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TAXONOMY OF THE MANGO SHIELD SCALE *PROTOPULVINARIA MANGIFERAE* (GREEN) (HOMOPTERA: COCCIDAE)

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A B S T R A C T

Protopulvinaria mangiferae (Green, 1889) a pest of mango ***(Mangifera indica)*** in Florida, Israel and the Philippines, is transferred from ***Coccus*** L. to ***Protopulvinaria*** Cockerell. A lectotype is designated and numerical data on the variability in certain major morphological characters of the female are presented. The adult female and its three preceding nymphal instars are redescribed.

The mango shield scale, ***Protopulvinaria mangiferae*** (Green, 1889) (Homoptera: Coccidae), occurs in most tropical and subtropical mango-growing countries. (Zimmerman, 1948; De Lotto, 1957; Beardsley, 1966; and see Material Examined). Recorded from numerous host plants (Merrill, 1953, and Material Examined), it is a pest only of mango ***(Mangifera indica)*** in Florida (Merrill, 1953) Israel (Avidov and Harpaz, 1969; Ben-Dov, 1971), and the Philippines (Otanes, 1936).

Various aspects of the biology of ***P. mangiferae*** have been studied (Otanes, 1936; Avidov and Zaitzov, 1960), but its taxonomy is inadequately known. The species is practicall unrecognizable from the original description (Green, 1889), as well as from the later redescription (Green, 1904). Morrison (1920) figured the general outline of ***mangiferae*** which cannot be used for its separation from allied species. A detailed redescription, based on Hawaiian specimens, had been presented by Ferris (in Zimmerman, 1948). This redescription proved to

be inaccurate, since significant discrepancies, mentioned earlier by De Lotto (1957) and Reyne (1961), were observed upon comparing the type-series, as well as material from other regions, with Ferris' redescription. In addition to the question of its true taxonomic characters, the generic definition of *mangiferae* has not been clarified. Steinweden (1929) suggested that *Lecanium mangiferae* should be transferred to *Protopulvinaria* Cockerell, whereas other students (e.g. Fernald, 1903; Ferris in Zimmerman, 1948; De Lotto, 1959) assigned it to the genus *Coccus* L.

The present study is based on material from the British Museum (Natural History), London - (BM), the United States National Museum of Natural History, Washington, D.C. - (USNM), Auburn University Entomological Museum, Auburn, Alabama-(AU), collection of Y. Ben-Dov - (C). The above mentioned abbreviations are denoted respectively at the end of each collection datum.

Protopulvinaria mangiferae (Green, 1889)

Lecanium mangiferae Green, 1889:249; Green, 1904:216

Coccus mangiferae (Green); Fernald, 1903:172; Ferris in Zimmerman, 1948:306; De Lotto, 1957:303

Lecanium wardi Newstead, 1917:353; Williams, 1963:100.

Protopulvinaria mangiferae (Green); Steinweden, 1929:223.

The type-series of this species - originally described from mango (*Mangifera indica*) in the district of Punduloya, Ceylon - was available for this study.

A comparison of some major female features - i.e. the elongate shape of the anal opercula, extension of the anal cleft to near the center of the body, presence of only one pair of prevulvar setae, and the presence of median and submarginal bands of clistostomatic ducts - with the characters of the type-species of *Coccus* showed that *Lecanium mangiferae* cannot be accommodated in *Coccus*. The above characters point to the affinity of *mangiferae* with the type-species of *Protopulvinaria*, as suggested earlier by Steinweden (1929).

ADULT FEMALE (Fig. 1). Body flat, almost triangular in outline, bluntly pointed at the anterior apex, broadly rounded posteriorly; preovipositing female yellowish-green; the dorsal surface of a fully grown, reproducing female sclerotized and brown.

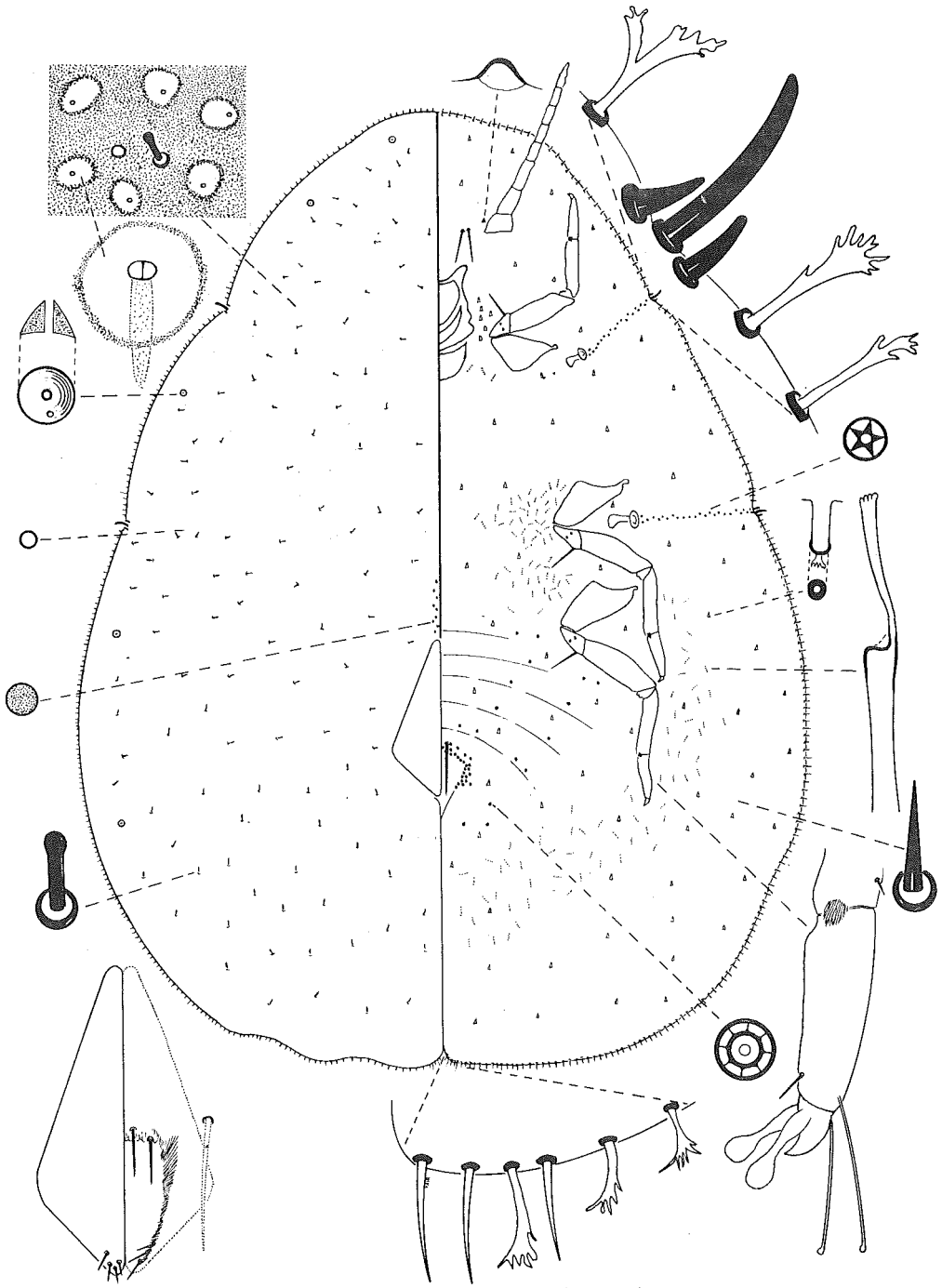

Fig. 1. *Protopulvinaria mangiferae* (Green) - Adult female.

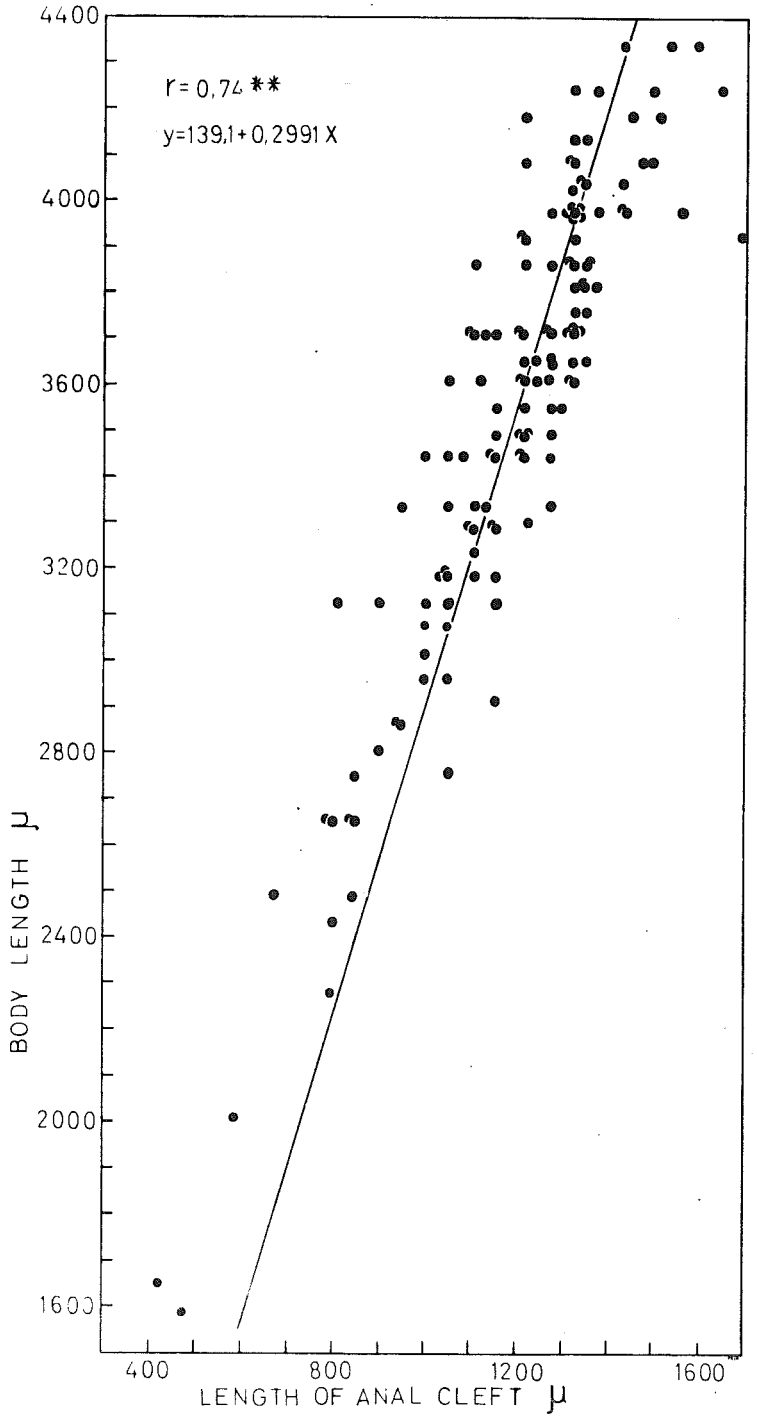

Fig. 2. Scatter diagram of body length to length of anal cleft (in μ) for female *Protopulvinaria mangiferae* (Green), from mango in Israel (C-546).

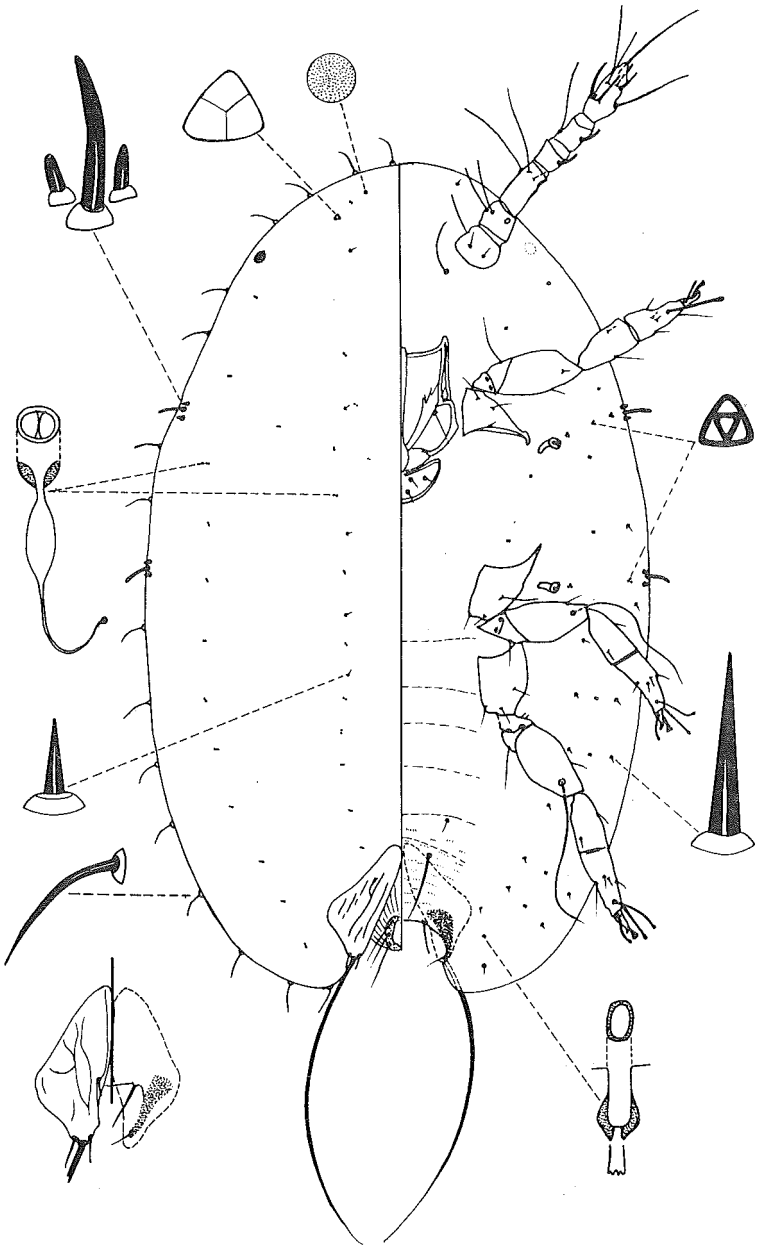

Fig. 3. *Protopulvinaria mangiferae* (Green) - First instar nymph.

Mounted female almost triangular in shape; bluntly pointed at anterior apex, broadly rounded posteriorly; size ranging from 1,3 x 1,6 mm (young female) to 3,4 x 4,4 mm (fully grown female). Dorsal surface with numerous, irregularly distributed, circular bright areas; each area surrounded by a dark rim, and with a minute bilocular pore in its center; these areas less conspicuous in young females, becoming very distinct in fully grown ones. Dorsal setae, distributed throughout surface, with conspicuous clavate apices. Paraopercular pores, 15-25 in number, placed just anteriorly to anal opercula. Submarginal tubercles placed dorsally from level of posterior margin of anal opercula to head; their numbers given in Table 1. Anal operculum triangular; narrow and elongate, 3,2 - 3,6 times as long as wide; length and width of anal operculum given in Table 1; cephalolateral margin 2,0 - 2,3 times as long as the caudolateral one; each operculum with 4 apical setae and 2 or 3 subapical (ventral) ones. Anal fold with 4 fringe setae. Anal ring rectangular, with 10 anal ring hairs, of which 2 pairs are smaller and shorter than others. Lengh of anal cleft (measured from the posterior margin to the posterior apices of the anal opercula) correlated with body length; these measurements (in μ) in the six specimens of the type-series are 432/1643, 486/1802, 837/2491, 837/2756, 972/2915, 1377/3975 respectively. This correlation as measured in a sample of 143 specimens from mango in Israel (C-546), is presented in Fig.2. Marginal setae (10-20 μ long) all variously branched or fimbriate at their apices, except for 3-5 simple, pointed setae on each side of the anal cleft; their numbers given in Table 1. Three spiracular spines placed marginally at the end of each spiracular furrow; median spine 17-25 μ long. Multilocoular pores set in a band around the genital opening, and in loose transverse rows on preceding abdominal segments. Quinquelocular pores disposed in rows, 1-2 pores wide, along the spiracular furrows; their numbers given in Table 1. Ventral clistostomatic ducts distributed as figured. Invaginated microducts with sclerotized inner extremities scattered over venter; forming concentrations on each side of the mouth parts. Ventral setae pointed. Legs well developed; tibio-tarsal articulation free and with an articulatory sclerosis; measurements of legs in Table 1, meso- and metathoracic legs larger than prothoracic ones; claw without denticle; tarsal digitules slender, slightly expanding at apices, longer than claw digitules; claw digitules with broadly expanded apices. Antennae usually 8-segmented, rarely with seven; total length given in Table 1. One or two conical disc pores anterior to each antennal base. One pair of prevulvar setae present, about 120μ long.

MATERIAL EXAMINED. *A S I A*. CEYLON. Six syntype females on a slide labelled "*Lecanium mangiferae* Green, from mango tree, Punduloya, Ceylon", these were remounted each on a separate slide, one female was selected and it is here designated Lectotype, BM; on *Litsea zeylanica*, Pundaluoya, BM; Paradeniya, II. 1911, on Cinnamon, BM; Pundaluoya, III.1902, mango, E.E. Green, USNM; Paradeniya, 28.VII.1954, mango, H.A. Bess, USNM. HONG-KONG, 1.IV.1958, *Rhodomyrtus tomentosa*, N.L.H. Krauss, USNM. INDIA. Debra-Dun, XI.1910, mango, R.S. Woglum, USNM; Pusa, mango, H.M. Lapoy, BM; Sikkim, Regitam, 17.IV.1952, on orange, C.K. Samuel, BM; West Bengal, Dali, 20.II.1957, Jak Fruit, S.K. Ghose, BM. ISRAEL. Nes Ziyona, 28.II.1947, mango, C-335; Rehovot, 12.I.1968, *Thevetia peruviana*, Y. Ben-Dov, C-185; Rehovot, 6.I.1973, mango, Z. Sela, C-546. MALAYSIA. Java, Garoet, X.1929, on citrus, USNM; Pamenang, Lombok, 20.IV.1937, on citrus, R.H. Le Pelley, USNM. PAKISTAN. Mirpurkhas, 10.IX.1966, mango, BM. PHILIPPINES. 28.IV.1954, mango, Gayden, USNM. SINGAPORE. Botanic Gardens, XI.1921, *Psidium guajava*, J.W. Sinkiel, USNM.

A F R I C A. GHANA, Ayimensah, 29.I.1922, mango, W.H. Patterson BM. MAURITIUS. 13.V.1934, *Cordia myxa*, R. Mamet, BM. SEYCHELLES ISLANDS, on mango, R. Dupont, BM; Mahe, V. 1937, *Eucalyptus citriodora*, D.V. Fitzgerald, BM; Mahe, 5.V.1952, *Eugenia jambosa*, D.V. Fitzgerald, BM; Mahe, 12.II.1952, Jak fruit, D.V. Fitzgerald, BM; Mahe, 30.XII.1952, *Artocarpus* sp., E.S. Browne, BM; Mahe 30.XII.1952, *Plumeria* sp. E.S. Browne, BM; Grande Base, 30.XII. 1952, Cinnamon, E.S. Browne, BM; Sans Souci, 10.VII.1952, Bread fruit, E.S. Browne, BM.

A M E R I C A. BARBADOS, intercepted at New York, 27.XII.1937, Papaya, USNM. BRITISH GUIANA, Georgetown, 24.IX.1918, *Artocarpus integrifolia*, H. Morrison, USNN. COLOMBIA, Palmira, 8.X. 1971, *Eugenia* sp., H. Martin, USNM. COSTA RICA, intercepted at Hoboken, 28.VII.1941, on mango, Adams, USNM. CUBA, Santiago de las Vegas, 22.IV.1905, mango, W.T. Horne, USNM. ECUADOR, Quito, 24.VII.1969, *M. indica*, D.P. Stewart, AU. HONDURAS, Coyoles, 5.XII.1967, *M. indica*, Q.L. Holdeman, AU. MARTINIQUE, San Juan, 6.IX.1952, mango, D. Laddey, USNM. MEXICO, Eldorado, 3.VI.1943, on orange, H.D. Smith, USNM. NICARAGUA, 14.II.1952, mango, R.B. Swain, USNM. PANAMA. Corozal, C.Z., 26.X.1918, mango, H.F. Dietz, USNM; Taboga Is., 31.III.1922, mango, Zetek, USNM. SAN SALVDOR, 8.VI.1945, mango, Pettit, USNM. U.S.A. FLORIDA: Miami, 6.XI.1940, *Ficus* sp., W. Mathis, USNM; Miami, 3.I.1947, *M. indica*, T.B. McClelland, Au; Miami, 8.IX.1973, *M. indica*, C.H. Ray, Jr., AU; Ft. Lauderdale, 16.IV.1974, *M. indica*, K.L.Tyson, AU; Coral Gables, 15.I.1966, *M. indica*, S. Nakahara, AU. TEXAS,

TABLE 1: Frequency and size range of certain structures of *Protopulvinaria mangiferae* female from localities all obtained from mango

Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CEYLON	6	304-360	I 114-138	151-179	103-120	58-65	248-268	69-83	58-83	12-28	81-96	13-27	26-41	8-11
Type - series		(331)	(126)	(170)	(112)	(62)	(261)	(73)	(77)	(25)	(88)	(21)	(31)	(9)
			II 134-165	158-203	107-131	69-79								
			(155)	(189)	(124)	(72)								
			III 144-169	172-206	120-138	69-76								
			(161)	(195)	(128)	(72)								
CEYLON	6	325-360	I 117-138	158-172	107-120	62-65	251-261	69-93	69-103	20-33	78-117	12-28	24-35	6-10
Various		(343)	(124)	(165)	(112)	(63)	(258)	(79)	(86)	(27)	(90)	(19)	(30)	(8)
			II 138-166	175-193	117-125	69-76								
			(146)	(185)	(122)	(72)								
			III 144-173	189-199	125-131	69-72								
			(158)	(194)	(126)	(70)								
ISRAEL	10	291-346	I 110-127	158-175	103-117	65-69	272-292	72-83	80-97	25-33	74-102	17-29	23-40	7-11
		(321)	(121)	(168)	(107)	(68)	(282)	(77)	(89)	(29)	(92)	(23)	(31)	(10)
			II 144-158	186-206	117-131	72-76								
			(150)	(196)	(123)	(73)								
			III 141-165	189-206	120-138	69-79								
			(155)	(198)	(130)	(74)								
SEYCHELLES	9	311-346	I 100-131	155-179	103-114	62-72	248-268	72-86	66-81	22-28	74-81	17-34	21-35	6-9
		(325)	(120)	(164)	(109)	(68)	(258)	(77)	(75)	(24)	(77)	(24)	(27)	(7)
			II 144-155	182-203	120-127	72-76								
			(150)	(193)	(124)	(74)								
			III 138-169	186-206	127-131	72-78								
			(155)	(197)	(128)	(75)								
U.S.A.	4	318-346	I 125-138	172-182	111-125	65-72	292-302	86-93	89-94	21-31	85-98	22-38	30-44	12-14
Texas		(333)	(131)	(178)	(118)	(69)	(299)	(89)	(91)	(27)	(91)	(31)	(36)	(13)
			II 152-166	200-217	131-138	73-83								
			(159)	(209)	(135)	(76)								
			III 159-173	206-224	138-145	78-84								
			(166)	(217)	(140)	(77)								

EXPLANATION OF COLUMN NUMBERS: The measurements (in μ) or the frequency numbers show the range, followed by the average in parentheses. I, II, III denote the pro- meso- and metathoracic legs respectively. 1. Numbers of specimens. 2. Length of antenna. 3. Length of coxa. 4. Length of trochanter + femur. 5. Length of tibia. 6. Length of tarsus. 7. Length of operculum. 8. Width of operculum. 9-11. Numbers of marginal setae between anterior stigmatic spines (9), between anterior and posterior stigmatic spines (10), between posterior stigmatic spines and anal cleft (11). 12-13. Numbers of quinquelocular pores on anterior spiracular furrow (12), on posterior furrow (13). 14. Numbers of submarginal tubercles

McAllen, 15.V.1950, mango, E.W. Linnard, USNM. VENEZUELA, Maracay, 21.XII.1938, mango, C.H. Ballow, USNM. VIRGIN ISLANDS, Croix, 15.VI.1919, mango, C.E. Wilson, USNM.

MALE. Males are unknown according to Green (1889, 1904), and were not observed in Florida by Merrill (1953). The occurrence of males had been reported from the Philippines (Otanes, 1936), and from Israel (Avidov and Zaitzov, 1960). According to the latter, males are very scarce, never exceeding 1% of the population.

We have seen only one second instar male which we mounted from dry material originally collected in Miami, Florida, from *M. indica* (3.I.1947, T.B. McClelland). It is morphologically similar to the second instar female except for the presence of numerous clistostomatic ducts along the dorsal margin.

FIRST INSTAR NYMPH (Fig. 3). Living specimens flat, light-yellow in color.

Mounted specimens elongate-oval to oval in outline, about 0,35 mm long, 0,2 mm wide, posterior end widest, derm membranous. Marginal setae 17-24 µ long, hairlike and usually curved toward posterior of body, distributed as follows: 12 between anterior stigmatic clefts, 2 between anterior and posterior stigmatic clefts, 8 between posterior stigmatic cleft and anal cleft. Each stigmatic cleft with 3 spines; median spine thick, 11-15 µ long, lateral spines bullet-shaped, 3-5 µ long, all spines rounded apically. Dorsal body setae bristle-like, about 2 µ long, arranged in 2 submedian rows of 4-5 each. Submarginal tubercles absent. Dorsal bilocular pores in 2 submedian and 2 submarginal rows. Trilocular and simple disc pores present on anterior part of head. Anal operculum triangular, somewhat elongate, 49-62 µ long, 19-27 µ wide; cephalolateral margin 37-43 µ long, caudolateral margin 21-13 µ long. Each operculum with 4 spical setae, one of these inserted in a notch about midway along the inner margin, and 1 subapical (ventral) seta. Anal fold with 1 pair fringe setae. Anal ring with 6 hairs. Eyes present near margin lateral of antennal bases. Ventral submarginal setae short, hairlike, distributed as follows: 2 at apex of head, 1 between anterior and posterior stigmatic clefts, 7 between posterior stigmatic cleft and anal cleft. Ventral body setae similar to ventral submarginal setae, arranged in

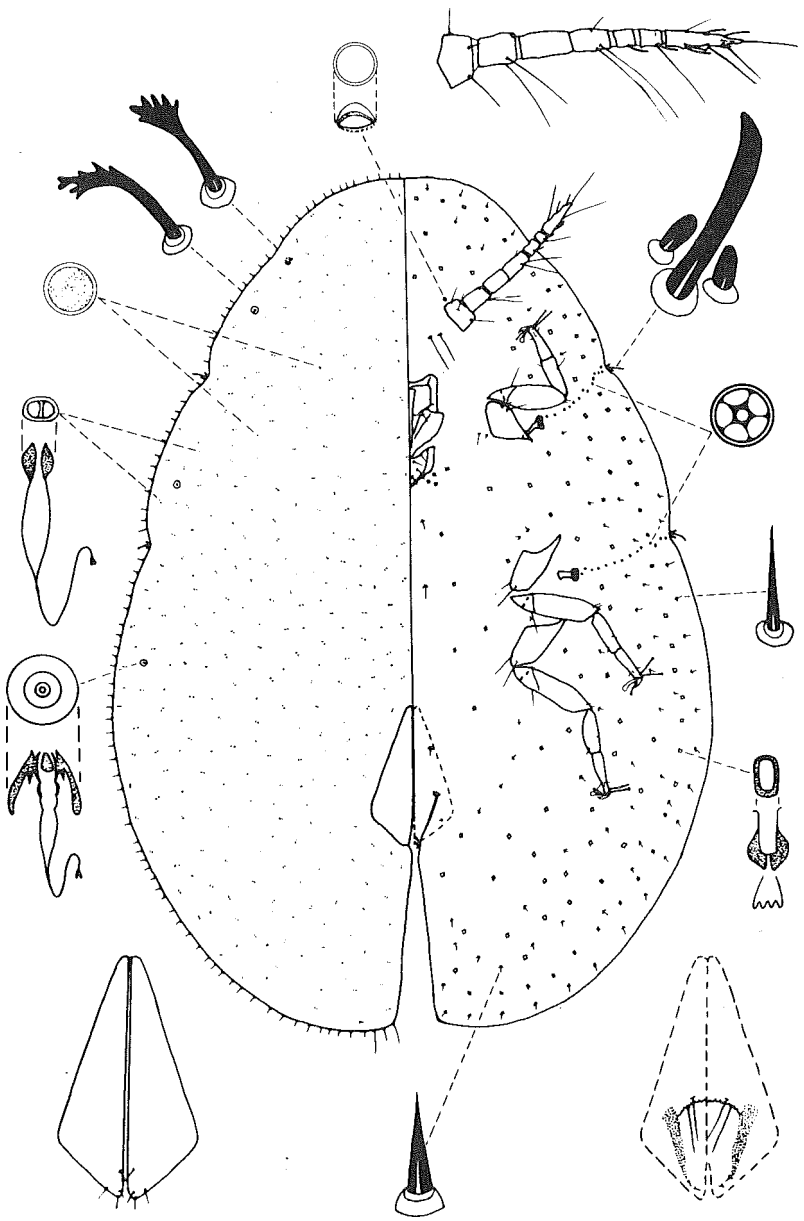

Fig. 4. *Protopulvinaria mangiferae* (Green) - Second instar female.

2 submedian rows on abdomen, each row with about 7 setae. Two long hairlike setae between antennal bases. Two pairs of ventral submedian setae, the posterior pair longer and thicker than anterior pair. Antennae 6-segmented, well developed, total length 96-117 µ. Legs well developed, 145-172 µ long, tibia and tarsus fused, without an articulatory sclerosis; each claw with a small denticle; 2 knobbed claw digitules, one slender, one expanded; 2 slender, knobbed tarsal digitules each except prothoracic tarsus which has 1 of the 2 digitules setiform. Meso- and metathoracic legs with a femoral seta as long as tibia and tarsus combined. Stigmatic furrows with 2-3 trilocular pores in each furrow. Small microducts with sclerotized inner extremities arranged in a row between ventral abdominal setae and ventral submarginal setae, with a few scattered elsewhere on venter.

MATERIAL EXAMINED U.S.A.: California, Baja, 12.VII.1971, mango, W.E. Gunderson, AU; Florida, Ft. Meyers, 21.III.1939, *M. indica*, H. Spencer, AU; Florida, Miami, 3.I.1947, *M. indica*, T.B. McClelland, AU; Florida, Miami, 8.XI.1973, *M. indica*, C.H. Ray, Jr., AU; Florida, Ft. Lauderdale, 16.IV.1974, K.L. Tyson, AU.

SECOND INSTAR FEMALE (Fig. 4). Living specimens flat, ovoid in outline, having a faint yellow-green color but appearing almost transparent when settled on host.

Mounted specimens ovoid in outline, usually with slight indentations of body margin in area of stigmatic spines, Body 0,7 - 1,1 mm long, 0,5 - 0,8 mm wide. Dorsal derm with numerous scattered bilocular and simple disc pores. Dorsal body setae absent. Marginal setae fimbriate except for a few long slender pointed setae near anal cleft, distributed as follows: 28-33 between anterior stigmatic clefts, 6-7 between anterior and posterior stigmatic clefts, 25-27 between posterior stigmatic cleft and anal cleft. Each stigmatic cleft with 3 stigmatic spines: median spine 17-25 µ long, lateral spines 5-7 µ long, all spines rounded apically. Two submarginal tubercles, 1 each positioned submarginally between stigmatic furrows on each side of body. Anal operculum elongate, triangular in shape, 100-125 µ long, caudolateral margin 42-52 µ long; each operculum with 4 apical setae and 1 subapical seta. Anal fold with 2 pair of fringe setae. Anal ring with 6 hairs. Eyes present lateral of antennal bases. Ventral submarginal setae short, slender and pointed, distributed

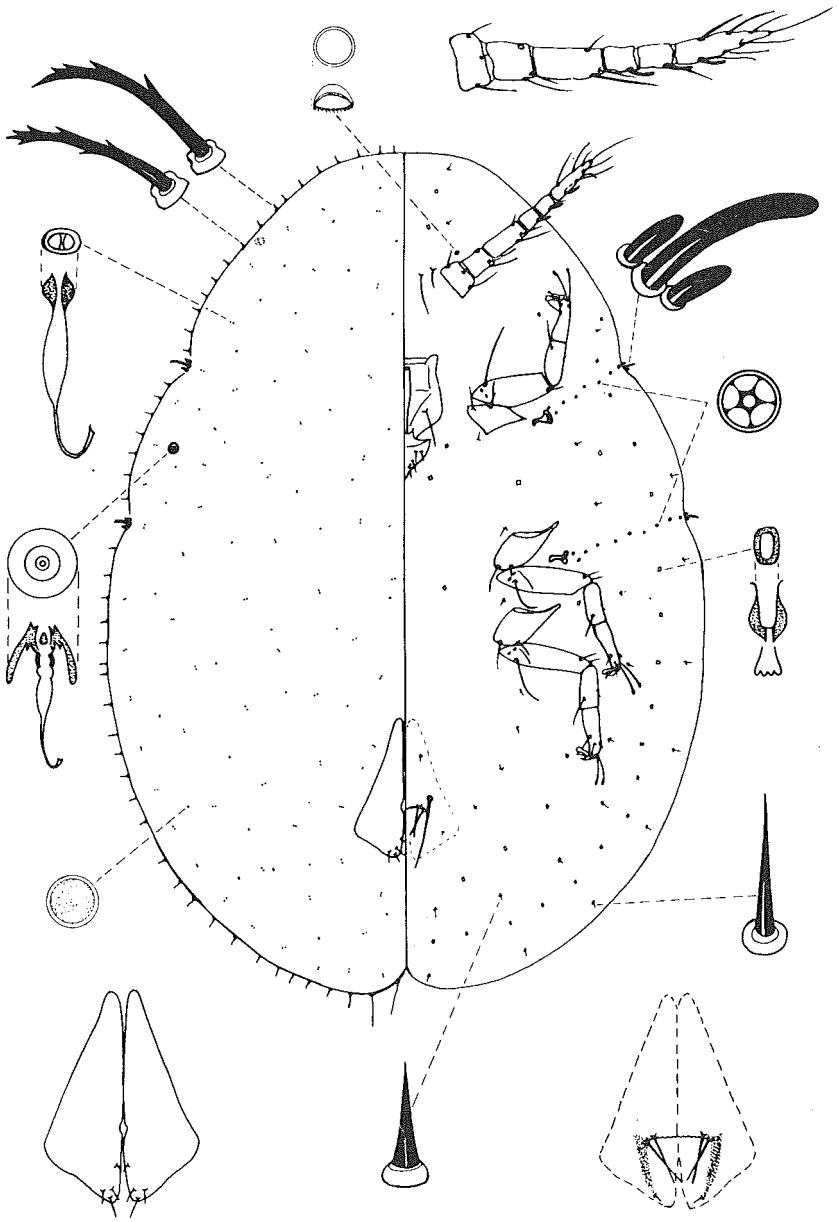

Fig. 5. *Protopulvinaria mangiferae* (Green) - Third instar female.

as follows: 4 between anterior stigmatic clefts, 2 between anterior and posterior stigmatic clefts, 7 between posterior stigmatic cleft and anal cleft. Ventral body setae similar in form, arranged in 2 submedian rows on abdomen, with a few scattered near leg bases and elsewhere on body. Two pairs of long hairlike setae between antennal bases, median pair longest. Two pairs of ventral submedian setae, the posterior pair much longer and thicker than anterior pair. Antennae 6-segmented, well developed, 148-173 µ long. Legs well developed, 207-243 µ long; tibia and tarsus fused, without an articulatory sclerosis; each claw with a denticle; 2 knobbed claw digitules, 1 slender, 1 expanded; 2 slender, knobbed tarsal digitules , A simple, convex disc pore located anterior to each antennal base. Stigmatic furrows with 7-9 quinquelocular pores in each furrow, with an occasional trilocular or quadralocular pore. Small microducts with sclerotized inner extremities arranged in a submarginal row and scattered elsewhere on venter of body.

MATERIAL EXAMINED. U.S.A. Florida, Ft. Meyers, 21.III. 1939, *Mangifera indica,* H. Spencer, AU; Florida, Miami, 3.I.1947, *M. indica,* T.B. McClelland, AU; Florida, Ft. Lauderdale, 16.IV.1974, *M. indica,* K.L. Tyson, AU.

THIRD INSTAR FEMALE (Fig. 5) Living specimens yellow-green, flat, ovoid to deltoid in outline, appearing almost transparent when settled on host.

Mounted specimens ovoid to deltoid in outline, usually with slight indentations of body margin in area of stigmatic spines; 0,8 - 1,9 mm long, 0,5 - 1,3 mm wide. Dorsal derm with numerous scattered bilocular and simple disc pores. Dorsal body setae absent. Marginal setae fimbriate except for a few long slender pointed setae near anal cleft, distributed as follows: 53-65 between anterior stigmatic clefts, 13-19 between anterior and posterior stigmatic clefts, 48-65 between posterior stigmatic cleft and anal cleft. Each stigmatic cleft with 3 stigmatic spines; median spine 20-38µ long, lateral spine 7-10µ long. With 4-6 submarginal tubercles around body margin anterior to anal plates. Anal operculum elongate, triangular in shape, 117-200µ long, caudolateral margin 47-73µ long; each operculum possesses 4 apical setae and 2 subapical setae. Anal fold with 2 pairs of fringe setae. Anal ring with 8 hairs. Eyes present laterad

of antennal bases. Ventral submarginal setae short, slender, and pointed, distributed as follows: 9-17 between anterior stigmatic clefts, 3-5 between anterior and posterior stimatic clefts, 14-18 between posterior stigmatic cleft and anal cleft. Ventral body setae similar in form, scattered over venter, with a few near leg bases. Two pairs of long hairlike setae between antennal bases, median pair longest. Two pairs of ventral submedian setae, the posterior pair much longer and thicker than the anterior pair. Antennae 7-segmented, well developed, total length 162-227μ.Legs well developed, 215-421μ long; tibia and tarsus fused, without an articulatory sclerosis; each claw with a denticle; 2 knobbed claw digitules, one slender, one expanded; 2 slender knobbed tarsal digitules. A simple convex disc pore located anterior to each antennal base. Stigmatic furrows with 9-18 quinquelocular pores in each furrow, with an occasional trilocular, quadralocular, or 6-locular pore. Small microducts with sclerotized inner extremities in a submarginal row and scattered over venter.

MATERIAL EXAMINED. U.S.A. Florida, Miami, 3.I.1947, *Mangifera indica,* T.B. McClelland, AU; Florida, Ft. Lauderdale, 16.IV. 1974, *M. indica,* K.L. Tyson, AU. Mexico, San Antonio 4245, 20.VII.1972, *Citrus* sp. (leaf) Parker, AU. (Mexico)

The larval instars and the female of *P. mangiferae* may be distinguished from each other by the differences in several characters as summarized in Table 2.

TABLE 2. Comparison between several structures of the larval instars and the female of *Protopulvinaria mangiferae*.

		First nymph	Second instar ♀	Third instar ♀	♀
1) Antenna		96-117	148-173	162-227	291-360
2) Marginal setae	a-	12	28-33	53-65	58-103
	b-	2	6-7	13-19	12-33
	c-	8	25-27	48-65	74-117
3) Spiracular pores	a-	2-3	7-9	9-18	12-38
	b-	2-3	7-9	9-18	21-44
4) Submarginal tubercles		-	2	4-6	6-14
5) Ventral multilocular pores		-	-	-	+
6) Clistostomatic ducts		-	-	-	+

1) Length in μ. 2) Number of setae between (a) anterior spiracular spines, (b) anterior and posterior spiracular spines, (c) posterior spiracular spines and anal cleft. 3) Number of locular pores on (a) anterior spiracular furrow, and (b) posterior one. 4) Number of tubercles for whole body. 5) Multilocular pores absent (-) or present (+). 6) Clistostomatic ducts absent (-) or present (+); see note on these ducts in the male second instar, above.

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