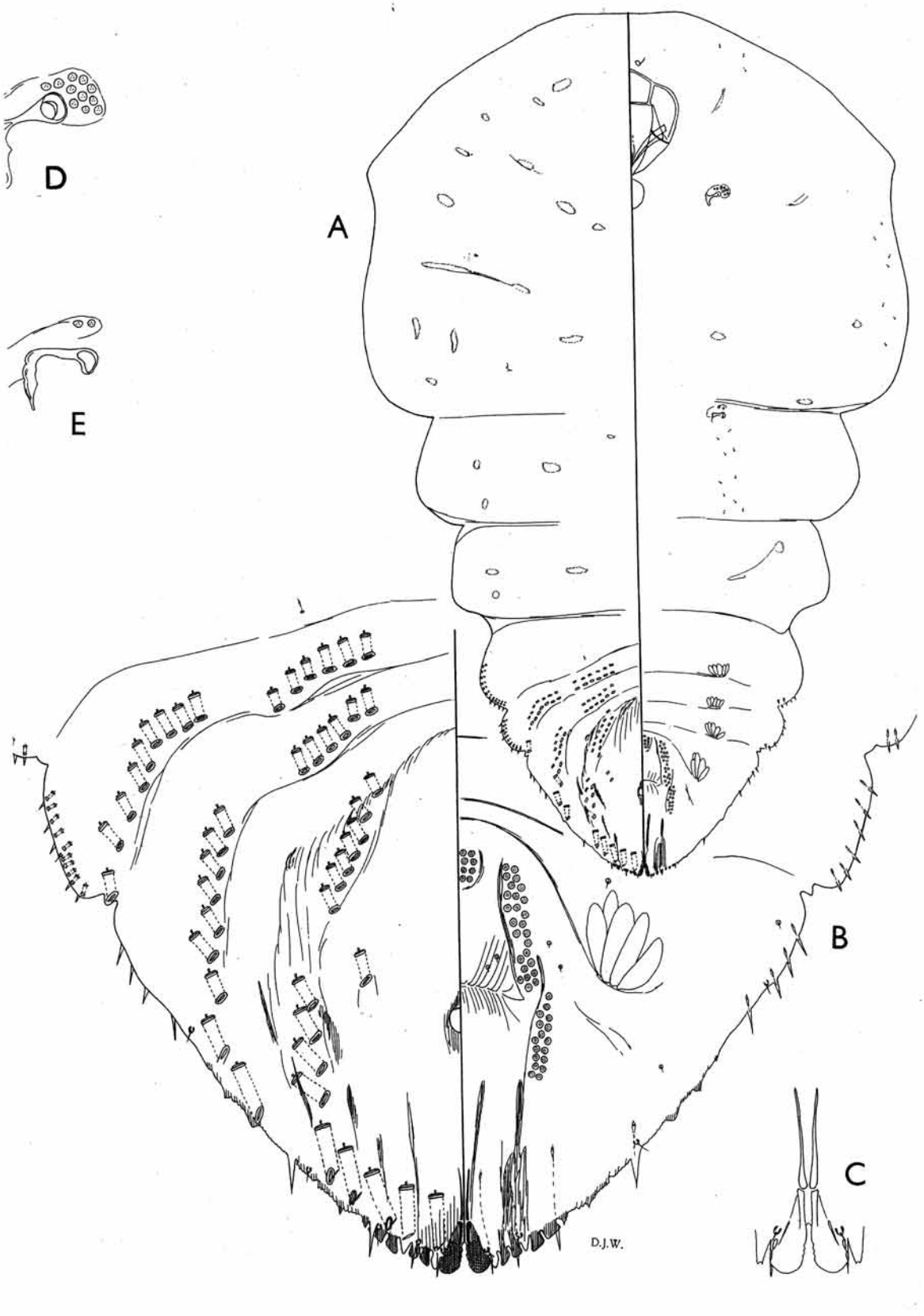

FIGURE 2. *Aulacaspis thorntoni* Williams and Miller. A. Adult female, B. Pygidium, C. Median lobes, D. Anterior spiracle, E. Posterior spiracle.

Descriptions of species

***Aulacaspis thorntoni* Williams and Miller, sp. n.**
(Fig. 2)

Adult female. Body 0.8–0.9 mm long and 0.8–1.0 mm wide, with prosoma swollen, rounded, but with lateral tubercle near juncture of head and prothorax; body widest at pro- and mesothorax, other prepygidial segments with lateral lobes moderately developed; pygidium rounded.

Pygidium with median lobes forming narrow notch at apex, diverging slightly, with inner edges serrate and longer than outer edges, rounded apically. Second and third lobes smaller, bilobed, rounded, usually without serrations, rarely with 1 or 2 on each lobule. Gland spines with 1 on each side of each of segments V–VIII, with 4 or more on each side of segments II–IV. Marginal macroducts longer than wide on segments IV–VII, shorter elsewhere, with submarginal and submedian clusters on segments III–VII, with 1 or 2 submedially on segment VI, total of 35–52 macroducts on each side of body. Microducts uncommon, usually 1–5 in submedian area of segment II. With conspicuous boss on segment I. Anal opening near centre of pygidium, posterior of position of vulva. Ventral surface with perivulvar pores in 5 groups. Microducts sparse, most abundant in lateral areas of head, prothorax, and mesothorax, with cluster near posterior spiracle. Antennae each with single seta. Anterior and posterior spiracles each with groups of disc pores. Peribuccal sclerosis absent.

Type material. Holotype adult female. Indonesia, Rakata Island, Krakatau, x.1933, on *Calophyllum* sp., K. W. Dammerman BM196, 1 adult female on 1 slide (BMNH).

Paratypes. Same as holotype. 11 adult females on 11 slides (ANIC, BMNH, NMV, USNM). Java, Ujung Kulon, Pulau Peucang 6°45'S 105°11'E, 15.ix.1984, 21.ix.1984, on *Calophyllum inophyllum* 144-4, 144-9, 4 adult females, 1 second-instar nymph on 6 slides (BMNH, NMV, USNM). Java, Ujung Kulon, Cikalappabeurren, Ciramea track, 6°47'S 105°14'E, 20.ix.1984, on *Barringtonia nudica* (NMV) 1 adult female on 1 slide (BMNH),1.ix.1984. Malaysia, Kuala Lumpur, 8.i.1931, on “Tembrusu”, no. 7725, 1 adult female on 1 slide (BMNH).

Notes. This species is similar to *Aulacaspis bambusae* (Green) especially in the distribution of the dorsal ducts. Contrasting characters for *Aulacaspis bambusae* are given in parentheses. *Aulacaspis thorntoni* differs from *A. bambusae* by having prepygidial body margin converging towards apex of pygidium (parallel sided), median lobes nearly parallel (divergent), margin of segment II weakly produced (strongly produced). This species is also similar to *Aulacaspis tubercularis* but differs by lacking a distinct peribuccal sclerosis and having more dorsal macroducts (see Takagi & De Faveri (2009) for an illustration of *A. tubercularis*).

Etymology. This species is named in honour of the late Ian Thornton, one of the organizers of the expeditions to Krakatau.

***Greeniella calophylli* Williams and Miller, sp. n.**
(Fig. 3)

Adult female. Body about as long as wide, 0.8–0.9 mm long and 0.8–1.0 mm wide, reniform, with pygidium projecting posteriorly beyond lobes formed by prepygidial segments of abdomen. Body membranous except for pygidium.

Pygidium with small space between median lobes, without yoke, parallel; apex of each lobe truncate, without notches. Second and third lobes similar in shape and size as median lobes. Without definite gland spines or plates, but with small swelling near marginal apex of macroduct furrows between median and second lobes, and between second and third lobes. Single gland spine on each lateral margin of segment V anterior of third lobes. Single paraphysis on each side of macroduct furrows between median lobes, median and second lobes, and second and third lobes, paraphyses sometimes fused. Macroducts slender, apparently with 2 between median lobes, 3 or 4 between median and second lobes, and 1 or 2 between second and third lobes. Microducts apparently absent. Perivulvar pores absent. Anal opening located in centre of pygidium, anterior of position of vulva.

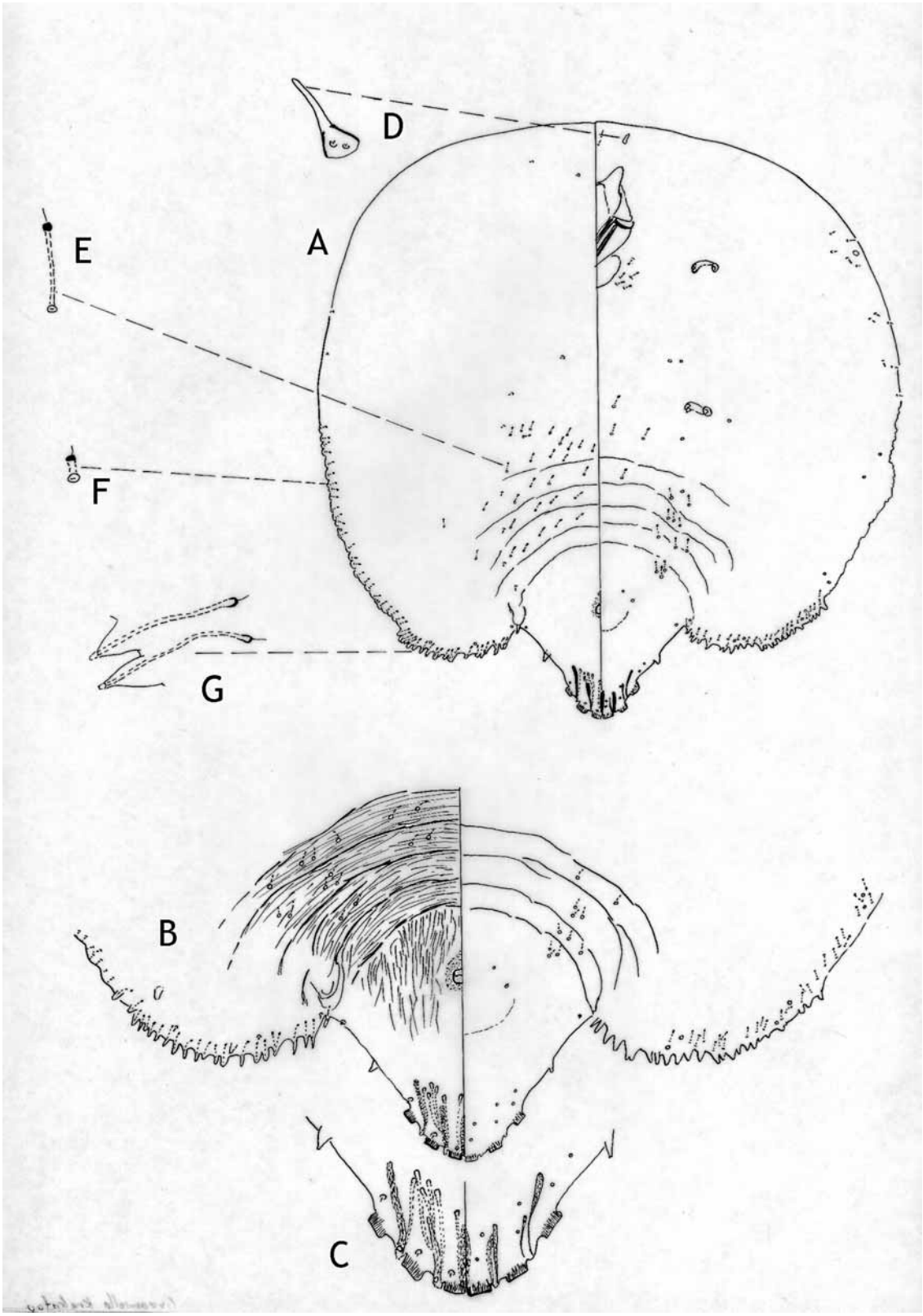

FIGURE 3. *Greeniella calophylli* Williams and Miller. A. Adult female, B. Pygidium, C. Pygidial margin, D. Antenna, E. & F. Two sizes of microducts, G. Gland spines.

Prepygidial dorsum with series of gland tubercles on lateral margins of areas forming prepygidial lobes; small microducts present on lateral margins of abdomen anterior of gland tubercles; longer microducts abundant in medial areas of anterior abdominal segments. Prepygidial venter with small microducts near gland tubercles and in submedial areas of anterior abdominal segments. With a few microducts laterad of mouthparts and submedially on posterior thorax.

Antennae with single conspicuous seta, fused with antennal base.

First-instar embryos unusually large, 0.3–0.4 mm long, antennae 5-segmented, apical segment unusually long; 2 pairs of lobes.

Type material. Holotype adult female. Java, Ujung Kulon, Pulau Peucang 6°45'S 105°11'E, 17.ix.1984, on *Calophyllum inophyllum* 143-1 (NMV).

Paratypes. Same data as holotype. 5 adult females on 5 slides (4 females containing 1, 2, 3, and 4 embryos respectively) (BMNH, NMV, USNM).

Notes. Adult females of species of *Greeniella* Cockerell are pupillarial with the adult female remaining within the previous (second) instar after the final moult. We have had no access to second-instar nymphs of this species. *Greeniella calophylli* is similar to *G. javanensis* (Green) and *G. mesuae* (Green) in that both have many gland tubercles on the prepygidial lobes, large embryos, and a wide body. Contrasting characters for *G. javanensis* and *G. mesuae* are given in parentheses. *Greeniella calophylli* differs from *G. javanensis* by having 3 pairs of truncate lobes (2 pairs of narrow rounded lobes) and no processes between the lobes (long processes between the lobes). *Greeniella calophylli* differs from *G. mesuae* by having median lobes of the same size and shape as the second and third lobes (median lobes smaller and with rounded apex) and only a single process between lobes 2 and 3 (3 or 4 processes between lobes 2 and 3).

Etymology. This species is named after the host plant genus *Calophyllum*.

Key to species of *Greeniella* Cockerell (Adult females)

1.	Margin of pygidium either without processes or with fewer than 24 processes	2
-	Margin of pygidium with 24 long, pointed processes	*ferreae* (Rutherford)
2(1)	Pygidial processes long and conspicuous, more than 3 times length of lobes	3
-	Pygidial processes short, either absent or no more than 3 times length of lobes	11
3(2)	Long processes on pygidium pointed	4
-	Long processes on pygidium fingerlike	9
4(3)	Median process with bifid tip, second processes long with divided tips, third processes pointed with single tip	*columnifera* (Green)
-	Not with this combination of characters	5
5(4)	Pygidium not forming parallel sided projection at apex	6
-	Pygidium forming long parallel sided projection at apex	*lahoarei* (Takahashi)
6(5)	Apex of pygidium truncate	7
-	Apex of pygidium not truncate	8
7(6)	Median and second lobes elongate each longer than wide; pygidial processes numbering 5 pairs at most	*javanensis* (Green)
-	Median and second lobes short and pointed, each about as wide as long; pygidial processes numbering 6 pairs or more	*fimbriata* (Ferris)
8(6)	With second pair of processes bifurcate, third pair trifurcate, fourth pair simple	*viridis* (Lindinger)
-	With second pair of processes trifurcate, third pair with more than 3 projections, fourth pair with 2 or more projections	*dentata* (Lindinger)
9(3)	Apex of pygidium elongate and projecting; with more than 7 pairs of pygidial processes	*tentaculatus* (Green)
-	Apex of pygidium if projecting, not elongate; with fewer than 7 pairs of pygidial processes	10
10(9)	Finger-like processes simple apically, without finger-like projections	*cornigera* (Green)
-	Finger-like processes divided apically, each process with 3 to 5 short finger-like projections	*ramosa* Williams
11(2)	Pygidial apex rounded	12
-	Pygidial apex truncate	13
12(11)	With 3 pairs of lobes, all about same size	*calophylli* Williams and Miller, sp. n.
-	With 3 pairs of lobes increasing in size anteriorly	*mesuae* (Green)

13(11) With 6 or 7 long ducts in first interlobular space and 3 or 4 in second interlobular space. *capitata* Brimblecombe
- With 4 long ducts in each of first and second interlobular spaces..... *ornata* Brimblecombe

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