Taxonomic Study of Species Formerly Identified as *Anopheles mediopunctatus* and Resurrection of *An. costai* (Diptera: Culicidae)

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ABSTRACT *Anopheles (Anopheles) mediopunctatus* (Lutz) and *Anopheles (Anopheles) costai* Fonseca & Ramos are redescribed with illustrations of the male genitalia and larval and pupal stages. The pupa of *An. costai* has paired lateral projections on the wing case, a feature also known in members of the Umbrosus Group from Southeast Asia. *An. costai* is resurrected from the synonymy of *An. mediopunctatus* based on features of the male genitalia, larva, and pupa, and *An. bonneorum* Fonseca & Ramos (emended from *bonnei*) is considered to be a new synonym of *An. costai*. It is noted that the author of *An. mediopunctatus* is Lutz, not Theobald, as cited in most literature references.

KEY WORDS *Anopheles, mediopunctatus, costai,* Arribalzagia, redescription, taxonomy

Anopheles (Anopheles) mediopunctatus is commonly reported in lowland tropical South America (Deane et al. 1948; Forattini 1962; Tadei et al. 1983, 1988; Lourenço-de-Oliveira et al. 1989). It is primarily a forest species, often associated with simian malaria (R. Lourenço, personnel communication), and in the laboratory is very susceptible to human malaria (Klein et al. 1991a, b). This taxon is a member of the Arribalzagia series as defined by Reid and Knight (1961) and Wilkerson and Peyton (1990). Keys for the identification of adult female *An. mediopunctatus* usually use the following characters: lateral abdominal scale tufts, speckled femora, hindtarsomeres with broad white rings, hindtarsomere 5 all white, basal wing scales very broad, upper mesepimeron with a patch of scales, and sternum I with scattered white scales (Russell et al. 1943, Deane et al. 1946a, Lane 1953, Vargas 1959, Forattini 1962, Gorham et al. 1967). Wilkerson (1988), in a redescription of the holotype male of *An. mediopunctatus*, noted that none of the ≈40 male terminalia from specimens identified using the above criteria were true *An. mediopunctatus*. We report here on the identity of those specimens and others examined subsequently. We also address the status of the names associated with *An. mediopunctatus* and provide descriptions of 2 of the 3 species we now consider to belong to this group.

Materials and Methods

We follow Harbach and Knight (1980, 1982) for terminology of morphological characters and Wilkerson and Peyton (1990) for wing spot characters. Acronyms of depositories are as follows. The Natural History Museum, London, England (NHM); Faculdade de Saúde Pública, Universidade de São Paulo, Brazil (FSP). Abbreviations used are as follows: E, egg; G, genitalia; L, larva; Le, larval exuviae; P, pupa; Pe, pupal exuviae. An asterisk following the abbreviation of a given life stage indicates that at least part of the life stage was illustrated in the publication cited. Collection codes and numbers for most recent collections consist of a country code in capital letters followed by a collection number and an individual specimen number (e.g., BR 279-1 is an individual from collection 279 from Brazil) (specimen numbers 1-99 are used if there are associated larval and pupal exuviae, numbers 100 and up are used if there is only a pupal exuviae). Progeny from a single female are indicated by a number in parentheses, e.g., BR 279(12)-1 is an individual from female number 12.

Taxonomic Treatment

Anopheles (Anopheles) mediopunctatus (Lutz) (Figs. 1F, 2-4)

Cycloleppteron mediopunctatus Lutz, 1903. *In* Theobald 1903: 60-62. Type: holotype ♂, Santos, State of São Paulo, Brazil (NHM) (Belkin et al. 1971: 3, type information).

Cyclolepidopteron rockefelleri Peryassu, 1923: 68. Type: possible syntype ♀, State of Rio de Janeiro, formerly Guanabara, Brazil (NHM, examined =*intermedius* Peryassu) (Townsend 1990: 35, 128). Synonymy with *mediopunctatus* by Dyar (1925: 190).

Anopheles (Shannoniella) limai Fonseca & Ramos, 1940a: 384. Type: holotype ♂ (SPM33) with slides of

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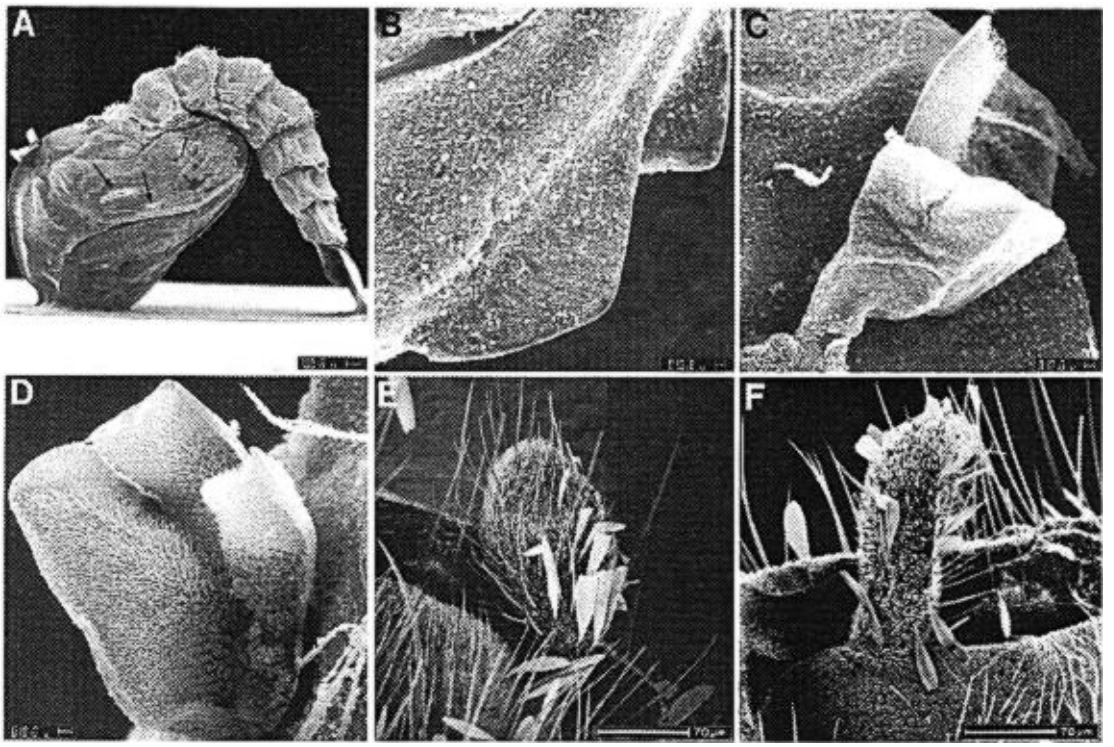

Fig. 1. *An. costai*, pupa. (A) Lateral view; arrows indicate lateral projections. (B) Mesothoracic wing case, dorsal view, showing lateral projections. (C) Trumpet, lateral view. (D) Trumpet, dorsal view. (E) Female cercus, ventral view. (F) *An. mediopunctatus*, female cercus, ventral view.

wing and male genitalia, São Vicente, State of São Paulo, Brazil (FSP) (Belkin et al. 1971: 3).

Anopheles (Shannoniezia) costalimai Coutinho, 1944: 425–434 (new name for *limai*) (preoccupied Galvão and Lane 1937: 227). Synonymy with *mediopunctatus* by Lane (1951: 6).

Other literature records: Christophers 1924: 3; Davis 1926: 18 (♂G, ♀*, as variety *rockefelleri*); Boyd 1926: 31, 40 (as variety *rockefelleri*); Russell et al. 1943: 55 (as *limai*); Lane 1949: 405 in Boyd 1949 (as *costalimai*); Correa 1950: 81, 82 (♀, L key, as *costalimai*); Lane 1953: 220 (♂*); Wilkerson 1988: 411 (redescription of holotype).

Female (Figs. 1F, 3D). Integument light to dark brown with grayish pollinosity, more evident on vertex. *Head.* Interocular space with 14–20 (n = 8 for this and the following measurements and counts except where indicated) long, white setae and row of small, narrow, appressed white scales; vertex, occiput and upper portion of postgena with numerous erect, truncate scales; patch of grayish white scales on anterodorsal area of vertex, nearly concolorous with pale scales on median area of anterior promontory, patch of black scales laterally on head concolorous with scales on anterior scutal fossa and upper antepronotum; head with 8–16 long, black ocular setae; postgena with long black setae ventrally. Clypeus bare. Pedicel of antenna with 4–11 small (n = 13), dorsolateral, narrow to broad, grayish white spatulate scales; flagellomere 1 mostly with numerous narrow to broad white scales and a few dark brown scales on ventral surface. Scales of maxillary palpus slender, spatulate, mostly dark brown with intermixed dark brown setae; scales on palpomeres 2–4 erect; palpomere 2 mostly dark-scaled, with pale yellow scales on basal 0.5 of inner portion; palpomeres 3 and 4 dark-scaled with pale yellow scales basally and with a few intermixed pale yellow scales; palpomere 5 with pale yellow scales basally and patch of pale yellow scales along middle of dorsal side; length of maxillary palpus 2.02–2.59 mm (mean = 2.30 mm), ratio of length of palpomeres 2–5 to total length of palpus, 2 = 0.26–0.31 (mean = 0.29), 3 = 0.33–0.37 (mean = 0.35), 4 = 0.21–0.24 (mean = 0.23), 5 = 0.13–0.15 (mean = 0.14); ratio of palpomere 4–5, 1.45–1.87 (mean = 1.68); palpus 1.00–1.29 (mean = 1.15) forefemur length. Proboscis dark-scaled, base with longer erect scales and setae; proboscis length 2.23–2.60 mm (mean = 2.42 mm), proboscis 0.99–1.11 (mean = 1.05) palpus length. *Thorax.* Scutum with 2 prominent dark spots on dorsocentral area just posterior to the ends of the prescutal sutures, another in prescutellar area continuing onto scutellum and 2 small spots at the end of lateral portions of prescutellar area. Scutal setae numerous, pale yellow with golden reflections, scutum mottled with small dark brown spots, mostly corresponding to setal insertions in acrostichal and dorsocentral areas; median

Table 1. *An. mediopunctatus* and *An. costai*: descriptive statistics for ratios of costal wing spot lengths/length of wing measured from humeral crossvein

Wing spot	*An. mediopunctatus*[a]		*An. costai*[b]	
	Range	Mean ± SD	Range	Mean ± SD
Basal pale	0.09–0.12	0.11 ± 0.01	0.07–0.12	0.10 ± 0.02
Prehumeral dark	0.40–0.44	0.42 ± 0.02	0.38–0.48	0.43 ± 0.04
Humeral pale	0.05–0.08	0.06 ± 0.01	0.02–0.07	0.04 ± 0.02
Humeral dark	0.17–0.34	0.24 ± 0.06	0.18–0.35	0.03 ± 0.05
Presector pale	0.05–0.08	0.06 ± 0.01	0–0.08	0.05 ± 0.02
Presector dark	0.42–0.56	0.47 ± 0.05	0.41–0.51	0.47 ± 0.04
Sector pale	0.26–0.43	0.33 ± 0.07	0.24–0.36	0.31 ± 0.03
Accessory sector dark	0.17–0.29	0.23 ± 0.05	0.11–0.28	0.22 ± 0.05
Sector dark	0.58–0.79	0.66 ± 0.06	0.57–0.77	0.67 ± 0.08
Subcostal area	0.74–1.00	0.85 ± 0.08	0.70–0.94	0.80 ± 0.08
Presubcostal dark	0.16–0.29	0.23 ± 0.04	0.10–0.30	0.20 ± 0.07
Presubcostal pale (proximal)	0.04–0.07	0.06 ± 0.01	0.04–0.07	0.05 ± 0.01
Presubcostal pale (distal)	0.04–0.09	0.08 ± 0.02	0.04–0.09	0.07 ± 0.02
Postsubcostal dark	0.15–0.30	0.23 ± 0.05	0.16–0.30	0.22 ± 0.05
Postsubcostal pale (proximal)	0.05–0.10	0.07 ± 0.01	0.05–0.08	0.06 ± 0.01
Postsubcostal pale (distal)	0.06–0.10	0.08 ± 0.01	0.05–0.09	0.07 ± 0.01
Subcostal dark	0.06–0.14	0.12 ± 0.03	0.08–0.17	0.14 ± 0.03
Preapical dark	0.57–0.81	0.71 ± 0.07	0.55–0.79	0.64 ± 0.07
Preapical pale	0.24–0.33	0.28 ± 0.04	0.26–0.36	0.30 ± 0.04
Accessory preapical dark	0.09–0.16	0.12 ± 0.03	0.10–0.22	0.15 ± 0.04
Apical dark	0.07–0.10	0.09 ± 0.01	0.08–0.20	0.13 ± 0.04

[a] Eight wings from 8 individuals.
[b] Ten wings from 10 individuals.

anterior promontory with patch of short, broad dark scales centrally and patch of long narrow falcate white to pale yellow scales on each side of dark patch; scutal fossa without scales except anterior scutal fossa with patch of broad, spatulate, dark brown erect scales with a few intermixed white to pale yellow scales, lateral margin of scutal fossa with a few pale yellow scales next to dorsal margin of postpronotum and on lateral sides of scutal suture; antealar area with sparse narrow to broad spatulate scales from scutal suture to supraalar area; supraalar area with pale yellow scales, these narrow falcate anteriorly and broad, spatulate posteriorly. Scutellum with 15–32 shorter and 14–17 long setae, short setae pale yellow, long setae brown with reddish reflections. Antepronotum with 11–23 yellowish to dark brown setae and numerous upper, dark spatulate scales (not counted). Pleural vestiture as follows, with all scales white to pale yellowish white, spatulate: upper proepisternum with 4,5 setae, without scales; prespiracular area with 3–7 setae, usually with 1 scale, rarely without a scale; prealar area with 5–12 setae; upper mesokatepisternum with 3–7 setae, 4–10 scales; lower mesokatepisternum with 2–4 setae, 8–13 scales; upper mesepimeron with 3,4 setae, 1–3 scales. *Legs.* Forecoxa with upper patch of yellow scales on anterior surface, a few dark scales below and small patch of dark scales near apex, laterally small patch of white scales and 1,2 white scales above, and patch of long white intermixed with few dark scales posteriorly; foretrochanter with small appressed pale yellow scales and dense patch of dark scales posteriorly, mid- and hindcoxae, and trochanters with patches of white scales except for patch of pale yellow scales on mesal side on trochanters. Extent and number of pale spots on femora and tibiae variable. Base and apex of forefemur pale; midfemur with ventral stripe of pale scales with well-demarcated borders; hindfemur dark-scaled with spots of pale scales; foretibiae mostly with yellow scales, anterior surface with dark spots, these sometimes extending to ventral surface, mid- and hindtibiae with ventral longitudinal stripe of yellow scales, anterior, posterior, and dorsal surfaces with spots of yellow scales, these sometimes encircling the segments; foretarsomeres 1–3 with longitudinal stripe of yellow scales on ventral surface and dark spots on posterior surface, these sometimes encircling the segment, foretarsomeres 4 and 5 yellow-scaled, 4 sometimes with dark spot near middle of posterior surface; midtarsomeres 1–4 with indistinct longitudinal stripe of yellow scales on ventral surface and dark spots on posterior, anterior, and dorsal surfaces, midtarsomere 5 yellow-scaled; hindtarsomeres 1–3 yellow-scaled with spots of dark scales sometimes encircling the tarsomeres, hindtarsomere 4 yellow-scaled with ring of dark scales encircling middle, hindtarsomere 5 entirely yellow-scaled. Forefemur length 1.89–2.18 mm (mean = 2.01 mm), ratio of forefemur length to proboscis length 0.74–0.90 (mean = 0.84). *Wing* (Table 1). Length (measured from humeral crossvein) 3.35–4.24 mm (mean = 3.80 mm). Dark scales brown to black, pale wing scales white and pale yellow. Costal wing spots (on C, Sc, R): basal pale spot always present; prehumeral pale spot absent; subcosta basad of humeral crossvein with patch of dark scales and 1, 2 white scales, ventrally with dense patch of broad dark scales near humeral crossvein; humeral crossvein dark-scaled dorsally and ventrally; accessory sector dark spot always present; always 2 pre- and 2 postsubcostal pale spots and 1 pre- and 1 postsubcostal dark spot; apical dark spot always present. Veins posterior to C, Sc, and R with intermixed pale and dark scales, vein R_{4+5} with small patch of white scales

followed by a small dark patch at proximal end of vein, M with area of dark scales extending along proximal 0.3, another on middle region and another on distal 0.3 near crossvein rm, birfurcation of M_1 and M_2 dark-scaled, M_{3+4} mostly dark-scaled with 2 small areas of pale scales, 1 on proximal region and another on distal region of vein, mcu mostly dark-scaled with a pale-scaled spot in the middle, CuA with intermixed pale and dark scales and area of dark scales near proximal end and another near distal end, 1A mostly dark-scaled with 2 distinct pale spots on basal 0.5. Pale fringe spots indistinct. *Halter.* Scabellum and pedicel with pale brown integument, dorsal surface of pedicel with white scales, capitellum with brown integument, dorsal surface with white scales, proximal part of concave center of capitellum without scales, ventral surface of capitellum dark-scaled. *Abdomen.* Integument brown to dark brown with some grayish pollinosity. Terga with numerous long yellowish setae; terga II–VII with erect, posterolateral dark scales or sometimes with intermixed pale yellow scales; tergum VIII with long, yellowish setae and a few narrow, pale yellow, spatulate scales on posterior portion of segment. Sterna with scattered brown to yellowish setae; sternum I with small patch of spatulate scales; sterna II–VII with scattered broad, white, spatulate scales and posteromedial patches of erect, spatulate, dark scales; sternum VIII with narrow, spatulate, pale yellow scales laterally, bare medially. *Genitalia* (Figs. 1F, 3D). Tergum IX narrow, with small fingerlike lobe on each side of median straight area; cerci elongate, somewhat elliptical in outline with dark scales and a few pale yellow scales on base of ventral surface; postgenital lobe weakly sclerotized, somewhat pentagonal in outline, with small posterior bridge bearing patch of minute spicules, caudal margin broadly rounded with 1, 2 strong setae at apex; 21–26 weak insular setae; upper and lower vaginal lips indistinct; upper vaginal sclerite well sclerotized.

Male (Fig. 2). As in female except for the following sexual differences. Maxillary palpus ≈0.95 length of proboscis (n = 4 for this and the following measurements); apex of palpomere 3 and all of palpomere 4 and 5 enlarged. Maxillary palpus with dark brown and pale yellow scales; base of palpomere 2 with erect scales, basal 0.5 with patch of pale yellow scales, a few pale yellow scales extending from apical 0.3 of dorsal surface to apex of ventral surface; palpomere 3 with pale yellow scales at base, a patch of pale yellow scales on apical 0.5 of dorsal surface and patch of pale yellow scales at apex; palpomere 4 dark-scaled with patch of pale yellow scales on middle region of dorsal surface, sometimes mostly pale yellow-scaled with a few dark scales at apex and base; inner surface with long, yellowish setae; palpomere 5 totally pale yellow, sometimes with a few dark scales on lateral surface. Proboscis length ≈2.60 mm, with small, decumbent, dark brown scales and ventrobasal patch of erect, dark scales; labela brown. Foreungues with curved submedian tooth and blunt, external basal tooth. *Genitalia* (Fig. 2 A–G). Ninth tergal lobes prominent, slightly curved dorsally and slightly arched outward from each other, interlobar area straight. Dorsal surface of gonocoxite (prerotational sense) with a few scattered, short to moderately long setae; lateral surface with slender, fusiform and spatulate scales; ventral surface with short to moderately long setae and a few scales proximally, most mesal parabasal seta stout, rodlike with slender, recurved tip, borne on strong tubercle, 2nd parabasal longer and more slender, most mesal parabasal ≈0.35 from base of gonoxite, 2nd parabasal ≈0.32 from base of gonocoxite; internal seta stout with slender tip, longer than most mesal parabasal, base 0.54 distance from base of gonocoxite. Dorsal lobe of claspette short, poorly separated from ventral lobe, area between ventral and dorsal lobes small, dorsal lobe with 3 modified, rodlike setae, 2 of these are shorter and rounded at apex, the 3rd with strong hook at apex; ventral lobe of claspette of nearly equal width, rounded toward apex in lateral view, with 1 strong, sinuous seta at apex, 2 smaller, slender setae just below the apex on ventromedial side and numerous long, strong spicules along dorsomedial surface which is slightly concave. Gonostylus with 10–14 minute setae on dorsal side; gonostylar claw short, spiniform and blunt. Aedeagus with 1 pair of leaflets, leaflets with small aciculae on base of inner margins.

Pupa (Fig. 3 A–C). Position and development of setae as figured; range and modal number of branches shown in Table 2. Integument weakly pigmented, slightly darker on wing and leg cases, antennal case with dark pigmentation at flagellomere joints; metathorax with poorly defined dark spot next to small projection; paddle slightly darker. *Cephalothorax.* Trumpet laticorn, tragus elongate, broad, rounded at apex; secondary cleft present. Seta 8-CT with 1–6 branches; 10-CT with 2–7 branches. *Abdomen.* Terga and sterna II–VIII with numerous small spicules, more evident medially and posteriorly; posterior margins of terga II–VII with sparse, small spicules, lateral margins of terga III–VIII with small spicules, more evident on segments V–VIII. Seta 1-III–VII well developed; 8-II usually present, sometimes absent or only alveolus present; 9-II–VIII peglike to long and pointed, 9-II minute, unpigmented, 9-III stout, short, ≈1.28 length of 9-II, 9-IV thick, ≈2.11 length of 9-III, dark, 9-V strong, ≈1.30 length of 9-IV, 9-VI strong, ≈1.22 length of 9-V, 9-VII strong, curved, usually pointed, occasionally branched at apex, ≈1.13 length of 9-VI, 9-VIII aciculate, ≈1.39 length of 9-VII, 9-II–IV ≈0.1 length of segment, 9-V, VI ≈0.15 length of segment, 9-VII,VIII ≈0.2 length of segment; 10-II usually present, rarely only alveolus present; 11-II rarely present, frequently present as alveolus only. Segment VII 1.11–1.25 (mean = 1.16) length of segment VI; segment VIII 1.12–1.39 (mean = 1.30) length of segment VI. Width segment VIII 0.92–1.03 (mean = 0.98) width segment VII). Width/length (width at posterior margins) of segment VI 2.71–3.14 (mean = 2.85), VII 2.14–2.43 (mean = 2.28), VIII 1.84–2.28 (mean = 2.00). Paddle length 0.62–0.72 mm (mean = 0.66 mm), width 0.44–0.52 mm (mean = 0.47 mm), length/width ratio 1.36–1.47 (mean = 1.41), somewhat oval, equally sclero-

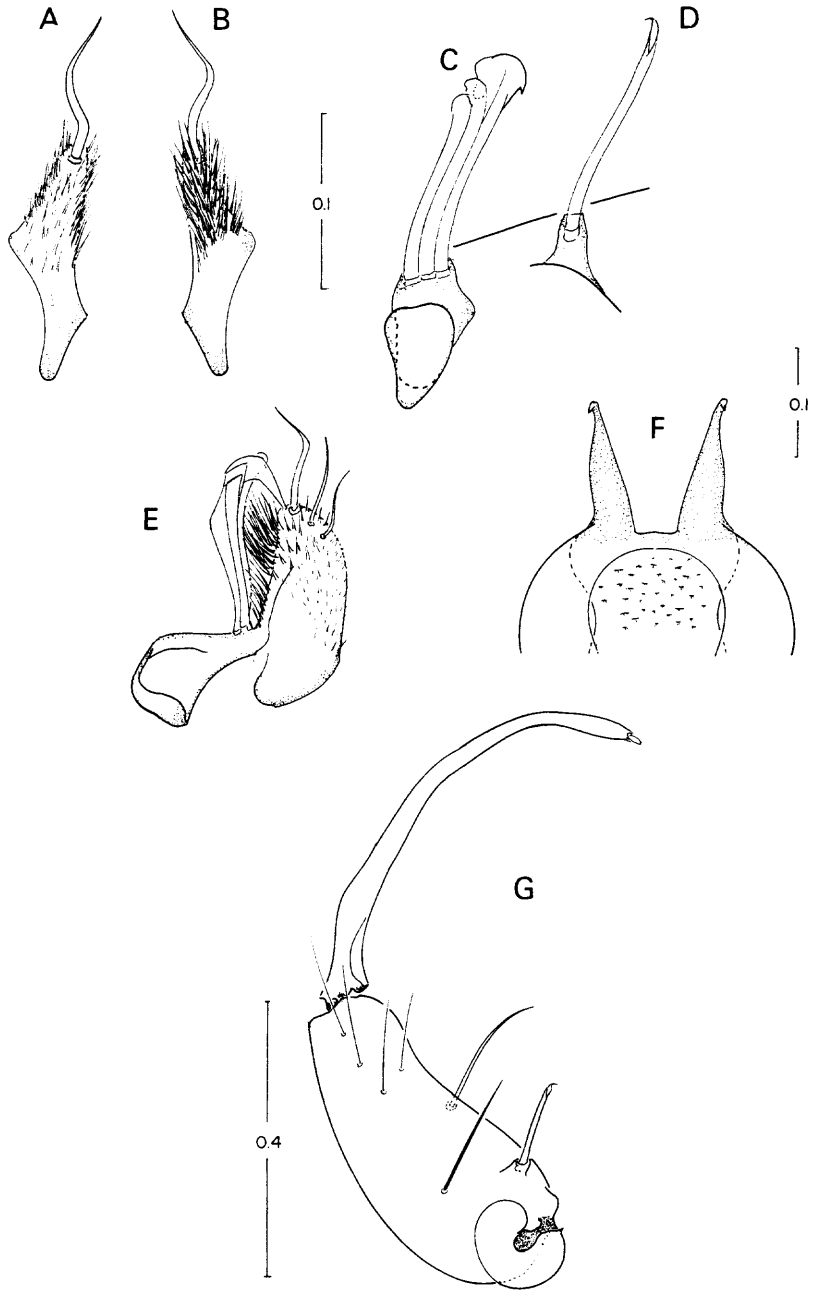

Fig. 2. *An. mediopunctatus*, male genitalia. (A) Ventral lobe of claspette, lateral aspect. (B) Ventral lobe of claspette, mesal aspect. (C) Dorsal lobe of claspette. (D) Mesal parabasal seta. (E) Claspette, lateral aspect. (F) Tergum IX, ventral aspect. (G) Gonocoxite and gonostylus, dorsal aspect. Scale in millimeters.

tized; refractile index 0.59–0.65 (mean = 0.62); length of marginal spicules 0.03–0.04 mm (mean = 0.04 mm).

Larva (Fig. 4). Position and development of setae as figured; range and modal number of branches as in Table 3. *Head.* Antennal length 0.23–0.27 mm (mean = 0.25 mm), tapered toward apex, 6.11–7.04 (mean = 6.46) longer than wide; with sparse spicules, longer and more numerous basal to seta 1-A on dorsal surface, ventral surface with few spicules; seta 1-A with 13–26 branches, inserted 0.33–0.37 (mean = 0.35) from base of antenna; 2-A pointed; 3-A truncate, tip weakly pigmented; 4-A plumose, shorter than 2-A or 3-A. Seta 2-C double to 5-branched on apical 0.5, 1.09–1.34 (mean = 1.27) length 3-C, 2-C close to mate of opposite side, distance between bases 1.38–2.30 (mean = 1.88) width base of single seta; 3-C ≈0.80 length of 2-C, with

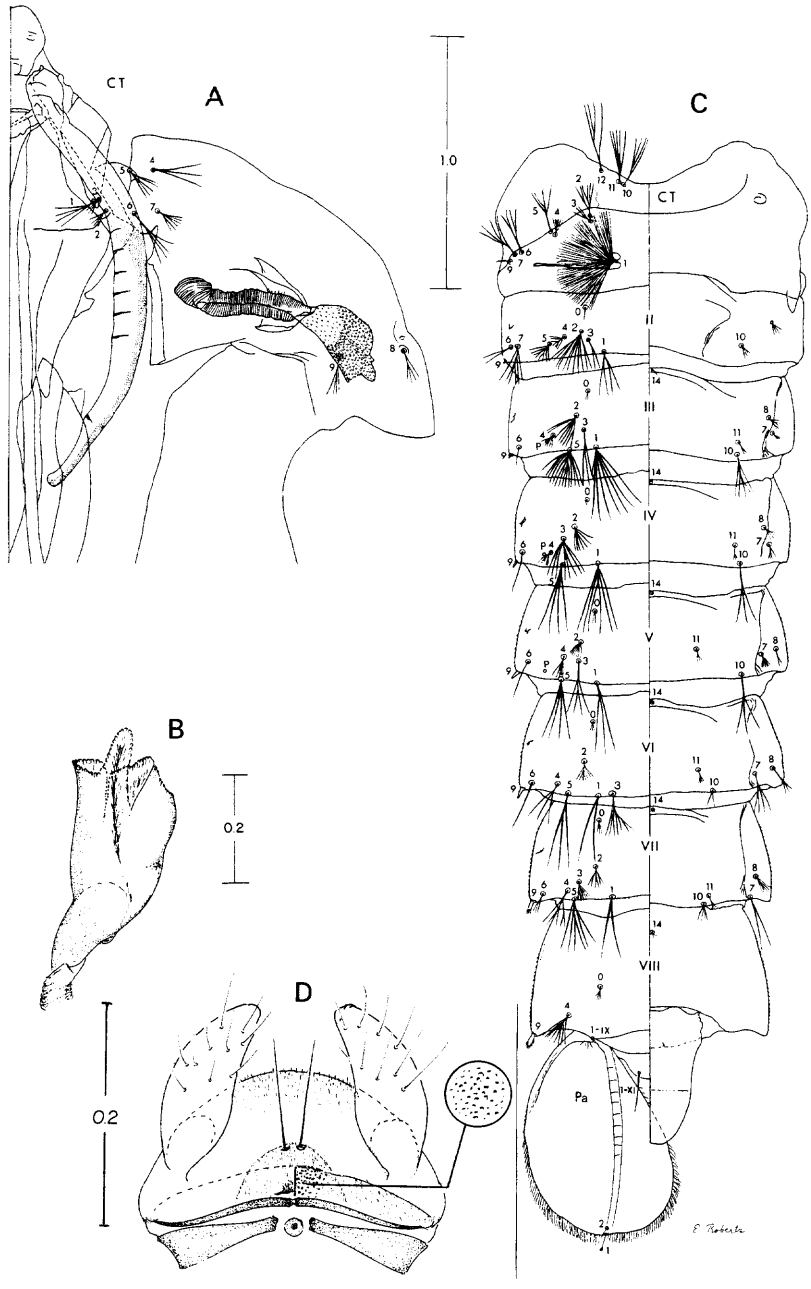

Fig. 3. *An. mediopunctatus*, pupa. (A) Cephalothorax. (B) Trumpet. (C) Metathorax and abdomen, left side dorsal, right side ventral. (D) Female genitalia, ventral aspect. Scale in millimeters.

6–19 branches, clypeal index (distance between bases 2-C and 3-C on 1 side/distance between bases of 2-C) 2.40–3.59 (mean = 2.93); 4-C single to triple; 8-C single to 5-branched; 9-C double to 9-branched. *Thorax.* Seta 1-P not palmate, single to triple; 9,12-P always single, 10-P usually single, occasionally double, 11-P frequently double; 9–11-M always single, 12-M usually double; 3-T palmate, hyaline. *Abdomen.* Integument hyaline with minute spicules on ventral surface. Seta 1-I, II palmate, poorly developed and weakly pigmented, 1-III–VII palmate, leaflets broad with jagged margins, apices weakly pigmented; seta 1-X inserted outside saddle, saddle spiculate laterally, integument of posterior margin of segment X with numerous, long spicules. *Spiracular Apparatus.* Pecten with 12–16 teeth, arrangement of teeth alternating long and short, sometimes alternating pattern interrupted by the presence of 2 short spines between long or by the absence

Table 2. Pupal setal branching for *An. mediopunctatus*: range mode ( ) based on counts made on 10–24 setae

Seta no.	Cephalothorax CT	Abdominal segments I	II	III	IV	V	VI	VII	VIII	IX	XI	Paddle Pa
0	—	—	1,2(1)	1-4(2)	1-3(2)	1-3(2)	2-4(2)	2-4(3)	2-4(3)	—	—	—
1	2-5(3)	7-12(10)[a]	1-5(3)	6-13(8)	4-10(7)	3-6(3)	2-4(2)	1-3(2)	—	1	0-3(1)	1-5(4)
2	2-5(4)	4-14(5)	7-11(9)	7-12(9)	4-11(6)	4-9(6)	5-10(8)	5-9(6)	—	—	—	1
3	2-6(4)	2-6(3)	1-3(2)	2-4(2)	3-12(9)	4-8(5)	1-9(6)	4-9(7)	—	—	—	—
4	2-5(3)	5-13(9)	2-11(5)	2-9(6)	1-9(6)	3-8(5)	1-5(3)	2-5(3)	4-8(6)	—	—	—
5	3-6(4)	3-10(5)	2-9(5)	9-19(11)	3-7(4)	3-5(4)	3-5(3)	3-7(5)	—	—	—	—
6	3-5(4)	2-9(5)	1-4(2)	1-3(3)	1	1	1	3-5(3)	—	—	—	—
7	4-8(7)	1-8(5)	3-9(6)	3-13(4)	4-8(5)	2-6(5)	2-5(3)	1-3(2)	—	—	—	—
8	1-6(3)	—	3-5(4)	2-6(4)	1-5(3)	1-4(3)	2-5(3)	5-8(6)	—	—	—	—
9	2-4(3)	1,2(1)	1	1	1	1	1	1	1	—	—	—
10	2-7(4)	—	0-7(5)	2-7(4)	2-5(2)	1-4(2)	1-5(2)	3-5(4)	—	—	—	—
11	3-6(5)	—	0-5(2)	1-5(1)	1-4(2)	1-4(3)	2-5(3)	2-4(2)	—	—	—	—
12	3-8(4)	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	1	1	1	1	1,2(1)	1-3(1)	—	—	—

[a] Main branches.

of short spine, with 8,9 long and 3–7 short; long teeth 2.46–3.81 (mean = 2.86) length of short teeth.

Type Material. *Cyclolepteron mediopunctatus:* see Wilkerson (1988) for a description of the holotype. *Cyclolepidopteron rockefelleri:* syntype female with the following labels: handwritten *"Cy. Rockefelleri;"* a printed label "Brit. Mus. 1924-240;" a printed/handwritten white label "S. America, Brazil (printed), Rio de Janeiro, L. G. Saunders (handwritten);" a white label with a blue circle "syntype;" and a handwritten white label *"Cy. rockefelleri,* ♀ ♀ only." This specimen was designated as syntype by Townsend (1990), but we found it to be *An. intermedius* (Peryassu). *Anopheles limai:* holotype male, adult on pin with 2 slides, 1 with the male genitalia and the other with a wing with the following handwritten labels. Adult: a small "33;" another *"A.(A.) mediopunctatus* Silva Ramos det., V-1939;" and *"Anopheles (Shannoniella) limai* Fonseca e Ramos, 1940, holotipo;" both slides with similar labels: "Serv. Profilax. Malaria, São Paulo, Brasil, *Anopheles (Shannoniella) limai* Fonseca e Ramos 1940;" male genitalia with "n°33;" slide number "2-G7, D5, São Vicente;" and wing with "n°33," slide number "3-G7, D5."

Other Material Examined. 6♂, 4♂G, 8♀, 14Pe, 12Le, and 2 4th-instars as follows: BRAZIL, São Paulo State, Iguape County, Iguape to Icapara Road Km 6, 24° 43' S 47° 33' W, II.1989, Peyton and Wilkerson colls., collected as larvae and pupae from several pools: BR 45-2, 1♀, 1Pe, 1Le; BR 59-1, 1♂, 1♂G, 1Pe, 1Le; BR 112-1, 1♂, 1♂G, 1Pe, 1Le; BR 114-100, 1♀, 1Pe, 2 progeny broods from females collected with "Shannon Trap," same collection data except for 27.II.1996, Wilkerson and Sallum coll.: BR 124-1-7, 2♂, 1♂G, 4♀, 6Pe, 7Le; BR 131-1, 1♀, 1Pe, 1Le; Ilha Comprida County, Pedrinhas District, collected as larva and pupae from ground pool: BR 189-1, 1♀, 1Pe, 1Le; BR 189-100, 1♂, 1Pe; BR 189-101, 1♂, 1Pe; 1 progeny brood from female collected with Shannon Trap, same collection data except for 7.V.1996, Forattini coll.: BR 191, 192, 2 4th-instars.

Distribution. Because *An. mediopunctatus* has been confused with *An. costai* throughout South America, its distribution requires reevaluation. Currently it is known to occur in the coastal regions of Brazil in the States of Rio de Janeiro and São Paulo.

Medical Importance. Not known.

Biology. Little is known about the biology of adult and immature stages of *An. mediopunctatus.* In the State of São Paulo it has been captured with a Shannon trap in coastal secondary growth vegetation in the Tropical Atlantic System. Immatures were taken from a heavily shaded stream and flood pools. The water was fresh, semipermanent, acid (pH ≈4.5), colored, and without aquatic vegetation and algae.

Anopheles (Anopheles) costai Fonseca & Ramos (Figs. 1 A–E, 5–7)

Anopheles (Shannoniella) costai Fonseca & Ramos 1940a: 385. Type: holotype ♂, State of São Paulo, Brazil [FSP examined] (Belkin et al. 1971: 3, type information). Synonymy with *mediopunctatus* by Lane (1953: 220). RESURRECTED FROM SYNONYMY WITH *An. mediopunctatus.*

Anopheles (Shannoniella) bonneorum Fonseca and Ramos 1940a: 386. Type: None designated, based on description of *An. mediopunctatus* of Bonne and Bonne-Wepster (1925: 538). Spelling here emended from the singular *bonnei.* NEW SYNONYMY.

Confirmed literature records for *An. costai:* Bonne 1923: 115–117 (♂* only); Komp 1942: 60, 106, 147 (♂*,♀*,P*, L*, Colombia, Trinidad); Russell et al. 1943: 51; Correa and Ramos 1944: 23 (♂*, L*, E*); Causey et al. 1944: 5, 6 (E*); Causey et al. 1946: 25 (♂*, key); Deane et al. 1946a: 13 (♀*, key); Deane et al. 1946b: 41, (L*, key); Lane 1953: 220 (♀*, P*, L*, E* Panama, except ♂* *mediopunctatus;* syn. with *mediopunctatus*); Bejarano 1959: 316 (Argentina); Forattini 1961: 171, 179, 185 (keys for ♂G, ♀, L); Forattini 1962: 331 (♂*, ♀*, L); Garcia and Ronderos 1962: 128, 129, 132, 145 (♂,♀, L key).

Other literature records which might refer to *An. costai* (as *An. mediopunctatus*) or to the undescribed

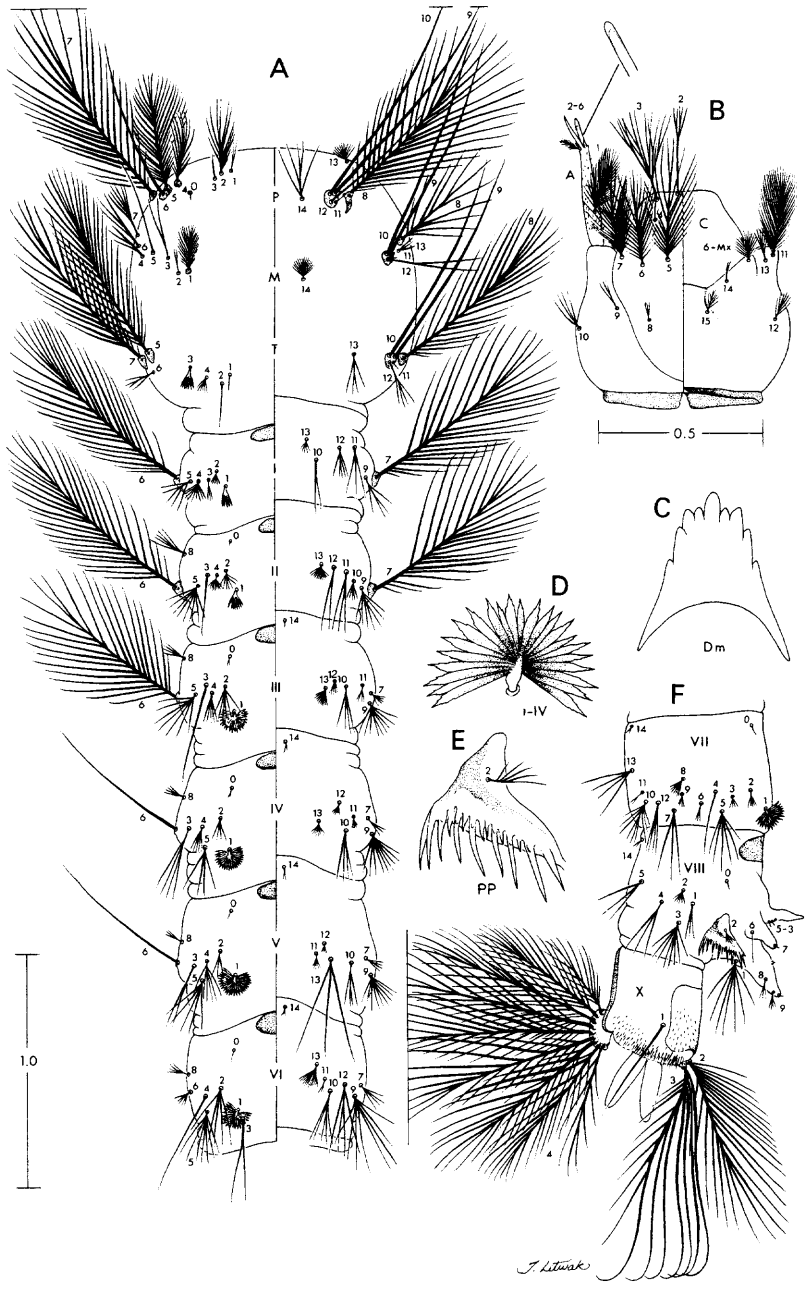

Fig. 4. *An. mediopunctatus*, larva. (A) Thorax and abdominal segments I–VI, left side dorsal, right side ventral. (B) Head, left side dorsal, right side ventral, antennal seta 2 above. (C) Dorsomentum. (D) Seta 1-IV. (E) Pecten and pecten plate. (F) Abdominal segments VII–X, side view. Scale in millimeters.

taxon are Dyar and Knab 1906: 176 (L key, Mexico); Aiken and Rowland 1906: 24, 25 (♀, British Guiana); Peryassu 1908: 80 (wing*, ♀); Theobald 1910: 34 (wing*, key); Aiken 1911: 190 (♀); Howard et al. 1913: plate 41–17 (wing*); Howard et al. 1917: 993, 996 (♀, dist., notes on taxonomy); Peryassu 1921: 43 (wing*, ♀); Bonne-Wepster and Bonne 1921: 676, 677 (L*); Pinto 1923: 78 (♀); Christophers 1924: 34,88 (♀ key); Bonne and Bonne-Wepster 1925: 538 (♂*, ♀, L*, Surinam); Davis 1926: 18 (♂G, ♀*); Root 1927: 601; Dyar 1928: 461 (♂,♀, L, notes on biology); Lima 1929: 280; Shannon and Davis 1930: 487 (notes on biology); Townsend 1934: 490 (notes on taxonomy); Cova-Garcia 1939: 22 (♀ key); Ramos and Unti 1940: 57 (E*); Vargas 1942: 72 (♀ key); Simmons and Aitken 1942: 69 (dist., notes on

Table 3. Larval setal branching for *An. mediopunctatus*: range mode ( ) based on counts made on 13–22 setae, except for 11-C and 1-II, III

Seta no.	Head	Thorax			Abdominal segments								
	C	P	M	T	I	II	III	IV	V	VI	VII	VIII	X
0	—	1	—	—	—	1,2(1)	1,2	1,2(1)	1,2(1)	1,2(1)	1-2(1)	1,2(1)	—
1	1	1-3(2)	21-31(22)	1-3(1)	4-11(4)	6-11(6)	23-36(28)	21-34(29)	24-32(25)	21-29(24)	16-25(22)	2-4(3)	1
2	2-5(3)	8-15(10)	1-3(2)	1-3(1)	4-6(5)	5-10(7)	4-10(8)	2-6(4)	2-5(3)	3-6(4)	10(6)	4-9(6)	17-31[a]
3	6-19(12)	1	1,2(1)	5-12(11)	1-4(3)	1-3(1)	1-3(2)	3-5(4)	1,2(1)	1-4(1)	2-7(4)	6-12(9)	11-25(15)
4	1-3(1)	15-21(18)	1-3(1)	4-8(6)	7-15(11)	7-16(12)	3-7(6)	3-6(6)	4-9(5)	1,2(1)	1	2-4(3)	8,5,9(9)[b]
5	16-25(23)	22-35(30)	1,2(1)	22-33(30)	3-6(5)	5-11(6)	5-13(7)	3-6(4)	4-6(5)	4-8(7)	5-8(8)	3-5(3)	—
6	23-31(25)	1	1-5(3)	3-6(5)	28-35(31)	30-38(35)	26-33(29)	1	1,2(1)	3-7(5)	3,6(4)	1-S	4-8(7)
7	23-33(27)	26-37(30)	4-9(6)	20-29(22)	23-30(27)	24-33(26)	3-7(4)	3-5(3)	3-5(3)	3,4(3)	3-6(4)	2-S	3-6(4)
8	1-5(2)	26-33(31)	10-17(16)	20-30(26)	—	3-6(3)	1-4(4)	1-5(3)	2-5(4)	2-5(3)	3-9(4)	6-S	1,2(1)
9	2-9(3)	1	1	1	3-6(4)	6-11(8)	5-11(6)	6-9(9)	5-9(8)	5-8(8)	3-6(5)	7-S	1
10	2-5(3)	1,2(1)	1	1	1-3(3)	3-6(4)	1-5(4)	2-6(4)	3-6(4)	4-6(5)	8-14(11)	8-S	1-3(3)
11	34-59[a]	1,2(2)	1	1	3,4(3)	2-5(4)	3-5(4)	2-5(4)	3-7(4)	2-4(3)	2-3(3)	9-S	3-5(4)
12	4-8(7)	1	1-3(2)	2-5(3)	3-6(4)	2-4(3)	3-5(4)	3-6(5)	2-6(4)	2-4(3)	2-5(3)	—	—
13	5-12(5)	8-14(13)	1-6(4)	2-6(4)	4-6(4)	7-14(11)	8-13(9)	7-12(8)	3-6(5)	9-13(11)	2-4(4)	—	—
14	1-3(2)	3-6(4)	13-20(14)	—	—	—	1-3(1)	1-3(2)	1-3(2)	2-4(3)	1-3(3)	1-3(2)	—
15	6-13(8)	—	—	—	—	—	—						

[a] Mode indefinite.
[b] Pairs.

biology); Cerqueira 1943: 18 (Bolivia); Gast Galvis 1943: 24 (Colombia); Russell et al. 1943: 47 (dist., notes on biology); Levi-Castillo 1945: 79–90 (♂*, ♀*, P*, L*, E*, dist.); Cova-Garcia 1946: 51, 101, 136 (♂*, ♀*, L*, E*); Deane et al. 1948: 922 (notes on biology); Lane 1949 (*in* Boyd 1949): 405 (notes on biology); Kuyp 1950: 63–78 (♂, L key, Surinam); Correa 1950: 81, 82 (♀, L key); Senior-White and Lewis 1951: 152 (L); Floch and Abonnenc 1951: 75–77 (♂*, ♀*, L*, E, French Guiana, Bolivia); Senevet and Andarelli 1955: 116, 339 (L); Vargas 1959: 375, 381 (♂ key); Cova-Garcia 1961: 51, 102, 147 (♂, ♀, L*, E*); Vargas 1963 (*in* Russell et al. 1943): 644, 649, 652 (♀, L key); Gorham et al. 1967: 26, 37, 57 (♀*, L* illust. key); Ortiz 1968: 71 (notes on identification); Gorham et al. 1973: 118–130 (♀*, L* illust. key, notes on biology); Navarro C.J.C. 1996: 36 (L* key).

Female (Figs. 1E, 6D). Integument light to dark brown with grayish pollinosity, more evident on vertex. *Head.* Interocular space with 12–18 long, white to pale yellow setae and row of small, narrow, appressed white to pale yellow scales; vertex, occiput and upper portion of postgena with numerous erect, truncate scales; patch of grayish white scales on anterodorsal area of vertex and patch of black scales laterally on head nearly concolorous with scales on anterior scutal fossa and upper antepronotum; head with 9–15 long, dark, ocular setae; postgena with long dark setae ventrally. Clypeus bare. Pedicel of antenna with 3–16 small (n = 10 for this and following measurements), dorsolateral, narrow to broad, grayish white spatulate scales; flagellomere 1 with numerous narrow to broad dark scales with intermixed grayish white scales on mesal and ventral surfaces. Scales of maxillary palpus slender, spatulate, mostly dark brown with intermixed dark brown setae, scales on palpomeres 2–4 erect or, sometimes scales on palpomere 2 erect, scales on palpomere 3 erect on ventral surface and on basal 0.5 of dorsal surface, appressed on apical 0.5 of dorsal surface, palpomere 4 with erect scales on basal 0.5 of ventral surface, palpomere 5 always with appressed scales; palpomere 2 entirely dark-scaled or sometimes with dark scales and a few pale yellow scales, variable in number on basal 0.5 of inner side; palpomere 3 mostly dark-scaled with a few intermixed pale yellow scales, sometimes with patch of pale yellow scales on base; palpomere 4 with dark scales and small patch of pale yellow scales on base, more evident on lateral and ventral sides; palpomere 5 mostly dark on dorsal surface, lateral and ventral surfaces mostly with pale yellow scales, with intermixed dark scales and patch of nearly white scales on base, more evident on lateral and ventral surfaces, palpomere 5 sometimes dark-scaled with a few pale yellow scales at apex; length of maxillary palpus 1.81–2.31 mm (mean = 2.08 mm), ratio of length of palpomeres 2–5 to length of palpus, 2 = 0.27–0.32 (mean = 0.30), 3 = 0.33–0.38 (mean = 0.35), 4 = 0.19–0.22 (mean = 0.21), 5 = 0.13–0.16 (mean = 0.14); ratio of palpomere 4–5 1.23–1.64 (mean = 1.49); palpus 0.99–1.09 (mean = 1.03) fore-

femur length. Proboscis dark-scaled, base with larger, erect, spatulate scales and setae; proboscis length 2.10–2.49 mm (mean = 2.28 mm), proboscis 1.00–1.21 (mean = 1.10) palpus length. *Thorax.* Scutum, integument dark brown, with 2 prominent dark spots on dorsocentral area just posterior to ends of prescutal sutures, another in prescutellar area continuing onto scutellum and 2 small spots at end of lateral portions of prescutellar area. Scutal setae numerous, pale yellow with golden reflections, and with more developed setae on prescutellar area and on posterior end of acrostichal area dark brown with golden and reddish reflections. Scutum mottled with small pale to dark brown spots, mostly corresponding to setal insertions on acrostichal and dorsocentral areas; median anterior promontory with patch of short, broad scales, these variable in color from totally dark to totally pale yellow; scutal fossa without scales except anterior scutal fossa with patch of broad, spatulate, dark brown, erect scales intermixed with a few pale yellow scales, lateral margin of scutal fossa with patch of a few broad, appressed, pale yellow scales next to postpronotum and scutal suture with a few broad, appressed, pale yellow scales; antealar area with sparse patch of broad, spatulate, nearly white scales intermixed with narrow falcate scales similar in color to broad scales, patch of scales extending posteriorly from dark spot of scutum to the supraalar area; supraalar area with a few narrow, falcate, pale yellow scales anteriorly and a few broad, spatulate, pale yellow scales with intermixed dark scales posteriorly. Scutellum with 19–31 shorter and 11–19 long setae, short setae pale yellow with golden reflections, long setae brown with golden and reddish reflections. Antepronotum with 12–25 yellowish to dark brown setae, numerous upper, dark spatulate scales intermixed with a few pale yellow scales and a few lower, pale yellow and dark, spatulate scales. Pleural vestiture as follows, with all scales white to pale yellow, spatulate; upper proepisternum with 1–5 setae, usually with a single scale, scale rarely absent; prespiracular area with 2–7 setae, frequently with 1,2 scales, scales rarely absent; prealar area with 6–12 setae; upper mesokatepisternum with 5–9 setae, 4–9 scales; lower mesokatepisternum with 2–4 setae, 8–12 scales; upper mesepimeron with 1–9 setae, 2–7 scales. *Legs.* Forecoxa with an upper patch of pale yellow scales on base and a few, sparse, dark scales extending from base to apex of anterior surface, laterally with patch of long, white scales on apical 0.5, basal 0.5 devoid of scales, posteriorly with patch of long, dark scales; foretrochanter without scales on anterior surface, laterally with patch of small, appressed, white to pale yellow scales on apical region, posterior surface with patch of dark scales and inner surface with dark scales on apical 0.5 and pale yellow on basal 0.5, midcoxa with patches of nearly white scales on base of lateral surface and on apex of anterior and posterior surfaces, hindcoxa with patch of nearly white scales on apex of anterior surface. Extent and number of pale spots on femora and tibiae variable. Base and apex of forefemur pale-scaled; midfemur dark-scaled with spots of pale scales, pale-scaled on base and with ventral stripe of pale scales, with well-demarcated borders, on ventral surface, extending 0.70 from base; hindfemur dark-scaled with spots of pale scales; fore- and hindtibiae yellow-scaled with spots of dark scales, ventral surface entirely yellow-scaled, midtibiae dark-scaled with spots of yellow scales; foretarsomeres 1–3 mostly yellow-scaled with spots of dark scales sometimes encircling the segment, ventral surface most often yellow-scaled, foretarsomeres 4,5 entirely yellow-scaled; midtarsomeres 1–4 dark-scaled with spots of yellow scales, sometimes with indistinct longitudinal stripe of yellow scales on ventral surface, midtarsomere 5 pale-scaled; hindtarsomere 1 yellow-scaled with spots of dark scales except ventral surface with indistinct longitudinal stripe of yellow scales, hindtarsomeres 2, 3 yellow-scaled with dark-scaled spots, hindtarsomere 4 yellow-scaled with dark ring on middle region, hindtarsomere 5 entirely pale-scaled. Forefemur length 1.80–2.26 mm (mean = 2.02 mm), ratio of forefemur length to proboscis length 0.82–0.95 (mean = 0.89). *Wing* (Table 1). Length (measured from humeral crossvein) 3.45–4.23 mm (mean = 3.70 mm). Most wing scales especially on posterior veins, broad, obovate. Dark scales brown to black, pale wing scales white to pale yellow. Costal wing spots (on C, Sc, R): basal pale spot usually present, rarely absent; prehumeral pale spot absent; subcosta basad of humeral crossvein with patch of small, appressed, truncate, dark scales, ventrally with dense patch of broad, dark scales near humeral crossvein; humeral crossvein with dark scales dorsally and ventrally; accessory sector dark spot always present; always 2 pre- and 2 postsubcostal pale spots and 1 pre- and 1 postsubcostal dark spot; apical dark spot usually present. Veins posterior to C, Sc, and R with intermixed pale and dark scales, vein R_{4+5} with small patch of white scales followed by small dark patch at proximal end, M mostly dark-scaled, scales broad, truncate at apex, with small patch of white scales near crossvein rm and at bifurcation of M_1 and M_2, proximal end of veins M_1, M_2 with dark scales, M_{3+4} with 3 spots of dark scales and 2 white spots, 1 dark spot at proximal end, another on middle region, and another at distal end of vein, mcu mostly dark-scaled with patch of white scales on middle region, CuA with intermixed pale and dark scales and a spot of dark scales near proximal end, 1A mostly dark-scaled, with alternating 6 black and 5 white spots. Pale fringe spots indistinct. *Halter.* Scabellum and pedicel with pale brown integument, dorsal surface of pedicel white-scaled, capitellum with brown integument, dorsal surface with white scales except proximal portion of concave center without scales, ventral surface dark-scaled. *Abdomen.* Integument brown to dark brown with grayish pollinosity. Terga with numerous, long, yellowish setae; terga II–VII with erect, posterolateral patches of pale yellow and dark scales; tergum VIII with narrow, pale yellow and dark scales posteriorly. Sterna with scattered brown to yellowish setae; sternum I with small patch of spatulate scales, sterna II–VII with scattered broad, white, spatulate scales and posteromesal patches of erect, spatulate, dark scales, sometimes sternum VII

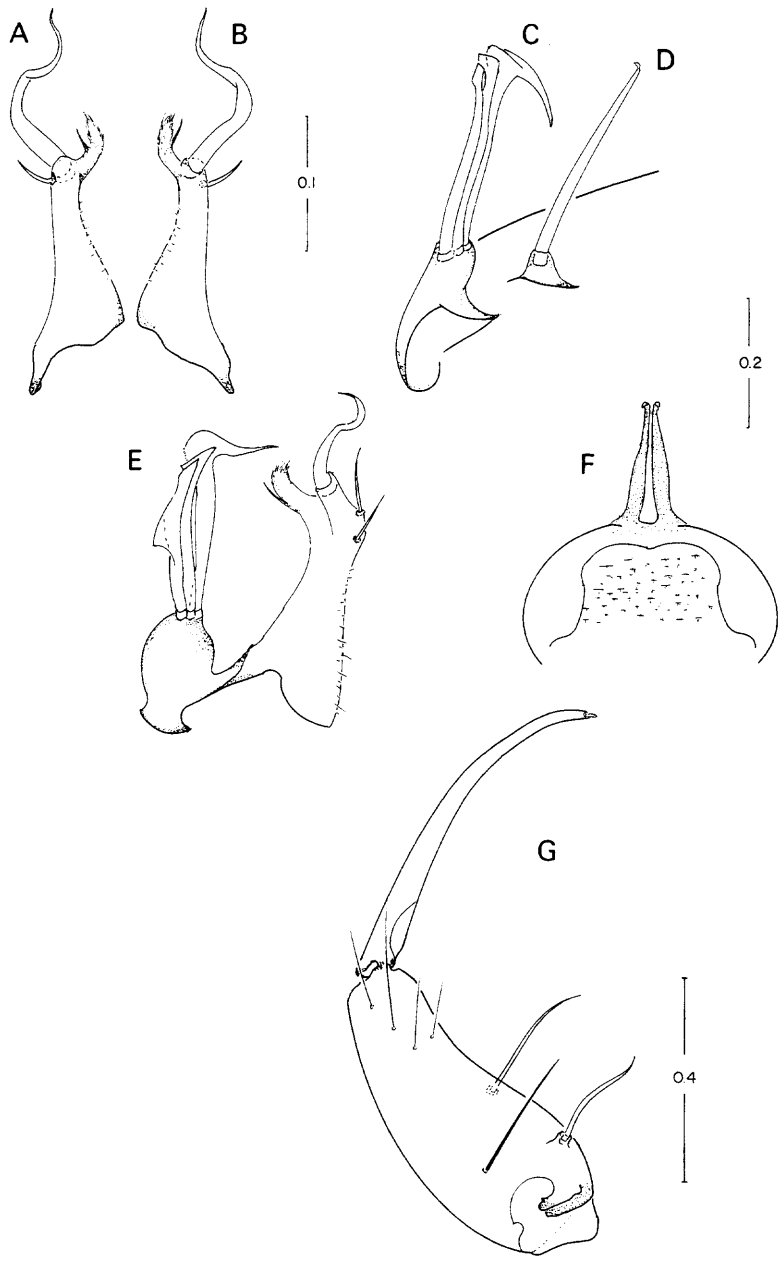

Fig. 5. *An. costai*, male genitalia. (A) Ventral lobe of claspette, mesal aspect. (B) Ventral lobe of claspette, lateral aspect. (C) Dorsal lobe of claspette. (D) Mesal parabasal seta. (E) Claspette, lateral aspect. (F) Tergum IX, ventral aspect. (G) Gonocoxite and gonostylus, dorsal aspect. Scale in millimeters.

with pale yellow scales lateral to dark posteromesal patch; sternum VIII with narrow, spatulate, yellow scales. *Genitalia* (Figs. 1E, 6D). Tergum IX narrow, with small, elongate, fingerlike lobe on each side of median straight line, this lobe sometimes very small, indistinct; cerci elongate, somewhat triangular in outline with dark scales posteriorly, pale yellow scales anteriorly; postgenital lobe weakly sclerotized, somewhat pentagonal in outline, with small posterior bridge bearing patch of minute spicules, margin broadly rounded with 2 strong setae at apex; 27–31 weak insular setae; upper and lower vaginal lips indistinct; upper vaginal sclerite well sclerotized.

Male (Fig. 5). As in female except for the following sexual differences. Maxillary palpus ≈0.90–1.03 length of proboscis (n = 10 for this and the following measurements); apex of palpomere 3 and all of palpomere 4 and 5 enlarged. Maxillary palpus with dark brown and pale yellow scales; palpomere 2 with patch of pale scales on basal 0.5 of dorsal surface and at apex, re-

mainder dark-scaled; palpomere 3 with pale scales on base and apex and patch of pale scales on apical 0.5 of dorsal surface, inner surface with long yellowish setae at apex; palpomere 4 pale-scaled, sometimes with dark scales on base and apex of dorsal and ventral surfaces, inner surface with long yellowish setae; palpomere 5 pale-scaled. Proboscis length ≈2.55–3.50 mm (mean = 2.90 mm), with small, decumbent dark brown scales and a patch of erect scales on basal 0.20 of ventral surface; labela brown. Foreungues with curved submedian tooth and blunt, external basal tooth. *Genitalia* (Fig. 5). Ninth tergal lobe prominent, slightly curved dorsally, nearly parallel, very close together at middle region, interlobar area very small, straight. Dorsal surface of gonocoxite (prerotational sense) with a few scattered short to moderately long setae except setae on apicolateral portion longer; lateral surface with numerous slender, fusiform and spatulate scales; ventral surface with short to moderately long setae and a few scales proximally; most mesal parabasal seta stout, rodlike with slender, recurved tip, borne on a strong tubercle, the 2nd parabasal longer and more slender than 1st, with straight tip, most mesal parabasal ≈0.32 from base of gonocoxite; 2nd parabasal ≈0.33 from base of gonocoxite, internal seta stout with slender tip, longer than mesal parabasal, base 0.48 distance from base of gonocoxite. Dorsal lobe of claspette short, somewhat square in outline, with 3 modified setae at apex of ventral border, 1 of these setae rodlike on basal 0.5, swollen at middle region, tapered toward apex, ending in blunt, slightly curved tip; the other seta stronger, swollen at middle region, apex blunt, slightly curved; the 3rd seta strong, rodlike, strongly enlarged on apical 0.3, dorsal side of enlarged portion rugose, apex rounded, less rugose, with slender, hooklike, elongate beak on ventral side, directed downward; ventral lobe of claspette columnar, with small spicules, and strong, sinuous, hooklike seta at apex, 2 smaller slender setae below on ventromesal side, 1 of these setae subapical in position, the other seta more basally inserted; apex of ventral lobe well developed, apicodorsal projection, directed upwards, projection with slender, fingerlike structures at apex. Gonostylus with 13–27 min setae on dorsal side; gonostylar claw short, spiniform and blunt. Aedeagus with pair of large leaflets bearing a few minute spicules on inner margin, sometimes with small needlelike leaflets at base.

Pupa (Figs. 1 A–D, 6 A–C). Position and development of setae as figured; range and modal number of branches as in Table 4. Integument weakly pigmented, with dark areas on wing and leg cases, antennal case with dark pigmentation at flagellomere joints; mesothorax wing case with 2 moderately developed projections of unequal size, lateral projection bigger than medial 1; metathorax with dark areas and closely associated small projection; abdominal terga weakly to moderately pigmented, dark laterally around seta 9-III–VI; paddle slightly darker. *Cephalothorax.* Trumpet laticorn, tragus well developed, thumblike, rounded at apex; secondary cleft present. Seta 8-CT with 4–6 branches; 10-CT with 5–12 branches. *Abdomen.* Terga and sterna II–VIII with numerous small spicules, more evident medially and posteriorly; posterior margin of terga II–VII with small denticles, more evident laterally; lateral margins of terga I–VIII with several small denticles, more evident on segments I, VI–VIII. Seta 8-II absent; 9-II–VIII peglike to long and pointed, 9-II minute, poorly pigmented, 9-III–VIII stout, dark, 9-III ≈1.20 length of 9-II, 9-IV ≈1.82 length of 9-III, 9-V ≈1.19 length of 9-IV, 9-VI ≈1.22 length of 9-V, 9-VII ≈1.33 length of 9-VI, 9-VIII aciculate, ≈1.09 length of 9-VII, 9-II, III ≈0.05 length of segment, 9-IV–VI ≈0.10 length of segment, 9-VII, VIII ≈0.13 length of segment; 10-I absent, 10-II usually present, sometimes absent; 11-II absent. Segment VII 1.05–1.22 (mean = 1.15) length of segment VI; segment VIII 1.19–1.40 (mean = 1.31) length of segment VI. Width segment VIII 0.97–1.03 (mean = 1.0) width segment VII. Width/length (width at posterior margins) of segment VI 2.72–3.03 (mean = 2.90), VII 2.22–2.55 (mean = 2.36), VIII 1.96–2.27 (mean = 2.09). Paddle length 0.78–0.93 mm (mean = 0.84 mm), width 0.59–0.70 mm (mean = 0.64 mm), length/width ratio 1.24–1.42 (mean = 1.30), somewhat rounded, homogeneously sclerotized; refractile index 0.61–0.67 (mean = 0.64); length of marginal spicules 0.03–0.05 mm (mean = 0.04 mm).

Larva (Fig. 7). Position and development of setae as figured; range and modal number of branches as in Table 5. *Head.* Antennal length 0.23–0.26 mm (mean = 0.24 mm), tapered toward apex, 4.68–5.68 (mean = 5.17) longer than wide; with spicules longer and more numerous dorsally in vicinity of seta 1-A; ventral surface with a few, short spicules; seta 1-A with 19–29 branches, inserted 0.25–0.31 (mean = 0.29) from base of antenna; seta 2-A pointed; 3-A truncate, fringed at apex; 4-A plumose, shorter than 2-A or 3-A. Seta 2-C single to 6-branched on apical 0.30, 1.00–1.19 (mean = 1.11) length 3-C, seta 2-C close to mate of opposite side, distance between bases 1.32–2.28 (mean = 1.76) width base of single seta; 3-C ≈0.84–1.00 length of 2-C, with 14–29 branches, clypeal index (distance between bases 2-C and 3-C on 1 side/distance between bases of 2-C) 3.17–4.44 (mean = 3.79). *Thorax.* Seta 1-P not palmate, with 4–6 branches; 9, 10, 12-P always single, 11-P often single, rarely double; 9–12-M always single; 12-m ≈0.30 length of 9, 10-M, 11-M very short; 3-T weakly developed, hyaline, palmate; 11-T very short, ≈0.25 length of 12-T, 12-T moderately developed. *Abdomen.* Integument hyaline, with minute spicules on ventral surface, more evident on central portion of each segment; seta 1-I, II, VII palmate, weakly developed, setae III–VI well developed, leaflets broad with jagged margins, apices weakly pigmented, usually single. Seta 1-X not inserted on saddle. Saddle with minute, sparse spicules on lateral surface. Integument of posterior margin of segment X with numerous, strongly developed spicules. *Spiracular Apparatus.* Pecten with 15–19 teeth; arrangement of teeth alternating long and short, with 5–8 long and 7–12 short; long spines 2.44–5.04 (mean = 3.39) length of short spines.

Type Material. Holotype male, adult on pin and 1 slide with a wing, male genitalia probably lost, with the

Table 4. Pupal setal branching for *An. costai*: range mode ( ) based on counts made on 10–20 setae

Seta no.	Cephalotorax CT	Abdominal segments I	II	III	IV	V	VI	VII	VIII	IX	XI	Paddle Pa
0	—	—	2-5(3)	1-5(4)	2-6(4)	2-6(5)	3-7(5)	3-8(5)	3-7(6)	—	—	—
1	2-4(3)	7-16(10)[a]	6-14(10)	8-20(10)	3-16(9)	3-8(3)	2-5(3)	2-5(3)	—	1,2(1)	1-4(2)	4-9(7)
2	3-4(3)	5-9(6)	8-14(10)	9-16(10)	8-12(10)	6-11(9)	7-14(12)	7-14(9)	—	—	—	2-5(3)
3	3-6(4)	1-3(3)	4-8(6)	2-7(4)	6-12(8)	3-9(6)	4-7(5)	6-9(7)	—	—	—	—
4	4-7(5)	7-14(10)	4-13(9)	6-13(6)	4-8(8)	4-8(6)	3-5(5)	3-5(4)	5-8(6)	—	—	—
5	3-9(6)	1-4(3)	3-7(5)	8-25(14)	3-6(3)	2-5(3)	2-4(3)	2-5(3)	—	—	—	—
6	3-8(4)	4-8(5)	2-6(3)	1-6(4)	1,2(1)	1,2(1)	1,2(1)	4-6(5)	—	—	—	—
7	5-10(7)	2-6(3)	4-8(7)	4-10(7)	5-9(7)	2-6(5)	3-5(4)	2-5(3)	—	—	—	—
8	4-6(5)	—	—	4-8(8)	3-9(5)	3-5(4)	3-7(4)	6-11(10)	—	—	—	—
9	3-6(5)	2-5(3)	1	1	1	1	1	1	1	—	—	—
10	5-12(7)	—	0-6(0)	3-8(5)	2-7(3)	2-4(3)	2-4(2)	1-6(3)	—	—	—	—
11	3-6(3)	—	—	4-8(4)	2-6(3)	3-8(5)	4-9(6)	1-4(3)	—	—	—	—
12	2-4(3)	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	1	1	1,2(1)	1-3(2)	2-4(3)	2-4(3)	—	—	—

[a] Main branches.

following handwritten labels: a small label "21"; "*A. (N.) mediopunctatus* S. Ramos det.;" "S. Vicente, M. Figueiredo col. 1934;" and "*Anopheles (Shannoniella) costai* Fonseca e Ramos, 1940, Holotipo." The slide with "Serv. Profilax. Malaria, São Paulo, Brasil, *Anopheles (Shannoniella) costai* Fonseca e Ramos 1940;" "number 21; slide number "1-G7, D5, SãoVicente."

Other Material Examined. 44♂, 23♂G, 17♀, 52Pe, 52Le, and 5 4th-instars as follows: BRAZIL, São Paulo State, Iguape, Peyton and Wilkerson colls., 4 progeny broods from females collected on human bait: BR 52(1)-1-8, 6♂, 2♀, 8Pe, 8Le; BR 58(1)-1, 3, 2♂, 2Pe, 2Le; BR 58(2) - A, B, C, E, P, 5 4th instars; BR 58(3) - 1, 3, 4, 2♂, 1♂G, 1♀, 3Pe, 3Le; collected as larvae: BR 49-4, 1♀, 1Pe, 1Le; BR 54-1 (Acc. 1303) 1♂, 1♂G, 1Pe, 1Le; BR 56-9, 11, 13, 15, 18–20, 25, 8♂, 5♂G, 4Pe, 4Le; BR 111–1, 1♀, 1Pe, 1Le; Wilkerson and Sallum colls., II-1996, 5 progeny broods from females collected with Shannon Trap; BR 117–1, 1♀, 1Pe, 1Le; BR 126-2-13, 6♂, 1♂G, 4♀, 12Le, 10Pe; BR 130–1, 1♀, 1Pe, 1Le; BR 134–1, 2, 1♂, 1♀, 2Pe, 2Le; BR 135–1, 1♀, 1Pe, 1Le; Rondônia State, Costa Marques, Harrison and Wilkerson colls., 4-X-1986, 1 progeny brood from female collected on human bait: BR 277(6)-1-3, 5, 6, 5♂, 2♂G, 5Pe, 5Le; collected as larvae, 19-07-85-22–15 (4553), 1♂, 1♂G, 1Pe, 1Le; Acc. 1315/001–6, 9, 13, 14, 4♀, 4Pe, 4Le; Bahia State, Pirajá, R.C. Shannon coll., I-1930, 2♂G, 2Pe; Minas Gerais State, 1♂G; Pará State, Marabá, Gleba 27, Lote 09, small stream pool, J. F. Reinert coll., 24-X-1974, 1♂, 1♀, 2Pe, 2Le. COLOMBIA, Meta, Int. Del Meta, R. F. Lab. coll., coefficient variation 576–2, 1♂G; Restrepo, Balconcito, jungle pool, 15-VIII-1935, 2Pe, 2Le; Villavicencio, "Tanane," pond in pasture - partial forest, 8 July 1965, COB 66–30, 31, 1♂G, 2Pe, 2Le. FRENCH GUIANA, Guyane, Cayenne, "foret de Cabossou," J. Clastrier coll., 6-V-1968, FGC 351–5, 12, 2♂, 2♂G; locality unknown, FGA 154, 1♂; 86–69, 70, 72, 3♂, 3♂G. SURINAM, Moengo, 1945, 86–64, 1♂G; PERU, Iquitos, R.C. Shannon coll., IV-1931, 2♂, 2♂G. Locality unknown, PERZ 33(86–63), 1♂, 1♂G.

Distribution. Based on specimens examined and literature records, *An. costai*, or the undescribed taxon (as *An. mediopunctatus*), is known from Argentina, Bolivia, Brazil, Colombia, Ecuador, the Guianas, Mexico, Panama, Peru, Suriname, Trinidad, Tobago, and Venezuela. *An. costai* is reported not only on the coast, but also in inland localities at higher altitudes.

Medical Importance. Records indicate that *An. mediopunctatus* could be involved in malaria transmission in northern Brazil. In our opinion, because *An. costai* has been misidentified as *An. mediopunctatus*, most literature could refer to the former species or perhaps to a 3rd unnamed species. These include studies by Klein et al. (1991a, b) that demonstrated a high susceptibility to *P. falciparum* and *P. vivax* by *An. mediopunctatus* s.l. In addition, *An. mediopunctatus* s.l. was the only *Anopheles* species collected during an outbreak of falciparum malaria in an Indian tribe in Amazonas State, Brazil (Genaro and Ferraroni 1984).

Biology. Little is known about the biology of *An. costai*. It is a nocturnal species, showing maximum biting activity between 1800 and 0700 hours. Adult females were collected on human bait in primary forest as well as near the forest, in cultivated areas and less frequently inside houses (Deane et al. 1948, Degallier et al. 1978, Pajot et al. 1978). Adults also were attracted to a Shannon Trap in secondary growth vegetation in the Ribeira Valley, southern São Paulo State. Immature stages were taken from forest ponds and pools, in temporary ground pools, and animal footprints (Deane et al. 1946b, Forattini 1962). The larval habitats were heavily shaded, the water with a dense accumulation of plant debris such as leaves, bark, and branches (Forattini 1962, Pajot et al. 1978).

Discussion

Species identified as *An. mediopunctatus* have been reported from throughout South America (see introduction). We now recognize the existence of 3 species, 2 of which are treated here, based on unambiguous correlated characters in the male genitalia, and pupal and larval stages. The adult females of *An. mediopunctatus* s.l. apparently are indistinguishable. The most unusual modifications indicating that the 3 are

Table 5. Larval setal branching for *An. costai*: range mode ( ) based on counts made on 12–20 setae

Seta no.	Head	Thorax			Abdominal segments								
	C	P	M	T	I	II	III	IV	V	VI	VII	VIII	X
0	—	1	—	—	—	1	1	1,2(1)	1–3(1)	2,3(2)	1–3(2)	1	—
1	1	4–6(4)	18–27(20)	2–5(3)	4,5	5,6	19–26(22)	18–28(20)	17–23(20)	15–22(18)	14–20(16)	1	1
2	3–6(4)	3–9(6)	1–4(3)	1–3(1)	4–6(5)	6–9(7)	6–9(8)	4–7(5)	3–7(5)	4–7(6)	5–9(6)	8–13(11)	19–23(20)
3	14–29(23)	1	1,2(1)	4,5	1–3(2)	1,2(1)	1	1–3(2)	1	1,2(1)	3–6(4)	11–15(12)	9–15(10)
4	2–7(4)	16–23(18)	1	4–7(5)	7–11(11)	8–11(9)	5–8(7)	4–9(5)	3–6(4)	1	1	1	8.5–9.0(9.0)[a]
5	15–21(20)	22–34(28)	1	23–31(27)	2–4(3)	5–10(8)	7–11(9)	5–10(5)	5–12(7)	7–13(9)	8–15(10)	6–9(7)	—
6	17–23(18)	1	1	2–3(2)	24–37(29)	25–36(31)	22–32(27)	1,2(1)	1	6–9(7)	5–8(6)	1-S	3–8(5)
7	18–23(18)	16–30(21)	2–5(3)	17–30(21)	19–28(21)	18–28(22)	2,3(3)	1–3(3)	2–4(3)	3,4(3)	4–7(5)	2-S	5–11(7)
8	4–8(6)	17–24(24)	7–11(8)	20–29(21)	—	2–4(3)	2,3(2)	1,2(2)	2–4(3)	3–5(4)	5–10(6)	6-S	1
9	5–8(5)	1	1	1	2–4(3)	4–7(6)	5–9(6)	5–8(6)	5–8(5)	7–11(10)	5–9(6)	7-S	1
10	3–7(4)	1	1	1	1	3,4(4)	1	1	1	2–5(3)	6–9(7)	8-S	2, 3(2)
11	>30	1,2(1)	1	1	2,3(2)	1	2–5(3)	2,3(3)	2–4(3)	1–3(2)	1,2(2)	9-S	3–5(3)
12	4–7(4)	1	1	2–4(2)	3,4(3)	1	2–4(3)	2–4(3)	3–5(3)	1	1	—	—
13	6–8(7)	11–17(13)	5–10(9)	2–4(2)	7–11(10)	7–13(12)	9–14(12)	7–12(10)	3–5(3)	8–14(11)	3–9(4)	—	—
14	1	3–5(3)	11–15(13)	—	—	—	1,2(1)	1,2(1)	1,2(1)	1,2(2)	1,2(2)	—	—
15	5–11(8)	—	—	—	—	—	—	—	—	—	—	—	—

[a] Pairs.

closely related are found in the male genitalia. These include much-elongated 9th tergal lobes and widely separated parabasal setae. The elongated 9th tergal lobes drew the attention of Fonseca and Ramos (1940a), who created a new subgenus *Shannoniella*, later renamed *Shannonesia* by Fonseca and Ramos (1940b), and emended to *Shannoniezia* by Coutinho (1944).

After examining the holotype of *An. mediopunctatus*, Wilkerson (1988) concluded that none of the specimens he had seen was in agreement with the holotype. Collections by Peyton and Wilkerson in 1989 near Iguape, State of São Paulo, contained both *An. mediopunctatus* and *An. costai*. Further collections in Costa Marques, State of Rondônia, consisted of *An. costai* and a sympatric undescribed species. Below is a summary of our conclusions about the identities of the species listed in synonymy with *An. mediopunctatus* (*An. rockefelleri*, *An. costai*, and *An. costalimai*) and an associated name, *An. bonneorum* (Fonseca and Ramos 1940a, Knight and Stone 1977).

Anopheles mediopunctatus. See Wilkerson (1988) for a description of the holotype male. Theobald usually has been given credit for the authorship of *An. mediopunctatus*, but we discovered that Theobald clearly cites Lutz for the description by stating "Lutz MS" as he did for other species descriptions, for example, *An. elegans* (James) (in Theobald 1903: 51) (E. L. Peyton, personal communication). Fonseca and Ramos (1940a) also recognized this, but Lutz was not given credit by subsequent authors.

Anopheles costai. We examined the holotype male genitalia and the original description and found it to be distinct from *An. mediopunctatus* as described here and contrasted below. This species was described simultaneously with its synonym *An. bonneorum*. We chose *An. costai* as the senior synonym because of its existence of type material.

Anopheles rockefelleri. Peryassu (1923) described *An. rockefelleri* from specimens probably collected in the vicinity of Rio de Janeiro (Belkin et al. 1971) and

Table 6. Distinguishing differences in larval and pupal chaetotaxy between *An. mediopunctatus* and *An. costai*

Seta no.	*An. mediopunctatus*	*An. costai*
	Pupa	
0-II	1,2(1)	2–5(3)
1-II	1–5(3)	6–14(10)
3-II	1–3(2)	4–8(6)
2-P	1	2–5(3)
	Larva	
4-C	1–3(1)	2–7(4)
6-C	23–31(25)	17–23(18)
7-C	23–33(27)	18–23(18)
11-II	2–5(4)	1
12-II	2–4(3)	1
10-IV	2–6(4)	1
10-V	3–6(4)	1
12-VI	2–4(3)	1
12-VII	2–5(3)	1
1-VIII	2–4(3)	1
4-VIII	2–4(3)	1

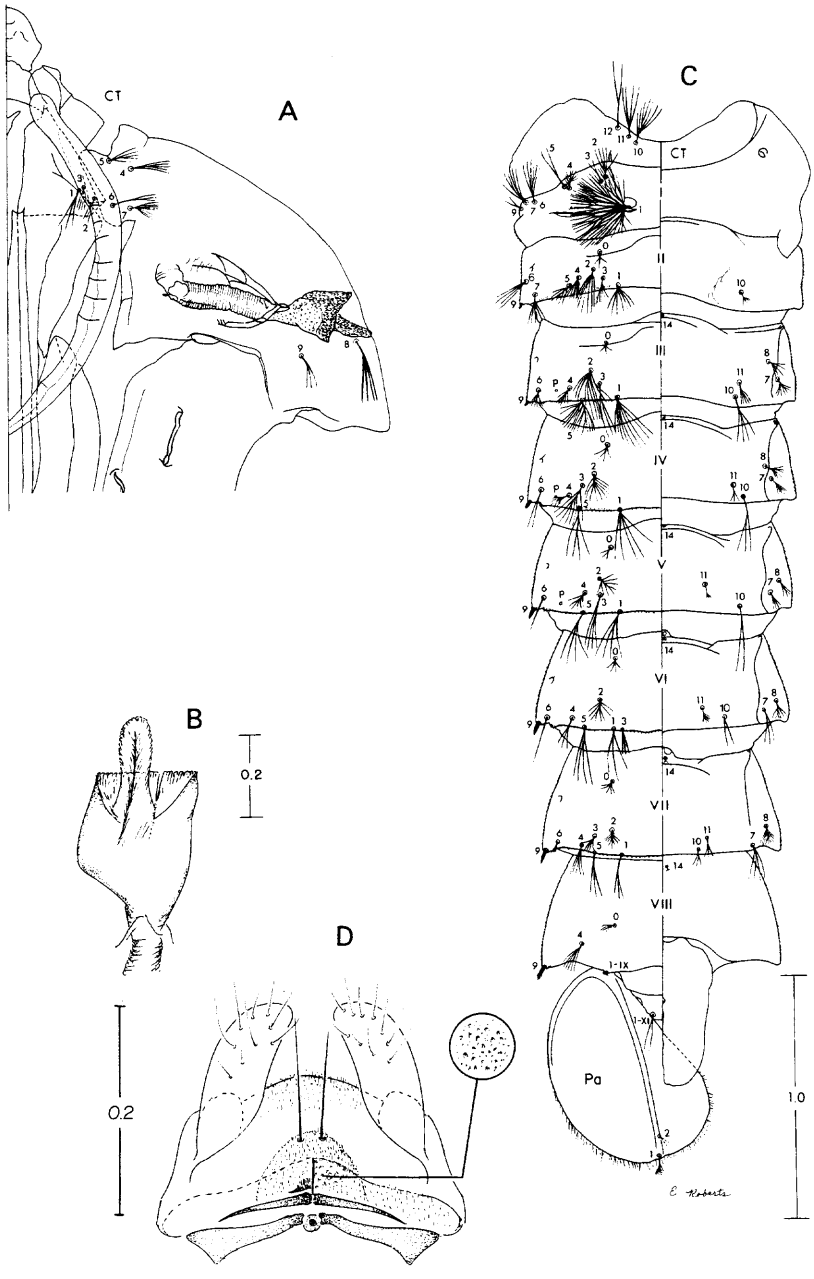

Fig. 6. *An. costai*, pupa. (A) Cephalothorax. (B) Trumpet. (C) Metathorax and abdomen, left side dorsal, right side ventral. (D) *An. costai* female genitalia, ventral aspect. Scale in millimeters.

suggested that it was similar to *An. mediopunctatus* (as *Cyclolepidopteron mediopunctatum*). However, no type series was designated and no indication was given of the number of specimens examined or where they were housed. The type series or other specimens Peryassu might have used were not located in Peryassu's collection in the Museu Nacional, Rio de Janeiro by us, by R. Lourenço (personal communication), or by Belkin et al. (1971). Neither were specimens found in the Natural History Museum (NHM) in London by Belkin (1968). The female cited by Townsend (1990) as a possible syntype in the NHM was examined by us (accession number Brit. Mus. 1924-240) and determined instead to be *An. intermedius* (Peryassu). The original description and accompanying illustration agree in all respects with that of female *An. mediopunc-*

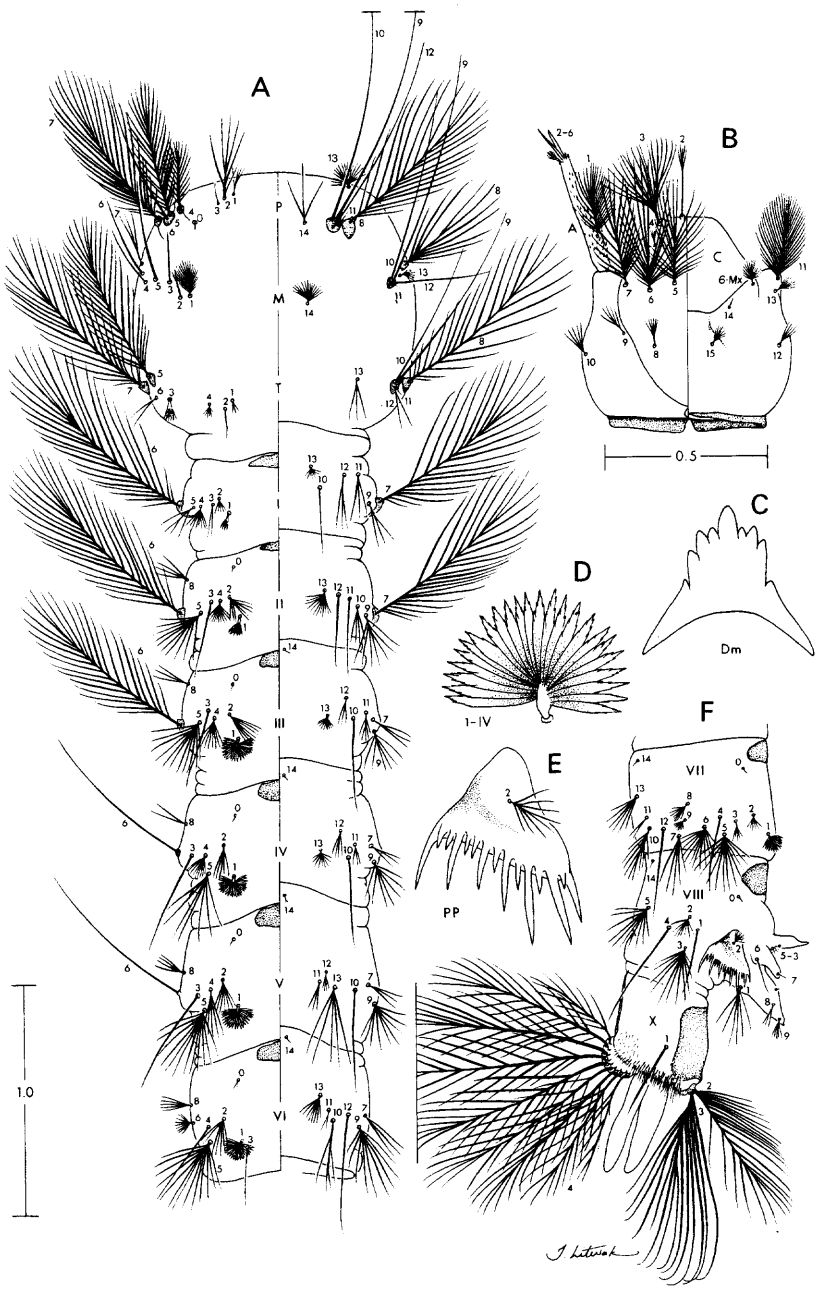

Fig. 7. *An. costai*, larva. (A) Thorax and abdominal segments I–VI, left side dorsal, right side ventral. (B) Head, left side dorsal, right side ventral. (C) Dorsomentum. (D) Seta 1-IV. (E) Pecten and pecten plate. (F) Abdominal segments VII–X, side view. Scale in millimeters.

tatus s.l., but it is not possible to definitely associate it with *An. mediopunctatus* or *An. costai*. We believe that it should retain its current status as a synonym of *An. mediopunctatus*.

Anopheles limai. We also agree with the current status of *An. limai* after examining the male genitalia of the holotype. This species was later renamed *An. costalimai*, because the name had already been used for what is now a synonym of *An. (Nys.) albitarsis* Lynch-Arribalzaga.

Anopheles bonneorum. This name was proposed by Fonseca and Ramos (1940a) for the species described by Bonne and Bonne-Wepster (1925) as *An. mediopunctatus*. No specimens were referenced in either publication; however, the illustration of the male genitalia, especially with reference to the shape of the ventral lobe

of the claspette and the most mesal parabasal seta, agrees with *An. costai*. *An. bonneorum*, therefore, is transferred to synonymy with *An. costai*.

The 2 species described here, and a 3rd undescribed species, are similar in the adult female in being yellow and brown in color, in having 3 small brown to dark brown spots on the scutum, legs speckled pale yellow on brown, tarsomere 5 of all legs yellowish, abdominal sternum I with a patch of spatulate white scales, middle portion of mesokatepisternum with a patch of spatulate scales, several scales on the upper mesepimeron, and abdomen with posterolateral patches of brown and yellowish scales on terga II–VI. As mentioned above, the 9th tergal lobes of all 3 species are elongated, which distinguishes them from all other members of the subgenus *Anopheles*. Fonseca and Ramos (1940a) separated 4 species (*An. mediopunctatus*, *An. limai*, *An. bonneorum*, *An. costai*) using color characters of the hind tarsomeres and the male palpus. We found that these characters were not constant in our sample, which we separated based on characters of the male genitalia.

Anopheles mediopunctatus and *An. costai* differ from each other by the shape of the female cercus, features of the male genitalia, and larva and pupa. In *An. mediopunctatus*, the cercus of the female genitalia is somewhat triangular in outline (Figs. 1F, 3D); the 9th tergal lobes of the male genitalia are arched away from each other and the interlobar area is small; the ventral lobe of the claspette is of nearly equal width, rounded toward the apex in lateral view, the dorsal surface slightly concave with numerous well-developed spicules along the dorsomesal aspect and has 1 strong sinuous seta at its apex and 2 smaller sinuous setae just below the strong apical seta on the ventromedial surface; the dorsal lobe of the claspette is short, poorly separated from the ventral lobe, somewhat triangular in outline in lateral view, the area between the ventral and dorsal lobes is small, the ventral lobe with 3 rodlike setae at apex, 2 of these are shorter and rounded at apex and the 3rd is longer with a hooklike structure at the apex. In *An. costai*, the cercus of the female genitalia is somewhat elliptical in outline (Figs. 1E, 6D); the 9th tergal lobes of the male genitalia are nearly parallel, close together toward the middle, the interlobar area is smaller than in *An. mediopunctatus*, the ventral lobe of the claspette is elongate, somewhat triangular in outline, curved dorsally at apex, the apex with a strong, sinuous, hooklike seta inserted in a strong tubercle, there are small spicules scattered along the dorsomedial surface, and there is an apicodorsal, upward projection with slender, fingerlike projections at the apex; the dorsal lobe of the claspette is well separated from the ventral lobe, the area between the lobes is larger than in *An. mediopunctatus*; the dorsal lobe is somewhat square in outline, with 3 setae at apex, 2 of which are rodlike and curved at the apex and the 3rd is slender, rodlike, rugose on dorsoapical aspect and with an elongate, hooklike beak on ventromedial side directed downward. The pupa of *An. costai* is easily distinguished from *An. mediopunctatus* by having 2 lateral projections on the wing case, a feature also known in the Umbrosus Group from Southeast Asia (Reid 1968). Various, mostly unambiguous, setal branch differences in the larva and the pupa of these 2 species are shown in Table 6.

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