

# Redescriptions of *Anopheles punctimacula* and *An. malefactor* (Diptera: Culicidae)

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**ABSTRACT** *Anopheles malefactor* Dyar and Knab is elevated from synonymy with *An. punctimacula* Dyar and Knab, and both species are described and illustrated. Primary morphological differences in the adult, pupal, and larval stages are provided for the separation and recognition of these species. *An. punctimacula* occurs from Mexico to northern Colombia and Venezuela, whereas *An. malefactor* is restricted to Panama and northwestern Colombia. Literature records indicate that *An. punctimacula* is naturally infected with malaria parasites in Panama and Colombia.

**KEY WORDS** Insecta, *Anopheles* spp., redescriptions, taxonomy

*Anopheles* (*Anopheles*) *punctimacula* Dyar and Knab is a presumed vector of malaria in Central and northern South America. Natural infections in this species have been found in Panama and Colombia (Simmons 1936, Rozeboom 1938, Huffaker et al. 1945, Rey et al. 1945). In addition, man-to-mosquito transmission of *Plasmodium vivax* (Grassi and Feletti) and *P. falciparum* (Welch) was demonstrated in the laboratory by Simmons (1937). Circumstantial evidence led other researchers to suggest that malaria in Costa Rica (Kumm & Ruiz 1939) and Colombia (Pinzon 1945, Ronnefeldt 1957) was transmitted by *An. punctimacula*.

As part of a study of the *Anopheles* (*Anopheles*) Arribalzagia Series, it was learned that the identity of *An. punctimacula* was in doubt. Examination of type material of *An. punctimacula* and its synonyms (*An. malefactor* Dyar and Knab, *An. strigimacula* Dyar and Knab, and *An. venezuelae* Evans), along with other material of "*punctimacula*" from Panama (type locality Colon, Panama, Canal Zone), revealed a second species, *An. malefactor*, that is similar to *An. punctimacula*. *Anopheles malefactor* originally was described by Dyar & Knab (1907) from a series of seven specimens and was later synonymized with *An. punctimacula* by Dyar (1918). Stone & Knight (1956) chose a female lectotype from this series which agreed with other specimens that were determined by others to be *An. punctimacula*. A male in the type series also is conspecific with the lectotype. The remaining five specimens in the series are *An. punctimacula*. *Anopheles malefactor* is here removed from synonymy.

The Arribalzagia Series (Reid & Knight 1961) originally was designated as a genus for *maculipes* by Theobald (1903). It since has been used by various authors as genus, subgenus, group, and series. As interpreted by Reid & Knight (1961), the Arribalzagia Series included New World species belonging to subgenus *Anopheles* with the following characteristics: laticorn pupal trumpet; costa with two pale spots near the junction of the subcosta, abdomen usually with short dorsolateral scale tufts, legs usually speckled, female maxillary palpus usually shaggy, forefemur somewhat swollen toward the base, coxae with scales, and abdominal sterna commonly with scattered white scales anteriorly.

*Anopheles punctimacula* and *An. malefactor* belong to a small group within the Arribalzagia Series, the Punctimacula Group. Adults of this group have the accessory preapical dark and apical dark wing spots somewhat small and intermixed with pale scales, and the male genitalia exhibit a broad transparent margin on the first pair of aedeagal leaflets. The other valid species in this group is *An. guarao* Anduze and Capdevielle.

During this study, the synonymy of *An. venezuelae* with *An. punctimacula* was reaffirmed (Wilkinson 1988), and *An. strigimacula* was found to be distinct, although inadequate material was available for verification. The holotype of *An. strigimacula* and specimens that match the holotype of this species were found in a small area in Veracruz State, Mexico. These specimens differ in wing markings from *An. punctimacula*, and it appears that the primary aedeagal leaflet of *An. strigimacula* has the transparent edge broad on both sides rather than only on one side as does *An. punctimacula*. Because this could be due to variation, *An. strigimacula* is left as a synonym of *An. punctimacula* until more material becomes available.

The views of the author do not purport to reflect the views of the supporting agency.

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### Materials and Methods

Morphological terminology, abbreviations, and numbering of larval and pupal setae follow Harbach & Knight (1980). Complete setal branching counts for larvae and pupae are presented in Tables 1-4. Setae which may be of taxonomic value are emphasized in the text. Except for specimens deposited at Johns Hopkins University School of Hygiene and Public Health [Hopkins], all are in the National Museum of Natural History (NMNH), Museum Support Center, Smithsonian Institution, Washington, D.C.

Wing measurements were made using a Nikon SMZ-10 dissecting microscope with a camera lucida and a Summagraphics SummaSketch Model MM1201 using "INPAD" software written by Joe Russo (Office of Information Resource Management, Smithsonian Institution) for IBM-compatible microcomputers. Other measurements were made using a calibrated objective reticule on a Nikon Optiphot microscope. The following parameters were measured on the wings: length; width; circumference; area; distance from humeral vein to the presector dark spot, presector dark spot, sector pale spot, sector dark spot, subcostal pale area, and preapical dark spot; lengths of veins Sc, R<sub>1</sub>, R<sub>2</sub>, R<sub>2+3</sub>, R<sub>3</sub>, R<sub>4+5</sub>, M, petiole of M, M<sub>1</sub>, M<sub>2</sub>, M<sub>3+4</sub>, CuA, and 1A. Where appropriate, the above measurements were corrected by dividing by wing length.

#### *Anopheles punctimacula* Dyar and Knab

(Fig. 1-21, 23)

*Anopheles punctimacula* Dyar and Knab 1906: 136 (holotype, ♀, NMNH; type locality Colon, Panama, Canal Zone; examined).

*Anopheles strigimacula* Dyar and Knab 1906: 136 (holotype, ♀, NMNH; type locality Cordoba, Veracruz, Mexico; examined).

*Anopheles malefactor* Dyar and Knab 1907: 198 (in part).

*Anopheles apicimacula*; Howard et al. 1917: 995 (= *punctimacula*).

*Anopheles (Arribalzagia) punctimacula*; Dyar 1918: 147 (key, biology, taxonomy, resurrection from synonymy with *apicimacula*).

*Anopheles (Arribalzagia) venezuelae* Evans 1922: 214 (holotype, ♀, British Museum (NH); type locality La Cabrera, Carabobo, Venezuela; examined); Evans 1923: 101-111 (= *punctimacula*).

*Anopheles (Anopheles) punctimacula* var. *strigimacula*; Christophers 1924: 35, 89 (taxonomy, key to females).

*Anopheles (Anopheles) punctimacula*; Dyar 1925: 27-31 (= *strigimacula* Dyar and Knab, synonymized without comment).

**Diagnosis.** A brown to dark brown species with a few pale scales at palpomere joints, 3 distinct dark thoracic spots, speckled femora and tibiae,

irregular dark and pale bands on hindtarsomeres 1-4, dark band usually on hindtarsomere 5, and joints of hindtarsomeres pale. Wing with 3 main dark costal spots and an indistinct apical dark area; costal spots dark brown-scaled bordered by white scales, remaining scales a mixture of brown and yellow. Abdomen with posterolateral scale tufts on terga and numerous dark brown and white scales on sterna, a distinct tuft of dark scales on tergum VII, and numerous slender pale yellow scales on tergum and sternum VIII.

**Female** (Fig. 1-6). **Head.** Scales spatulate, mostly slender with truncate tips, pale yellowish at vertex, changing to dark brown along postgena. Scales present to level of insertion of proboscis. Slender white recumbent ocular scales extending from vertex to frons in narrow rows. Frontal tuft of long pale yellowish erect setae. Dark brown ocular and postgenal setae present. A few yellowish scales and setae present ventrally on postgena at junction of eyes. Integument of head brown with slightly paler, thin layer of pollinosity. Labium with short, dark brown, recumbent setae and slender dark brown scales; scales numerous and erect on basal 0.33, smaller, less numerous and recumbent on remainder. Maxillary palpus with numerous slender erect dark brown scales, with a few pale yellowish scales at joints of palpomeres 2-3, 3-4, and 4-5 and often a few intermixed on palpomeres 3 and 5. Antennae brown, pedicel with small patch of pale yellowish white scales dorsally; flagellomere 1 with patch of long pale yellow scales mesally. **Thorax.** Scutum and scutellum pale brown in ground color, covered with silvery yellowish brown pollinosity and numerous long yellow setae. Anterior promontory with dense patch of slender yellow piliform scales. Brown speckling in ill-defined median and sublateral rows roughly corresponding to setal insertions. Large dark brown spots on antealar areas and one mid-dorsally on prescutellar area, continuing onto scutellum. A few slender yellow piliform setae just above wing base. Posterior scutellum with row of about 16 stout brown setae and row of smaller yellowish setae similar to those on scutum. Pleura dark brown in ground color with pattern of spots produced by areas of silvery pollinosity; accentuated dark areas just below wing, on lower mesanepimeron, mesomeron, lower mesokatepisternum, postspiracular area, and subspiracular area. Anteprototum with dense patch of dark brown spatulate scales, a few brown setae anteriorly, and a few small pale yellowish scales and setae posteriorly. Other vestiture as follows: 1-3 setae and occasionally 1 scale on proepisternum, ill-defined line of pale yellowish setae and scales on upper mesokatepisternum, patch of pale yellowish setae and scales on lower posterior mesokatepisternum, patch of yellow setae on prealar knob and a few pale setae on upper mesanepimeron. **Legs.** Speckled and banded, dark and light coloration caused by small appressed scales with underlying concolorous dark, white, or yellow pollinosity. Foreleg:

coxa, anterior surface with small basal patch of pale yellow scales and larger distal patch of small brown scales, entire anterior surface with long brown setae, posterior surface with distal patch of mixed long brown and pale yellow scales; trochanter with apical small pale yellow appressed scales and a few brownish setae; femur, basal 0.66 slightly enlarged, variable, predominantly brown with small pale yellowish spots, in some specimens basal 0.5 mostly dark with few spots; tibia brown with many white spots predominating dorsally, often indistinct ventrally, ventral apex with patch of golden yellow setae and small scales; tarsi, T1 brown with about 6 small white spots, apex pale, T2 with 1 or 2 small pale spots, base and apex pale, T3–T4 variable from all dark to having pale joints or spots or both, T5 variable, all pale or with dark band. Midleg: coxa, small basal and distal patches of pale yellowish scales; trochanter with small patches of proximal and distal pale yellowish scales on posterior side; femur brown with 6–8 pale yellowish spots and variable, often distinct pale line on ventral surface; tibia brown with 10–20 pale yellowish spots; tarsi, T1–T3 brown with variable spotting, T4 usually dark, T5 all pale or with dark spot or band, all joints pale. Hindleg: coxa with an apical posterior patch of pale yellowish scales and strong posterior dark setae; trochanter with a few small setae; femur brown with numerous small pale yellowish spots; tibia as femur with small spot of pale yellow and white scales and pollinosity posteriorly at apex; tarsi, T1 variable, usually with 4–6 pale yellowish spots and bands, T2 usually with 2 or 3 pale bands, T3 usually with 1 or 2 pale bands, T4 usually with 1 pale band, T5 usually with dark band, sometimes reduced to a spot or wholly pale (band absent or very faint in 7 of 100 females examined). All hind-tarsomere joints pale. *Wing*. Scales dark brown on 3 main dark costal spots (presector, sector, apical), white on either side of these dark spots, remaining dark spots pale brown, remaining pale spots yellow. Humeral crossvein with dark scales. Wing scales relatively broad, broadest toward base of wing but not rounded. Halter: capitellum dorsally with dense white scales encircling dark brown depressed center, pedicel dorsally with dense white scales, integument of halter dark brown with concolorous scales ventrally, scabellum yellowish brown. *Abdomen*. Brown to dark brown with numerous long yellowish brown setae on terga and sterna. Posterolateral borders of terga II–VII with mostly dark brown spatulate scales, terga V–VII with a few white scales intermixed, tergum VIII with numerous slender yellow scales; sterna II–VII with median apical patches of dark brown scales not in discrete patches except for large patch on VII, with scattered white scales anterior to these dark scales, white scales on sternum II in discrete patch, sternum VIII with scattered small yellowish scales.

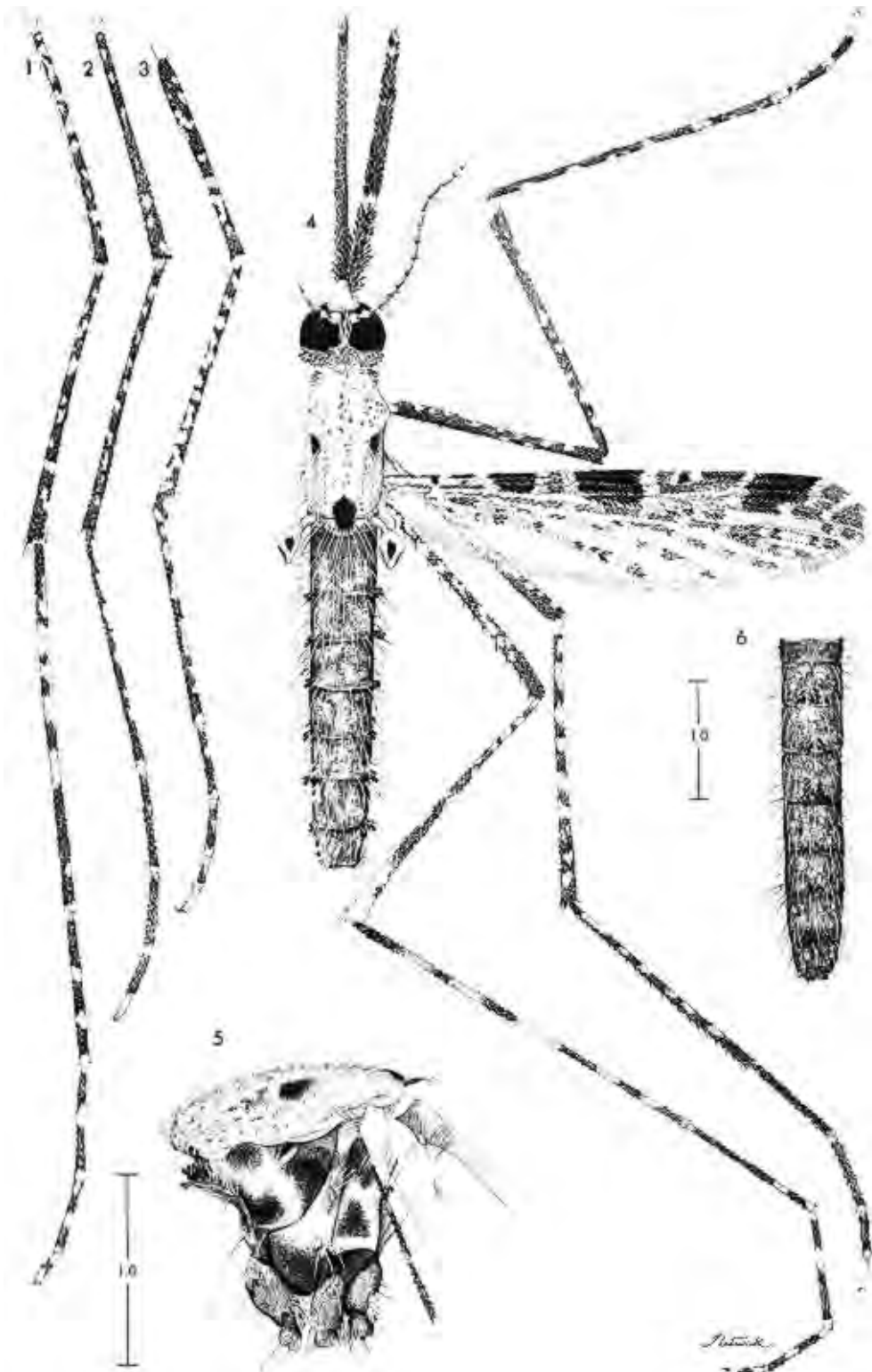
**Male** (Fig. 7). As female but paler, wing scales paler and less numerous. Palpomere 2 with basal 0.66 and apex with slender erect yellowish scales,

remainder brown-scaled; palpomere 3 pale yellow-scaled at base and apical 0.5 to 0.66, remainder dark brown-scaled; outer aspect of palpomeres 4 and 5 mostly pale golden yellow-scaled except for some brown scales at joint, inner aspect of 4 and 5 and apex of 3 with many long yellow setae. *Genitalia* not distinguishable from those of *An. malefactor* (see description).

**Pupa** (Fig. 8–13; Table 1). *Cephalothorax*. Laticorn trumpet, meatal cleft slitlike to slightly rounded, secondary cleft 0.31–0.44 ( $\bar{x} = 0.37$ ) length of trumpet; seta 8-CT usually single, sometimes bifid, 10-CT single or double. *Abdomen*. Seta I-II well developed with 6–24 branches, 1-IV with 2–7 branches, 1-V with 1–5 branches, 1-VI, VII usually single; 2-I with 1–4 branches, 2-II well developed with 3–7 branches; 3-III usually single, 3-VI single to triple, 3-VII with 1–4 branches (2); 4-I with 1–6 branches, usually double or triple, 4-V with 1–4 branches (2); 5-I single or double, 5-IV with 2–5 branches, 5-V with 2–4 branches, 5-VI single to triple; 6-I single to triple; 8-III usually single (1–3); 9-VIII often with numerous long aciculae; 10-II single to triple. *Paddle*. Width/length 0.68–0.81 ( $\bar{x} = 0.75$ ,  $n = 24$ ); refractile margin 0.45–0.56 mm ( $\bar{x} = 0.51$  mm,  $n = 24$ ); refractile margin/length 0.61–0.69 ( $\bar{x} = 0.65$ ); marginal spicules 0.032–0.04 mm ( $\bar{x} = 0.037$  mm,  $n = 18$ ), 0.47 length of seta 1-P. Terga and sterna with many small spicules, mostly on posterior 0.5, larger and more evident on posterior margins, many small spicules giving serrated appearance to posterolateral margins; size and extent of spicules variable.

**Larva** (Fig. 14–19; Table 2). *Head*. Antenna basally enlarged, spiculate with most and largest spicules basally on mesal surface; seta 1-A long, 4–16-branched, originating about 0.33 distance from base; 4-A with 3–6 branches, somewhat shorter than seta 2-A or 3-A; 3-A pointed, 2-A truncate at an angle, tip fimbriate. Seta 2-C usually aciculate along middle 0.33, 3-C usually about 0.5 length of 2-C, with 3–8 branches, 4-C single to triple, 8-C with 3–8 branches, 9-C with 2–6 branches. *Thorax*. Seta 1-P not palmate, with 4–7 branches, 3-P single, 9–12-P single; 4-M single, 9–12-M single; 3-T palmate, poorly sclerotized, 11-T single, 12-T usually bifid. *Abdomen*. Seta 1-I, II reduced and less sclerotized than 1-III–VII. Seta 3-I usually single, 3-VIII with 5–7 branches; 6-IV, V single, 6-VI with 2–4 branches; 8-II usually bifid (1–2), 8-III single or double; 9-I with 3 or 4 branches, 9-II with 4–7 branches, 9-III with 4–9 branches, 9-IV with 5–9 branches; 10-VI forked with 2–4 branches, 10-VII forked with 3–8 branches; 13-V with 2–5 branches. Pecten spines regularly alternating long and short, 7–9 of each, alternating pattern sometimes interrupted by absence of long tooth. Seta 1-X inserted outside or slightly within saddle but not surrounded by sclerotization, posterior portion of saddle with numerous long spicules.

**Type Material**. The holotype of *An. punctimacula* is a female with the following labels: hand-



**Fig. 1-6.** *An. punctimacula* female. (1) Hindleg. (2) Midleg. (3) Foreleg. (4) Habitus. (5) Thorax, side view. (6) Abdominal venter.

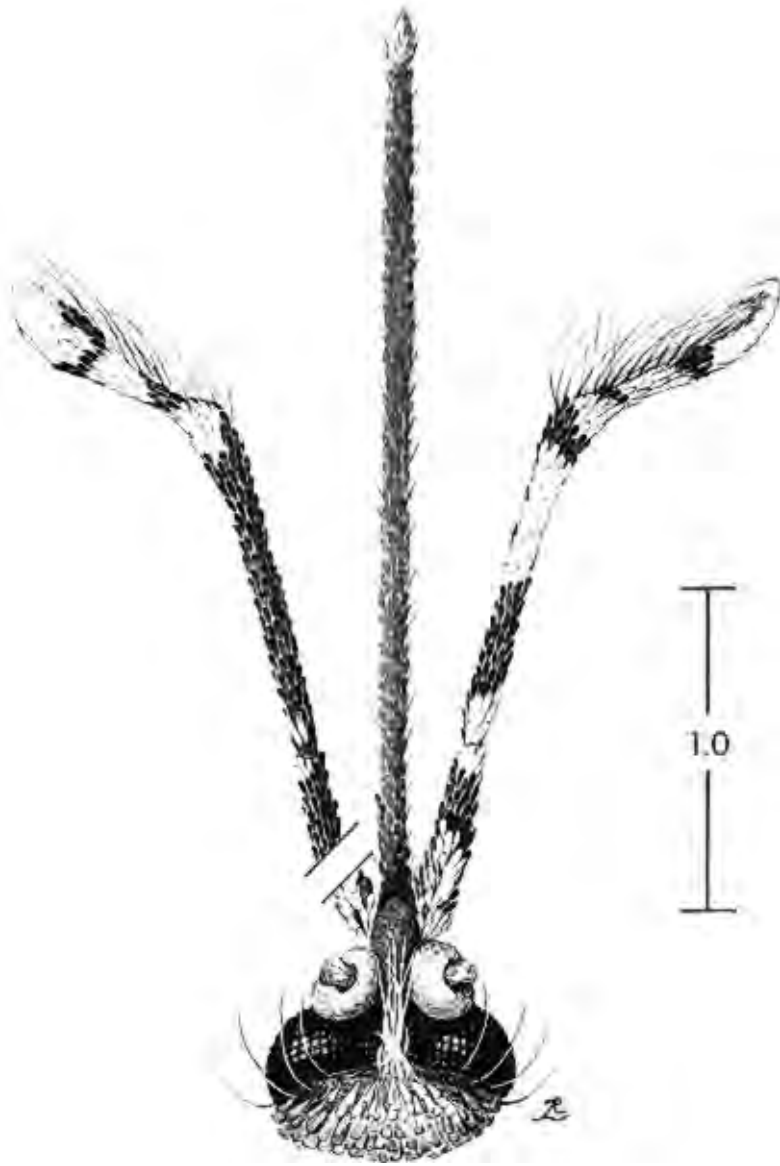


Fig. 7. Male head. *An. punctimacula*.

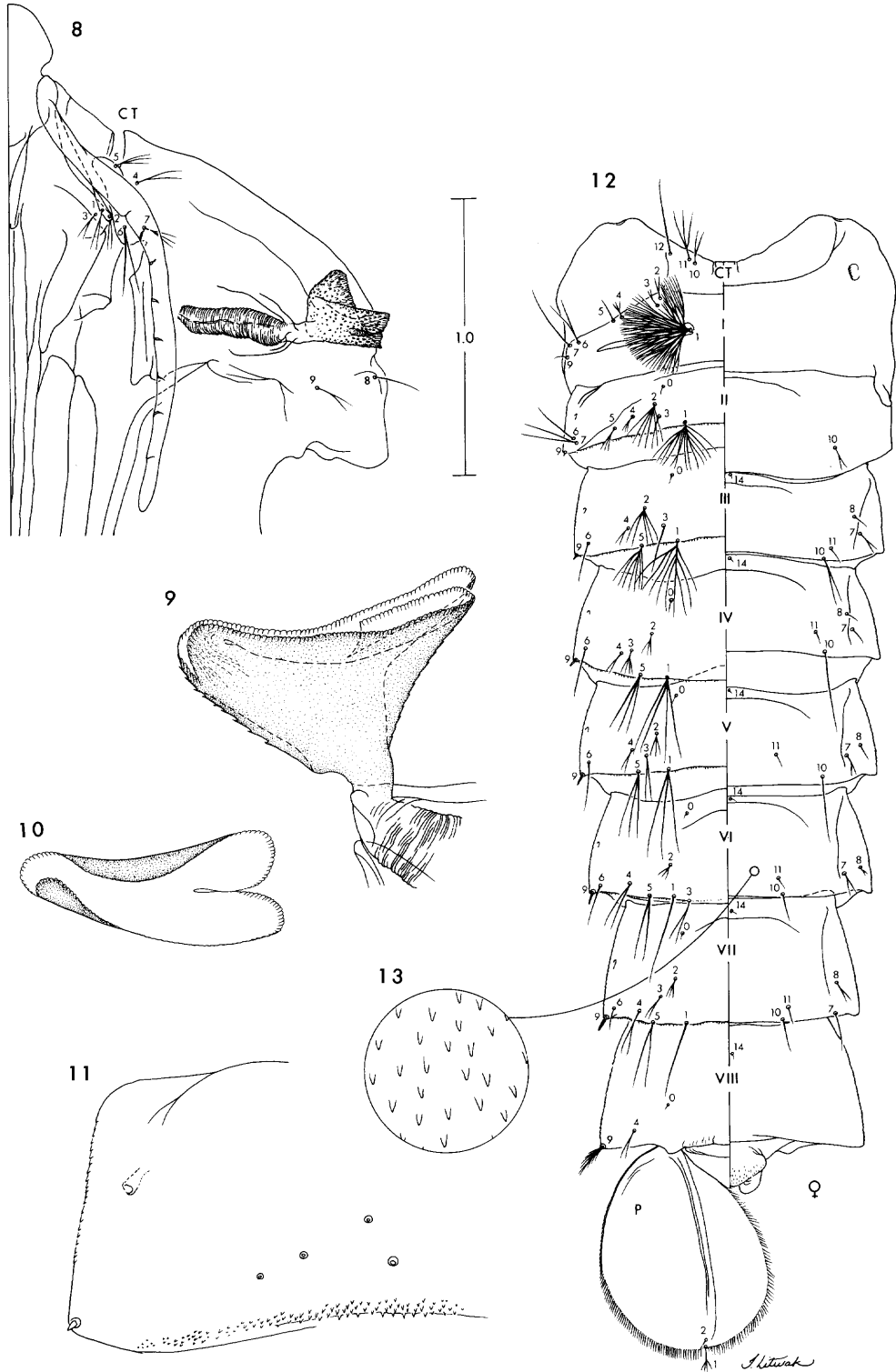
written "Feb. 2, 04 Maj. W M Black"; red "Type No. 9979 U.S.N.M."; handwritten "Anopheles punctimacula Type D&K"; handwritten "Colon Panama" and "see slide No. 549." The holotype is not in good condition, missing both antennae, the left maxillary palpus, the left foreleg from base of femur, the left midleg from femur, tarsomeres 2-5 of the right midleg (glued to point with specimen), hindtarsomere 5, the abdomen, and the left wing. The right wing is mounted dry on a slide numbered "549" as indicated above. The wing is intact but very faded so that the characteristic scale coloration cannot be seen.

**Other Material Examined** (detailed records to be published in a revision of the Arribalzagia Series). Total specimens examined included 836 fe-

males, 298 males, 38 associated larval exuviae, 67 associated pupal exuviae, and 34 male genitalia from the following countries and primary political divisions: BELIZE: Cayo District, Corozal District, Stann Creek District. COLOMBIA: Antioquia, Santander. COSTA RICA: Guanacaste, Puntarenas. EL SALVADOR: Usulután. GUATEMALA: Izabal. HONDURAS: Choluteca, Colón, Copán. MÉXICO: Veracruz. NICARAGUA: León, Zelaya. PANAMÁ: Bocas del Toro, Canal Zone, Colón, Darién, Panamá. VENEZUELA: Aragua, Carabobo, Monagas, Sucre.

**Distribution.** Mexico to northern Colombia and Venezuela (Fig. 20 and 21).

**Systematics.** The original description of *An. punctimacula* is of little use in defining this species:



**Fig. 8-13.** *An. punctimacula* pupa. (8) Cephalothorax. (9) Trumpet side view. (10) Trumpet dorsal view. (11) Abdominal segment II dorsal. (12) Metathorax and abdomen, left side dorsal, right side ventral. (13) Detail of ventral surface of segment VI.

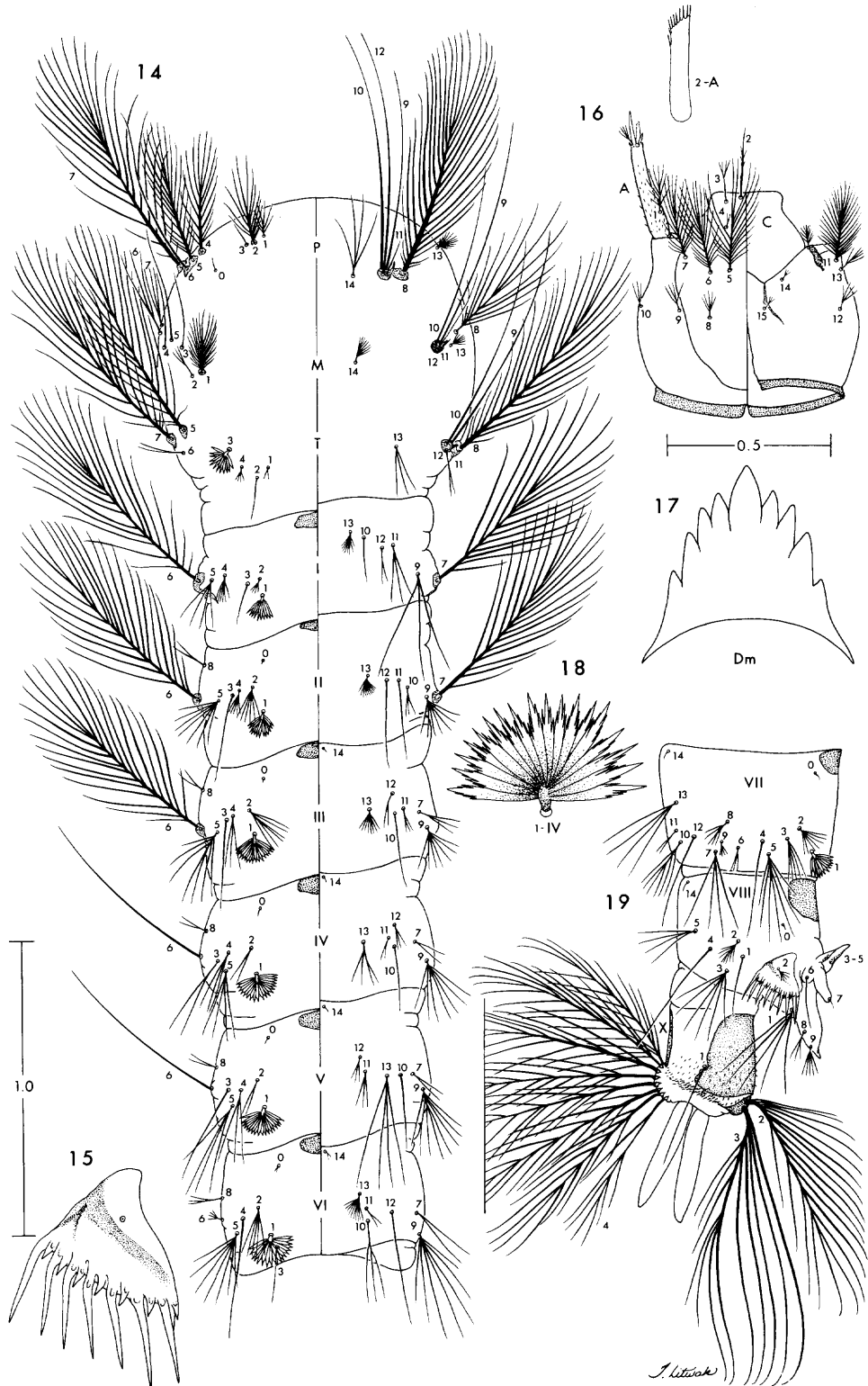


Fig. 14-19. *An. punctimacula* larva. (14) Thorax and abdominal segments I-VI, left side dorsal, right side ventral. (15) Pecten and pecten plate. (16) Head, left side dorsal, right side ventral, antennal seta 2 above. (17) Dorsomentum. (18) Seta 1-IV. (19) Abdominal segments VII-X, side view.

Table 1. Number of branches of pupal setae, *An. punctimacula*<sup>a</sup>

Seta no.	Cephalothorax CT	Abdominal segments									Paddle P
		I	II	III	IV	V	VI	VII	VIII	IX	
0	—	—	1-2 (1) [30]	1-2 (1) [32]	1-2 (1) [27]	1-2 (1) [24]	1-2 (1) [32]	1-2 (1) 1 [30]	1 [30]	—	—
1	1-3 (2) [30]	8-18 (12) [31]	6-24 (13) [31]	6-13 (10) [32]	2-7 (3) [28]	1-5 (2) [31]	1-2 (1) [31]	1-2 (1) [31]	—	1-3 (1) [20]	1-7 (5) [24]
2	1-3 (2) [27]	1-4 (2) [51]	3-7 (6) [32]	3-7 (5) [32]	2-4 (3) [50]	2-4 (3) [32]	2-4 (3) [29]	2-5 (3) [32]	—	—	1-2 (1) [24]
3	1-3 (2) [25]	1-3 (1) [52]	1 [32]	1-2 (1) [31]	2-5 (4) [31]	1-4 (2) [31]	1-3 (2) [31]	1-4 (2) [49]	—	—	—
4	1-3 (2) [32]	1-6 (2) [31]	1-5 (3) [32]	1-5 (2) [50]	1-4 (2) [32]	1-4 (2) [50]	1-2 (2) [29]	1-2 (2) [32]	1-3 (2) [32]	—	—
5	1-4 (3) [29]	1-2 (1) [32]	1-6 (3) [32]	5-10 (7) [32]	2-5 (3) [31]	2-4 (3) [30]	1-3 (2) [31]	1-3 (2) [32]	—	—	—
6	1-2 (2) [29]	1-3 (1) [43]	1-2 (1) [26]	1-2 (1) [26]	1 [32]	1 [31]	1 [32]	1-2 (1) [32]	—	—	—
7	1-4 (2) [32]	1-3 (1) [41]	1-4 (1) [25]	1-3 (2) [51]	1-3 (1) [32]	1-2 (2) [51]	1-2 (2) [32]	1-2 (1) [32]	—	—	—
8	1-2 (1) [49]	—	1-2 [2]	1-3 (1) [51]	1-3 (1) [32]	1-3 (1) [32]	1-3 (2) [32]	1-4 (2) [52]	—	—	—
9	1-3 (2) [32]	1-2 (1) [48]	1 [30]	1 [32]	1 [32]	1 [32]	1 [32]	1 [32]	1-5 (1) [32]	—	—
10	1-2 (2) [31]	—	1-3 (2) [37]	1-4 (2) [32]	1-2 (1) [32]	1-2 (1) [32]	1-2 (1) [27]	1-3 (1) [28]	—	—	—
11	2-3 (3) [32]	—	—	1-2 (1) [49]	1-2 (1) [52]	1-2 (1) [32]	1-4 (1) [50]	1-3 (1) [46]	—	—	—
12	1-3 (1) [31]	—	—	—	—	—	—	—	—	—	—
13	1 [20]	—	—	—	—	—	—	—	—	—	—
14	—	—	—	1 [6]	1 [24]	1 [24]	1 [24]	1 [20]	1 [18]	1 [1]	—

<sup>a</sup> Range; ( ), mode; [ ], number counted.

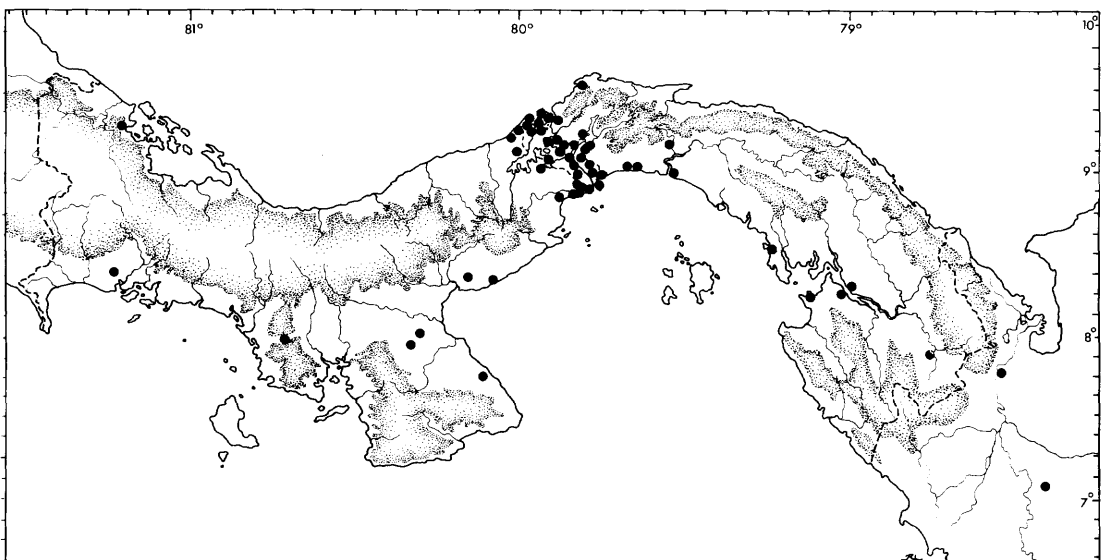
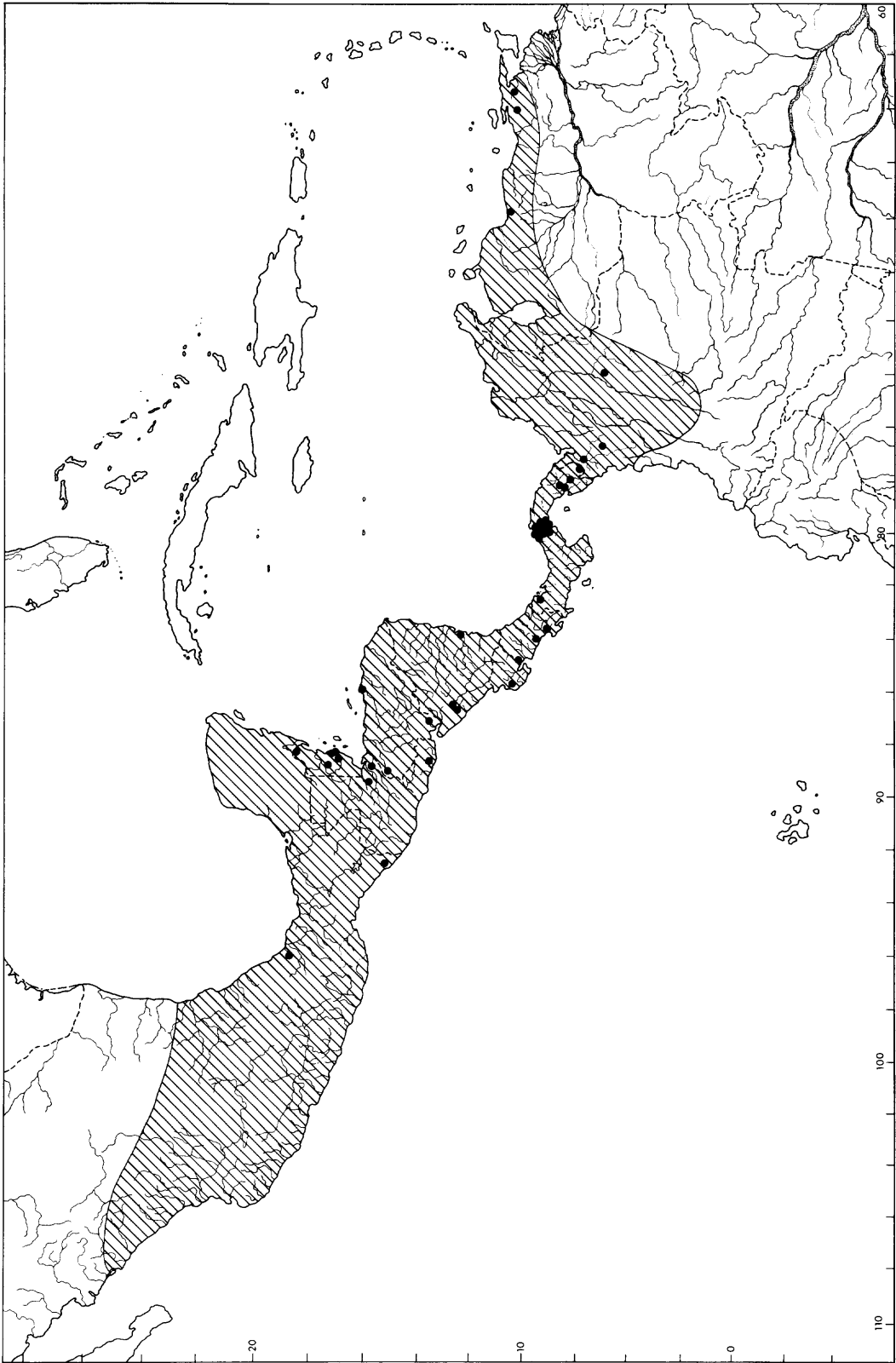


Fig. 20. Collection records of *An. punctimacula* in Panama and northwest Colombia. Stippled areas indicate altitudes above 330 m.

Table 2. Number of branches for fourth-instar setae, *An. punctimacula*<sup>a</sup>

Seta no.	Antenna	Head C	Thorax			Abdominal segments								Spiracular apparatus				
			P	M	T	I	II	III	IV	V	VI	VII	VIII		X			
0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	6-14 (10) [18]	1 [17]	4-7 (7) [13]	20-24 (20) [10]	1-4 (1) [12]	6-8 (6) [9]	7-15 (10) [10]	1 [4]	—	—	—	—	—	—	—	—	—	—
2	—	1-2 (1) [20]	10-13 (12) [11]	1-4 (3) [14]	1-4 (3) [14]	3-4 (4) [14]	5-10 (6) [13]	5-8 (5) [14]	2-3 (2) [14]	2-3 (2) [10]	3-8 (5) [14]	3-8 (5) [14]	5-10 (5) [12]	5-10 (8) [14]	—	—	—	—
3	—	3-8 (3) [20]	1 [14]	1 [14]	9-16 (9) [4]	1-2 (1) [14]	1 [14]	1 [14]	1-4 (2) [13]	1 [14]	1-4 (2) [14]	1 [14]	1 [14]	1 [14]	—	—	—	—
4	3-6 (4) [12]	1-3 (1) [18]	13-17 (13) [4]	1 [14]	3-4 (4) [14]	4-10 (8) [14]	3-7 (5) [14]	2-4 (3) [13]	2-3 (3) [14]	3-5 (3) [14]	3-5 (3) [14]	3-5 (3) [14]	3-5 (3) [14]	3-5 (3) [11]	—	—	—	—
5	—	14-23 (20) [16]	>20	1 [13]	>20	3-6 (4) [14]	5-9 (7) [13]	5-10 (8) [13]	2-6 (4) [13]	4-6 (4) [12]	4-6 (4) [12]	5-10 (6) [14]	5-9 (7) [12]	3-5 (4) [11]	—	—	—	—
6	—	15-24 (20) [16]	1 [11]	2-3 (3) [14]	1-3 (2) [13]	>20	>20	>20	1 [12]	1 [9]	1 [13]	2-4 (3) [13]	2-4 (2) [13]	—	—	—	—	—
7	—	12-21 (20) [15]	>20	2-3 (3) [10]	>20	>20	>20	3-5 (3) [14]	2-4 (3) [13]	2-3 (3) [14]	2-3 (3) [12]	2-3 (2) [12]	3-5 (5) [10]	—	—	—	—	—
8	—	3-8 (5) [19]	>20	8-15 (8) [4]	>20	—	1-2 (2) [11]	1-2 (2) [13]	1-2 (2) [13]	1-3 (2) [13]	1-3 (2) [13]	1-3 (2) [14]	3-7 (5) [13]	—	—	—	—	—
9	—	2-6 (5) [19]	1 [14]	1 [13]	1 [14]	3-4 (3) [13]	4-7 (7) [14]	4-9 (6) [14]	5-9 (7) [14]	6-10 (8) [14]	6-11 (8) [12]	6-11 (8) [12]	3-5 (3) [12]	—	—	—	—	—
10	—	2-3 (3) [19]	1 [14]	1 [13]	1 [14]	1 [13]	2-4 (3) [13]	1-2 (1) [13]	1 [13]	1 [13]	2-4 (3) [13]	2-4 (3) [14]	3-8 (6) [11]	—	—	—	—	—
11	—	16-28 (16) [8]	1 [14]	1 [14]	1 [14]	3-4 (3) [13]	1 [13]	2-3 (3) [13]	2-4 (3) [13]	2-3 (3) [13]	1-3 (2) [13]	1-3 (2) [13]	1-2 (2) [11]	—	—	—	—	—
12	—	3-5 (4) [19]	1 [14]	1 [13]	1-2 (2) [12]	2-3 (2) [13]	1 [12]	1-3 (2) [11]	2-4 (2) [13]	2-3 (2) [12]	2-3 (2) [12]	1 [14]	1 [9]	—	—	—	—	—
13	—	3-7 (5) [18]	9-15 (11) [14]	3-10 (8) [13]	2-3 (3) [14]	4-9 (8) [13]	5-13 (9) [13]	5-11 (7) [13]	3-6 (5) [11]	2-5 (3) [13]	2-5 (3) [13]	6-12 (11) [14]	2-5 (4) [11]	—	—	—	—	—
14	—	1-4 (3) [15]	3-6 (4) [14]	7-9 (8) [12]	—	—	—	1 [4]	1 [5]	1-2 (1) [6]	1 [2]	1 [2]	1 [4]	1 [4]	—	—	—	—
15	—	2-6 (3) [13]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

<sup>a</sup> Range; ( ), mode; [ ], number counted.



**Fig. 21.** Distribution of *An. punctimacula*. Dots indicate confirmed determinations, shaded area is an approximation derived from literature records and confirmed determinations.

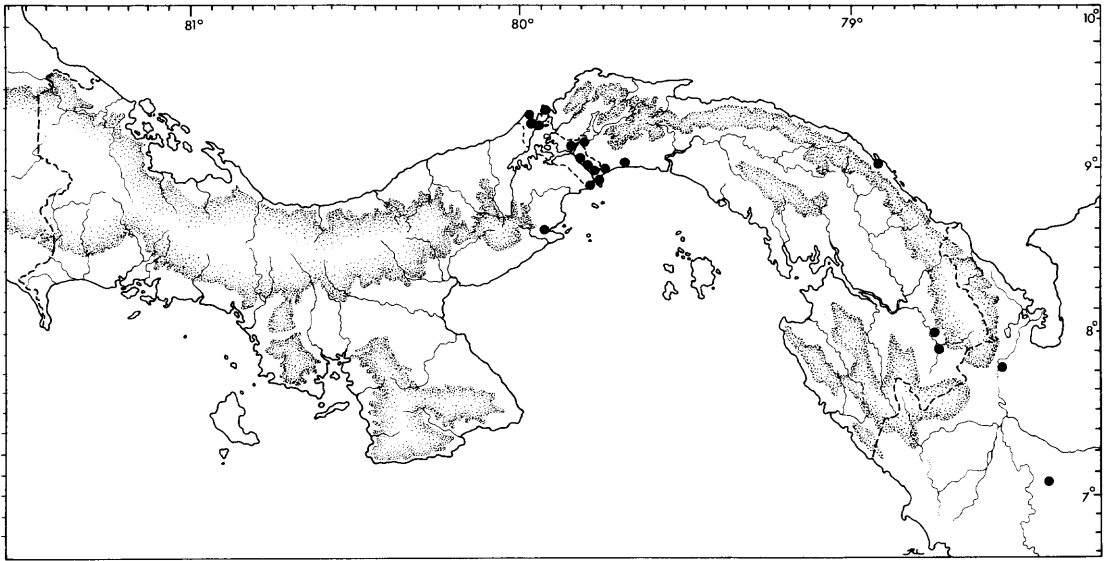


Fig. 22. Distribution of *An. malefactor*. Stippled areas indicate altitudes above 330 m.

"As in *A. strigimacula* D&K, but the last vein with a row of black dots." The description of *An. strigimacula* precedes *An. punctimacula* on the same page and also is very brief, stating that the last vein has "three black dashes." The choice of *An. punctimacula* as the senior synonym is upheld by Article 24 of the International Code of Zoological Nomenclature (1985), Principle of the First Revisor. The type of *An. strigimacula* is in excellent condition and the number of "dots" or "dashes" on the last vein (anal) differ on the two wings of the holotype. Consistent spotting of this vein is not evident in the examined material of *An. punctimacula* or *An. malefactor*; therefore, it is not of diagnostic value.

The condition of the holotype of *An. punctimacula* makes characterization of this species more difficult, and it could be argued that it is actually *An. malefactor*. I believe, based partly on measurements of wing spots (Fig. 23), that the holotype of *An. punctimacula* is different from the lectotype of *An. malefactor* and that the material examined for this paper is representative of these two species.

**Biology.** Information taken from specimen labels shows a wide variety of immature habitats for *An. punctimacula*. Larvae were taken in deep or sometimes partial shade in the following types of water: stream pool with clear water, in grass along a clear slow-moving stream with abundant vegetation, along a swamp margin, and in deep water of a large swamp. One reference to larvae collected in cut bamboo seems doubtful.

Fourth instars collected during a field study in August 1987 by D. Strickman, D. Roberts, and R. C. W. near Tapachula, Mexico, were relatively easy to rear to the adult stage but developed slowly. Eggs collected from wild-caught females, either captured engorged or fed on human blood in the

laboratory, were very difficult to rear. There was high mortality with a duration between egg and adult of about 4 or 5 wk. Wild-caught females often fed three or four times on humans before laying eggs (Darling [1910] also noted this). Adult females bite man and domestic animals and have been collected in Shannon traps, stable traps, horse traps, in corrals, and from human bait.

In Panama, *An. punctimacula* and *An. malefactor* are reported below 303 m (Fig. 20 and 22). Based on many collection localities, Kumm & Ruiz (1939) also found this to be true in Costa Rica for *An. punctimacula sensu lato*.

#### *Anopheles malefactor* Dyar and Knab (Fig. 22-51)

*Anopheles malefactor* Dyar and Knab 1907: 198 (lectotype, ♀, NMNH; type locality Rio Chagres, Panama; examined); Busck 1908: 59 (reference to collection of type series by Busck, in part); Theobald 1910: 87 (copy of original description); Howard et al. 1912 (1913): Plate 41 (wing photo); Howard et al. 1917: 1000; Dyar 1918: 191 (= *punctimacula*, apparent synonymy without comment); Stone & Knight 1956: 278 (lectotype designation). HERE RETRIEVED FROM SYNONYMY WITH *Anopheles punctimacula*.

**Diagnosis.** A brown to dark brown species with a few pale scales at the palpomere joints, 3 distinct dark thoracic spots, a few scales on upper mesanepimeron, speckled femora and tibiae, hindtarsomeres with irregular dark and pale bands, hindtarsomere 5 pale, and joints of hindtarsomeres pale. Wing with 3 main dark costal spots and an indistinct apical dark area, costal spots dark brown-scaled, the spots bordered by white scales, the re-

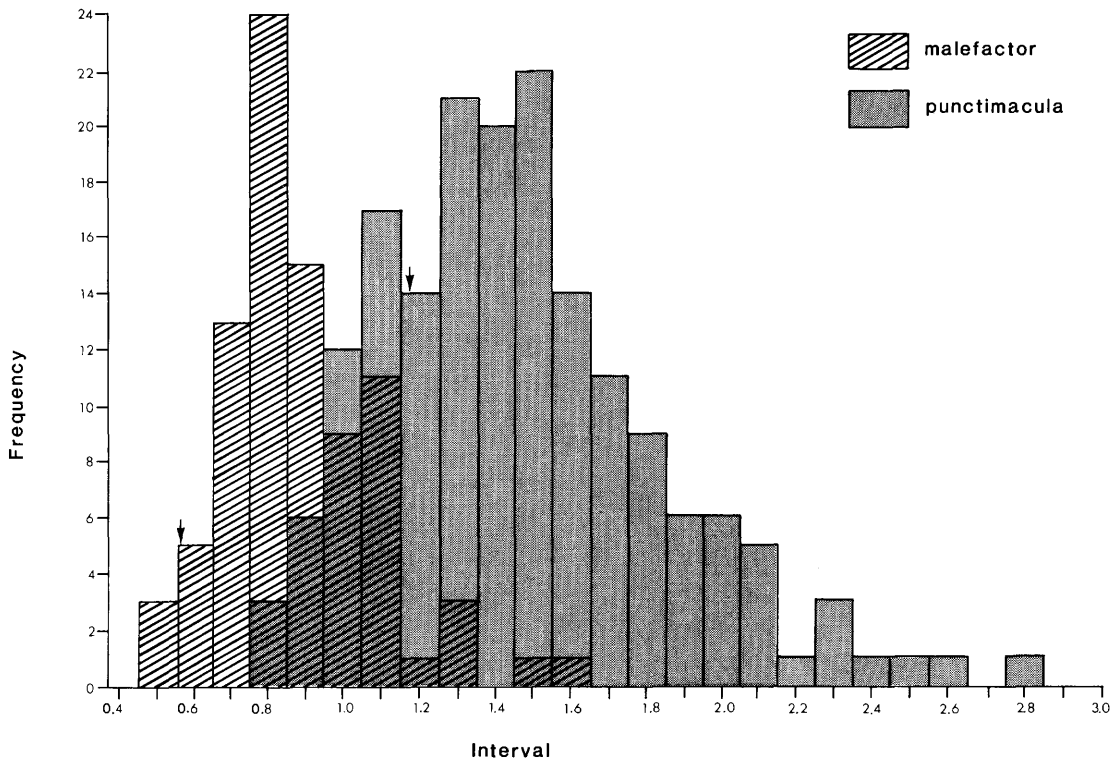


Fig. 23. Frequency distribution of presector dark wing spot to sector pale spot on the wings of *An. punctimacula* and *An. malefactor*. Arrows from left to right indicate ratios found on holotypes of *malefactor* and *punctimacula*, respectively.

maining scales a mixture of brown, white, and pale yellow. Abdomen with posterolateral scale tufts above and numerous dark brown and white scales below, a distinct tuft of dark scales on tergum VII, and numerous slender pale yellow scales on tergum and sternum VIII.

**Female** (Fig. 24–29). *Head*. Head scales extending from vertex to about level of proboscis, spatulate, some rounded apically, most with flat truncated ends; scales pale yellowish brown near vertex, changing to brown and dark brown at sides. Slender white recumbent ocular scales from vertex to frons in narrow rows next to each eye. Frontal tuft of long pale yellowish erect setae. Ocular and postgenal setae dark brown, a few white scales present ventrally on postgena at junction of eyes. Frons, clypeus, and gena dark brown showing through thin covering of pale pollinosity. Labrum dark brown, labellum yellowish brown. Labium with short dark brown recumbent setae and dark brown scales, numerous and erect on basal 0.2, smaller, less numerous and recumbent on remainder. Maxillary palpus with numerous slender erect scales giving shaggy appearance, these mostly dark brown but with pale scales at joints, at tip and a few intermixed on palpomere 3. Antennal pedicel dark brown with small patch of white scales dorsally; flagellomere I with patch of white scales on mesal surface. *Thorax*. Scutum and scutellum pale yellowish

lowish brown with thin coating of silvery pollinosity, heavier around (and thus accentuating) large lateral dark brown spots on antealar areas and large dark brown median spot of prescutellar area and scutellum. Brown speckling occurring elsewhere mainly along and in ill-defined median and sublateral rows. Scutum with rather evenly spaced short to moderately long setae, mostly yellowish, some brownish; sublateral areas of anterior pronotum with a few yellow piliform scales changing to broad brown spatulate setae laterally; median area with dense patch of yellowish piliform scales; supraalar area with sparse small narrow yellow spatulate scales. Posterior scutellum with row of about 14 stout brown setae and row of smaller yellowish setae similar to those on scutum. Pleura dark brown in ground color with pattern of spots produced by areas of silvery pollinosity, accentuated dark areas just below wing, on lower mesanepimeron, mesomeron, lower mesokatepisternum, postspiracular area, and subspiracular area. Antepronotum with dense patch of dark brown spatulate scales and a few pale scales intermixed. Other vestiture as follows: numerous yellow and brown setae on antepronotum; a few dark setae on proepisternum (some specimens with 1 pale or dark scale); line of pale spatulate scales and small pale setae on upper mesokatepisternum near mesopleural suture; horizontal row of pale scales and

pale setae on lower 0.5 of mesokatepisternum; a few pale setae on prealar knob; small patch of pale scales on upper anterior mesanepimeron and patch of long pale upper mesanepimeral setae. *Legs*. Speckled and banded, dark and light coloration caused by small appressed scales with underlying concolorous dark, white, or yellow pollinosity. Foreleg: coxa with basal anterior white scales and stout dark setae, a few distal posterior stout dark setae and a posterior fringe of distal lateral scales, mostly white but some specimens with dark posterior scales. Trochanter with small appressed white or yellowish white scales and slender yellowish setae. Femur with basal 0.66 enlarged, variable but usually mostly brown with yellowish white speckling, pale spots sometimes consisting of a few scales on basal 0.5, spots larger distally, overall posterior aspect relatively paler, apex dark or pale. Tibia with small white speckling on dark brown background; ventrally almost completely white with some yellowish spots; dorsally with ill-defined continuous dark line; apex with a few larger white spots dorsally and short dense golden yellow setae ventrally. Tarsi mostly pale, randomly speckled white dorsally, ventral surface pale, joints and tarsomere 5 pale. Midleg: coxa with several small patches of white scales and a few yellowish setae. Trochanter with sparse appressed white scales and numerous pale yellow setae. Femur dark brown with 10–12 white speckles, ventrally with well-defined white stripe extending to near apex. Tibia as femur but about twice as many white spots, ventral pale stripe continuous but not well defined. Tarsi dark ventrally with dorsal speckling varying from a few small spots to nearly all white, joints and tarsomere 5 white. Hindleg: coxa with patch of white scales and a few stout dark setae distally and 1 or 2 stout setae mesally on posterior surface. Trochanter as midleg. Femur dark with white speckling; predominantly white with apex dark ventrally. Tibia speckled as femur but apex white dorsally and with dense patch of short golden yellow setae ventrally. Tarsi dark brown- and white-banded but some of dark bands in most specimens do not circle tarsomeres (especially on T1), in addition isolated white scales sometimes found in dark areas; all joints and tarsomere 5 white; bands, T1 6–9, T2 2 or 3 (usually 3), T3 2 or 3 (usually 2), T4 1 or 2 (usually 2). *Wing*. Speckled with 3 main dark brown costal spots underlaid by dark pigment. A fourth dark area near wing apex with intermixed paler scales, not readily recognized without magnification. Humeral crossvein with patch of dark scales. Scales mostly medium to broadly lanceolate, those on basal 0.66 of  $R_{2+3}$  especially broad with either rounded or truncate apices, those toward tip of wing somewhat narrower and shorter, scales of CuA, except at very base, also smaller, narrower, and more appressed. Wing scale coloration dark brown on 3 main costal spots; white on either side of these with remainder of pale scales pale yellow except for scattered white scales near wing apex,

near subcostal dark spot, near base of  $R_{2+3}$  and  $R_{4+5}$ , on  $M_{1+2}$ , and 3 or 4 small patches on 1A. *Halter*. Capitellum dorsally with dense white scales encircling dark brown depressed center, pedicel dorsally with dense white scales, ventrally integument of halter dark brown with concolorous scales, scabellum yellowish brown. *Abdomen*. Ground color brown, mottled irregularly with black. Dorsum covered with numerous long yellowish brown setae; longer and more abundant on first tergum. Terga II–VII with posterolateral scale patches mostly dark brown but with a few pale scales intermixed on posterior terga. Scales spatulate, most with rounded apices but some on first few terga broad and truncate. Apical border of tergum VII with a few yellowish scales; tergum VIII with numerous narrow brown spatulate scales on posterior 0.25 and a few pale scales just anterior to them. Venter with scattered long yellowish brown setae. Scales broad, spatulate, dark brown and white except for some narrow yellowish scales on tergum VIII. Dark scales in patches on posterior median areas of sterna, most prominent on sternum VII, white scales more or less randomly distributed over rest of sternum but more numerous just anterior to dark scales.

**Male** (Fig. 30). As female but wing paler with fewer scales. Palpomere 2 dark brown-scaled, scales on basal 0.5 erect, apical scales pale yellowish white; base of palpomere 3 with pale yellowish white scales and sparse dark brown scales along most of length becoming slightly denser and erect toward apex, apex with yellowish scales and dorsal surface with patch of pale yellow white scales beginning about 0.66 from base; lateral surface of palpomere 4 mostly pale yellowish-scaled with patch of median dark brown scales; lateral surface of palpomere 5 slender pale yellow-scaled. Mesal surface of palpus beginning at apex of palpomere 3 and most of palpomeres 4 and 5 with long pale yellow setae. *Genitalia* (Fig. 31–39). Lobes of tergum IX variable in length, 1.0–4.0 times as long as wide, usually 3.0 times longer. Gonocoxite 2.0–3.0 times as long as wide at widest point, widest about 0.33 from base; dorsal (postrotational) surface with many long setae, a few very long setae distally, slender fusiform and spatulate scales and numerous very small spicules; ventrally as dorsally but with lateral scales and numerous longer spicules toward base; most mesal parabaasal sets (parabaasal 1) stout with slender recurved tip, borne on slightly raised base; parabaasal 2 longer and more slender than 1; both about 0.22 from base of gonocoxite; internal seta slender, about as long as parabaasal 1, base 0.5–0.6 distance from base of gonocoxite. Gonostylus widened at both ends. Claspettes: clubbed setae of dorsal lobe with 3 (occasionally 2 or 4) strong, closely appressed setae of about equal length, tip of most lateral seta curved forward over second, and second over third; depending on aspect these appear as truncate or bluntly pointed; tip of composite structure slightly club-shaped. Ventral lobe usually with 2 (sometimes 3) long apical or subapical setae, most apical

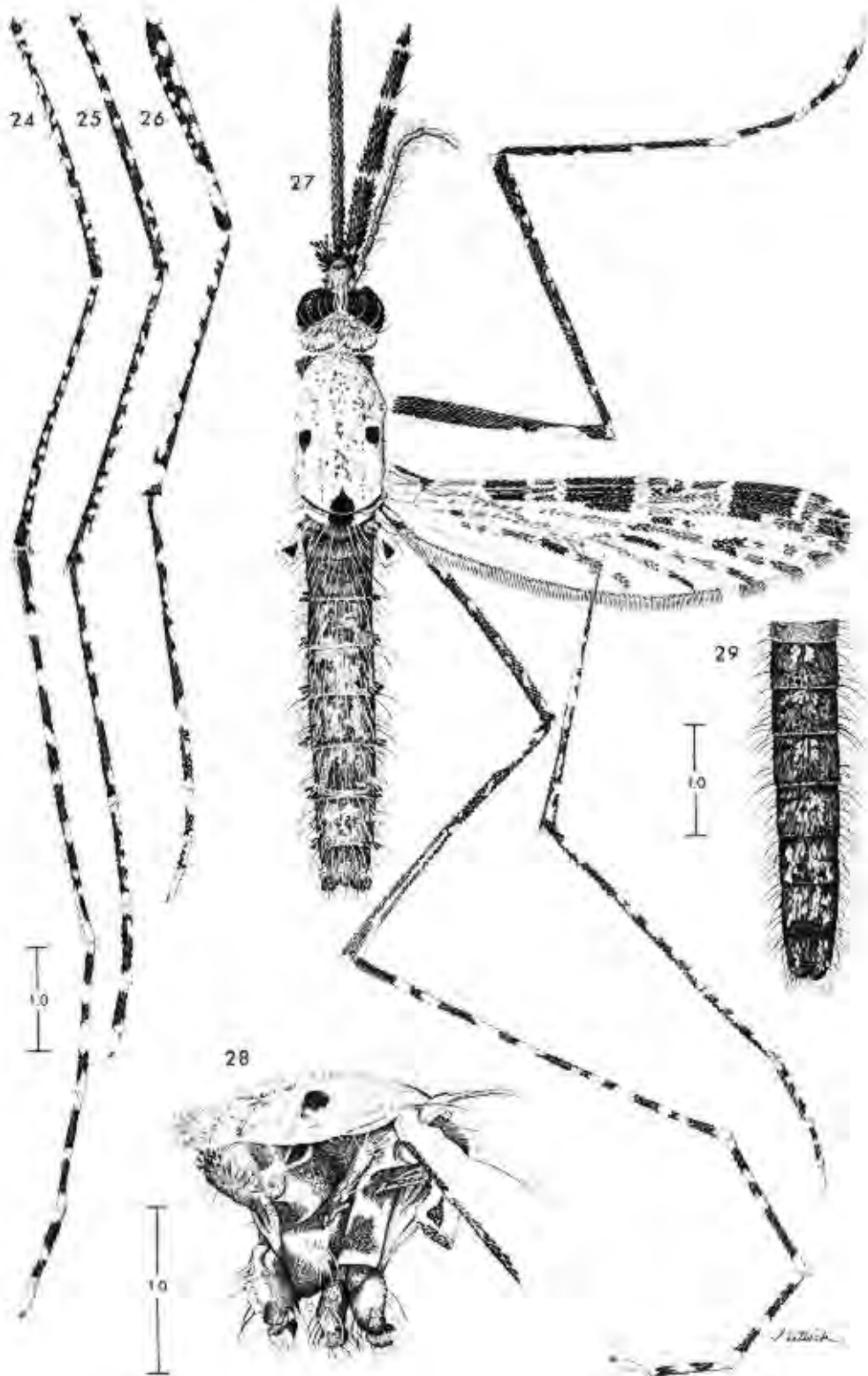


Fig. 24-29. *An. malefactor* female. (24) Hindleg. (25) Midleg. (26) Foreleg. (27) Habitus. (28) Thorax, side view. (29) Abdominal venter.

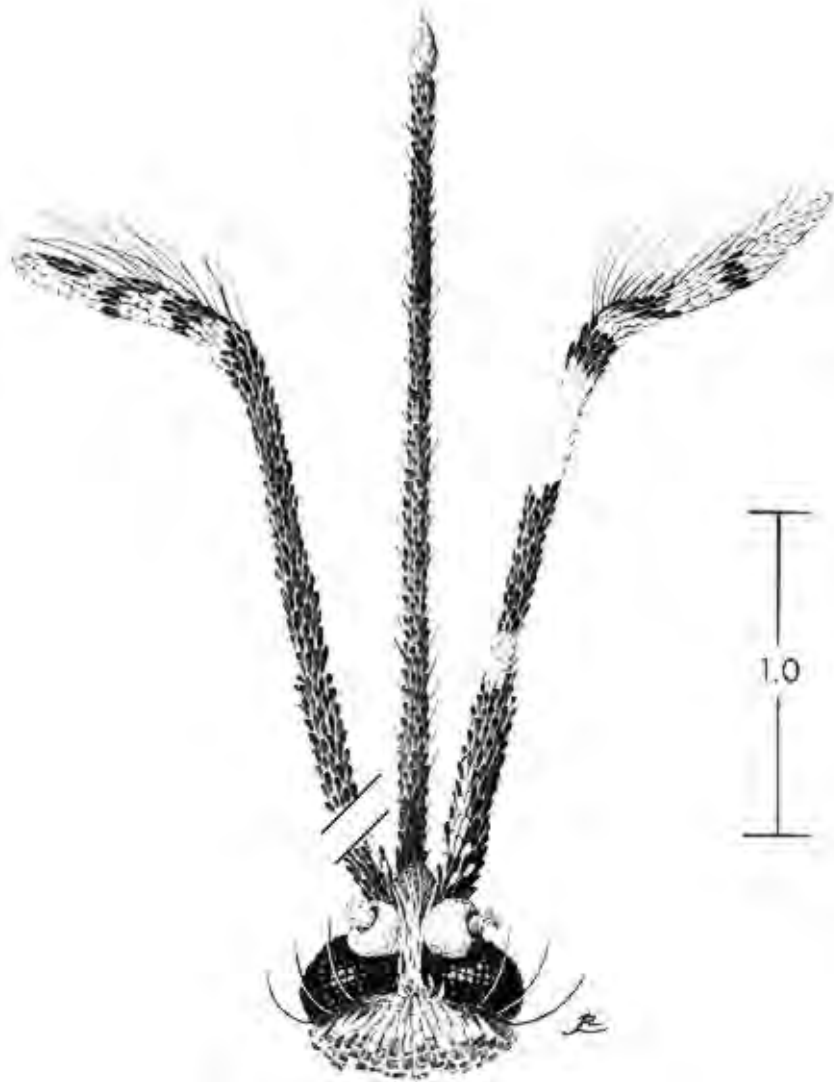


Fig. 30. Male head. *An. malefactor*.

usually longest; remainder of ventral lobe and area between it and dorsal lobe with many evenly spaced prominent short spicules. Aedeagal leaflets variable, 2–6 per side, most commonly 3; most mesal leaflet longest and broadest with broad, thin, nearly transparent inner margin and similar, slender, outer margin; second leaflet in some specimens also with slender, thin, nearly transparent inner margin.

**Pupa** (Fig. 40–45; Table 3). *Cephalothorax*. Laticorn trumpet, meatal cleft slitlike to slightly rounded, secondary cleft 0.47–0.56 ( $\bar{x} = 0.51$ ,  $n = 14$ ) length of trumpet; seta 8-CT usually triple (2–4), 10-CT with 1–4 branches. *Abdomen*. Seta 1-II well developed with 10–20 branches, 1-IV with 2–4 branches, 1-V with 1–5 branches, 1-VI, VII usually single; 2-I usually with 4 branches (1–6), 2-II well developed with 5–10 branches; 3-III single or double, 3-VI with 2–5 branches, 3-VII triple (1–5);

4-I usually with 4 branches (2–7), 4-V usually with 4 branches (1–5); 5-I double or triple, 5-IV with 3–5 branches, 5-V with 2–5 branches, 5-VI with 2–4 branches; 6-I single to triple; 8-III usually double (1–3); 9-VIII often with numerous long aciculae; 10-II absent. *Paddle*. Width/length 0.74–0.85 ( $\bar{x} = 0.77$ ,  $n = 10$ ); refractile margin/length 0.62–0.67 ( $\bar{x} = 0.64$ ); length of paddle marginal spicules 0.048–0.06 mm ( $\bar{x} = 0.052$ ,  $n = 14$ ), 0.61 length of seta 1-P. Terga and sterna with many small spicules, mostly on posterior 0.5, most numerous on posterior margins; many small spicules give serrated appearance to posterolateral margins. Size and extent of spicules variable.

**Larva** (Fig. 46–51; Table 4). *Head*. Antenna basally enlarged, spiculate with most and largest spicules basally on mesal surface; seta 1-A long, 6–16-branched, originating about 0.33 from base; 4-A

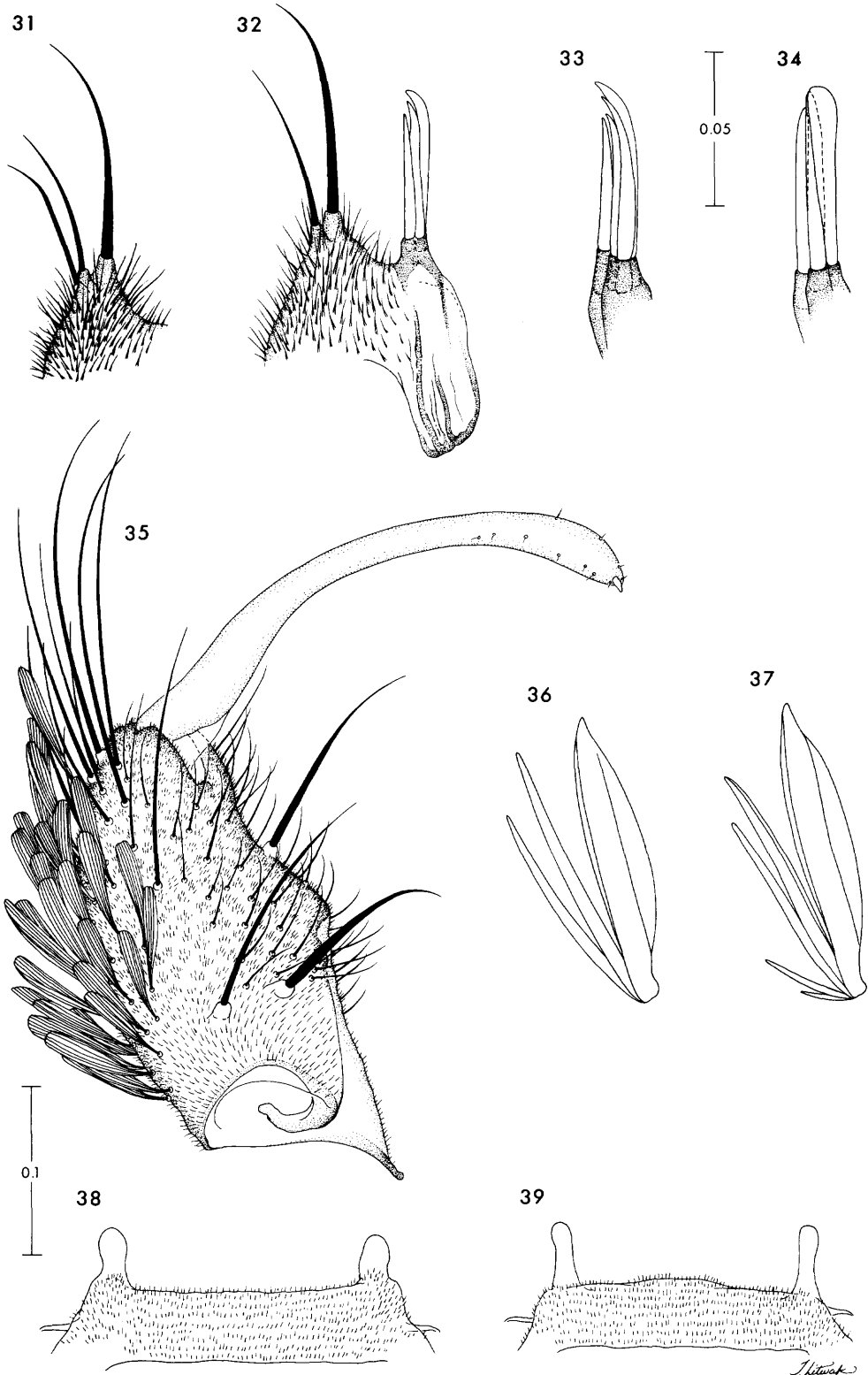


Fig. 31-39. *An. malefactor* male genitalia. (31) Ventral lobe of claspette. (32) Claspette. (33) Setae of dorsal lobe of claspette lateral view. (34) Setae of dorsal lobe of claspette dorsal view. (35) Gonocoxite and gonostylus dorsal aspect (prerotation sense). (36, 37) Aedeagal leaflets. (38, 39) Ninth tergite.

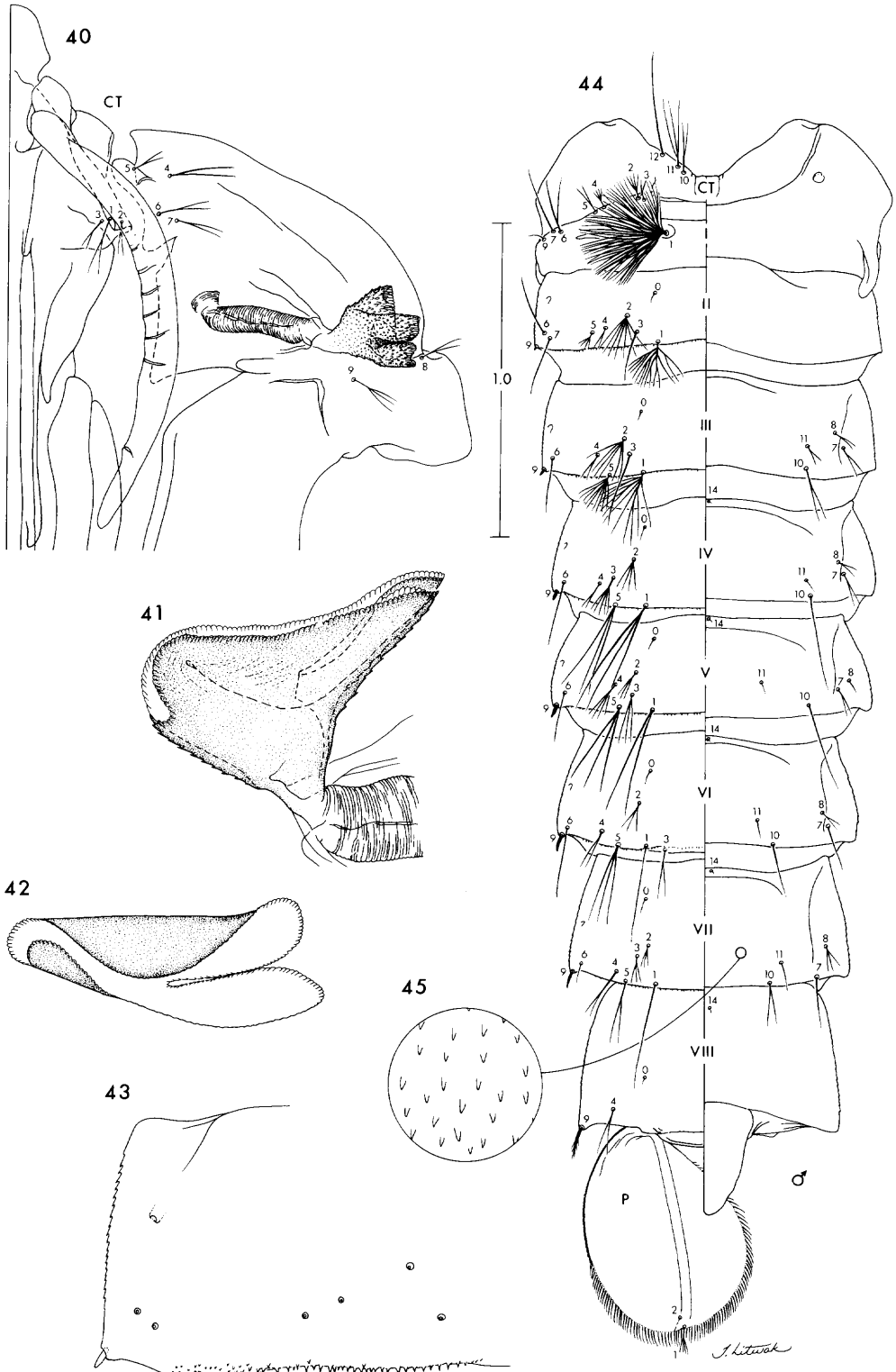


Fig. 40-45. *An. malefactor* pupa. (40) Cephalothorax. (41) Trumpet side view. (42) Trumpet dorsal view. (43) Abdominal segment II dorsal. (44) Metathorax and abdomen, left side dorsal, right side ventral. (45) Detail of ventral surface of segment VI.

**Table 3. Number of branches of pupal setae, *An. malefactor*<sup>a</sup>**

Seta no.	Cephalothorax CT	Abdominal segments									Paddle P
		I	II	III	IV	V	VI	VII	VIII	IX	
0	—	—	1-2 (1) [10]	1-3 (1) [8]	1 [6]	1-2 (1) [10]	1 [9]	1-2 (1) [10]	1 [10]	—	—
1	1-4 (2) [10]	12-17 (13) [10]	10-20 (10) [9]	3-16 (12) [10]	2-4 (3) [10]	1-5 (2) [10]	1-2 (1) [9]	1-2 (1) [10]	—	1-3 (1) [6]	2-6 (4) [10]
2	1-4 (2) [9]	1-6 (4) [29]	5-10 (6) [10]	4-11 (5) [10]	2-5 (4) [29]	2-4 (2) [10]	2-4 (2) [10]	2-4 (3) [10]	—	—	1 [10]
3	2-3 (2) [10]	1-4 (2) [30]	1 [10]	1-2 (1) [10]	4-7 (4) [10]	1-8 (2) [10]	2-5 (2) [10]	1-5 (3) [30]	—	—	—
4	1-2 (2) [10]	2-7 (4) [10]	1-5 (1) [9]	1-4 (2) [27]	1-5 (2) [10]	1-5 (4) [27]	1-3 (1) [10]	1-2 (2) [10]	1-4 (2) [10]	—	—
5	1-4 (2) [10]	2-3 (2) [10]	2-7 (3) [9]	5-15 (9) [9]	3-5 (3) [10]	2-5 (3) [10]	2-4 (3) [10]	1-4 (2) [10]	—	—	—
6	1-3 (2) [9]	1-3 (2) [26]	1-2 (1) [10]	1-2 (1) [10]	1 [10]	1 [10]	1-2 (1) [10]	1-2 (1) [9]	—	—	—
7	1-3 (2) [10]	1-2 (1) [24]	1-4 (2) [10]	1-4 (2) [29]	1-4 (2) [10]	1-4 (2) [29]	1-2 (1) [10]	1-3 (1) [10]	—	—	—
8	2-4 (3) [26]	—	—	1-3 (2) [28]	1-4 (2) [10]	1-3 (1) [10]	1-3 (2) [10]	1-4 (3) [30]	—	—	—
9	1-2 (2) [9]	1-2 (1) [26]	1 [10]	1 [10]	1 [10]	1 [10]	1 [10]	1 [10]	1 [10]	—	—
10	1-4 (2) [10]	—	—	2-4 (2) [10]	1 [10]	1 [10]	1-2 (1) [10]	1-3 (2) [9]	—	—	—
11	2-5 (3) [10]	—	—	1-3 (2) [30]	1-3 (1) [30]	1-2 (1) [10]	1-3 (1) [29]	1-3 (1) [28]	—	—	—
12	1-2 (1) [10]	—	—	—	—	—	—	—	—	—	—
13	1 [10]	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	1 [10]	1 [10]	1 [10]	1 [10]	1 [8]	1 [2]	—

<sup>a</sup> Range; ( ), mode; [ ], number counted.

3-5-branched, somewhat shorter than setae 2,3-A; 2-A truncate at an angle, tip fimbriate; 3-A pointed. Seta 2-C usually aciculate along middle 0.33, 3-C nearly as long as 2-C, with 7-16 branches ( $\bar{x}$  = 12), 4-C with 2-4 branches, 8-C with 5-9 branches, 9-C with 2-6 branches. *Thorax*. Seta 1-P not palmate, with 3-6 branches, 3-P single, 9-12-P single (one specimen with 11-P double on 1 side); 4-M single, 9-12-M single; 3-T palmate, poorly pigmented, 11-T usually single, 12-T single to triple. *Abdomen*. Seta 1 smaller and less pigmented on segments I and II than on other segments; 3-I usually double (1-3), 3-VIII with 7-13 branches; 5-VIII with 5 or 6 branches; 6-IV,V single, 6-VI with 3-7 branches; 8-II with 2-5 branches, 8-III double or triple; 9-I with 3-9 branches, 9-II with 7-11 branches, 9-III with 7-14 branches, 9-IV with 7-13 branches; 10-VI forked, 10-VII forked with 6-10 branches; 13-V with 3-6 branches. Pecten spines regularly alternating long and short, 7-9 each, alternating pattern sometimes interrupted by absence of long tooth. Seta 1-X usually surrounded by sclerotization of saddle; posterior portion of saddle with numerous long spicules.

**Type Material.** Lectotype, female, with the following labels: handwritten "Lectotype Stone & Knight 1956"; "WRBU prep. 86/159" (wing slide);

red label "Type No. 10877 U.S.N.M."; handwritten "Anopheles malefactor Type. D.&K."; "Collected by August Busck"; "Rio Chagres Panama"; handwritten "136.1." Associated with this specimen is a slide bearing the larval and pupal exuviae. Neither are in good condition, and the larval exuviae lacks the head and most of the thorax. The adult is in good condition except for a light covering of fungal hyphae. The left midtarsomeres 2-5 and right hindleg are missing. The right wing is mounted under a coverslip without mounting media. A male in the type series corresponds to the lectotype with labels as follows: "134"; "Rio Chagres Panama"; "Collected by August Busck"; "Type No. 10877 U.S.N.M."; "790312-7" (referring to a genitalia mount which has not been found). Five other specimens in the type series are *An. punctimacula*.

**Other Material Examined** (detailed records to be published in a revision of the Arribalzagia Series). Total specimens examined included 177 females, 71 males, 33 associated larval exuviae, 53 associated pupal exuviae and 20 male genitalia from the following countries and primary political divisions: COLOMBIA: Antioquia, Chocó. PANAMA: Canal Zone, Colón.

**Distribution.** Panama and northwestern Colombia (Fig. 22).

**Systematics.** *Anopheles malefactor* was described in 1907 by Dyar and Knab. Even though there are seven specimens in the type series, the description evidently refers to a single specimen because they mention that hindtarsomere 5 is all white and do not mention yellow scales on the wing. In their discussion, they describe variation in leg banding and compare it with the "type." Stone & Knight (1956) noted this and selected as lectotype the specimen with white hindtarsomere 5 (which is also the only one of the seven with an original label that states "type").

**Biology.** *Anopheles malefactor* has been collected in habitats similar to those of *An. punctimacula*. They usually are taken in deep or partial shade, but in two instances the site was in full sunlight. It was found in the following types of water: ground pool, jungle ditch, stream pool, ditch, jungle swamp, along the margin of a slow-moving stream, a jungle pond, swamp interior, and a rock hole. The most common habitats are residual stream pools, stream margins, ground pools, and swamps. The water is usually clear with little aquatic vegetation but with some grass, algae, or floating leaves. Females have been taken biting horses and from human bait. Like *An. punctimacula*, *An. malefactor* is found below 303 m in Panama (Fig. 22).

### Discussion

*Anopheles punctimacula* and *An. malefactor* usually can be separated as follows. **Adult Females.** *An. punctimacula*: upper mesanepimeron without scales, pale wing scales other than those adjacent to 3 main costal dark spots (presector, sector, apical) yellow, hindtarsomere 5 usually with a dark ring or spot; *An. malefactor*: upper mesanepimeron usually with several pale scales, pale wing scales other than those next to 3 main costal spots, pale yellow and white, hindtarsomere 5 entirely pale. **Larva.** *An. punctimacula*: seta 3-C 3-8-branched, seta 1-X inserted outside of saddle or slightly within the saddle but not surrounded by sclerotization; *An. malefactor*: seta 3-C 7-16-branched, seta 1-X surrounded by sclerotization of saddle. **Pupa.** *An. punctimacula*: secondary cleft of trumpet 0.31-0.44 length of trumpet, paddle marginal spicules relatively short, 0.03-0.04 mm, 0.47 length of seta 1-P; *An. malefactor*: secondary cleft of trumpet 0.47-0.56 length of trumpet, paddle marginal spicules relatively long, 0.048-0.06 mm, 0.61 length of seta 1-P.

Fig. 31-39 show the male genitalic structures of *An. malefactor*. There are no measurable differences evident in the male genitalia of the two species treated here. The variation in the number and form of the aedeagal leaflets and the number of dorsal and ventral lobe setae is of special interest. Aedeagal leaflets of *An. punctimacula* vary from two to six pairs ( $\bar{x} = 3.4$ , mode = 3,  $n = 68$ ) and of *An. malefactor* two to six pairs ( $\bar{x} = 3.0$ , mode = 3,  $n = 20$ ). For both species, the number of leaflets on

one side is not always the same as on the other in the same specimen, including several with two on one side, four on the other, and a few with four on one side and six on the other. The characteristic transparent margin of the first leaflet also is variable in both species. All have a relatively broad transparent inner margin on leaflet 1, but most also have a narrow transparent outer margin, and a small percentage also have a narrow transparent inner margin on leaflet 2.

Species of the *Punctimacula* Group and many others of the *Arribalzagia* Series exhibit considerable variation in wing spotting. Eighty-six wings (50 females) of *An. malefactor* and 176 wings (99 females) of *An. punctimacula* were measured (see Materials and Methods). No diagnostic measurements were encountered to separate *An. punctimacula* from *An. malefactor*, but the lengths of the presector dark and sector pale spots showed no overlap at one standard deviation. A frequency distribution of the presector dark/sector pale ratio (Fig. 23) shows that the presector dark spot is smaller in *An. malefactor* and the sector pale spot correspondingly larger than in *An. punctimacula*. The other pale and dark areas along the costa showed less variation between the two species. Wing length, width, circumference, and area and length of the forefemora all show that *An. malefactor* is slightly smaller than *An. punctimacula*. These results indicate the existence of two species but do not preclude the possibility that other taxa not detected by these methods may be present.

Various studies have suggested that *An. punctimacula* is a vector of malaria parasites in Central and South America. However, in light of the taxonomic evidence presented herein, it is not possible to identify the species positively, and this should be kept in mind while reading the following paragraphs.

Darling (1910) fed 17 *An. malefactor* (?*punctimacula*) on malaria patients and none became infected. Arnett (1947) dissected the midguts and salivary glands of "several hundred" *An. punctimacula* in an area of 90% malaria incidence without positive results. Kumm & Ruiz (1939) also reported negative results but had dissected only seven specimens. The first record of a natural infection of *An. punctimacula* was by Simmons (1936) at Ft. Sherman, Panama, Canal Zone. Simmons (1937) later did man-mosquito transmission experiments with both *Plasmodium vivax* and *P. falciparum*, obtaining infections in *An. punctimacula* in each of his published experiments. For *P. vivax*, he obtained 33% and 56% infection, encountering both oocysts and sporozoites from 10 and 18 mosquitoes, respectively. For *P. falciparum*, 6 experiments netted 2% to 86% infection, with parasites found on midguts and in salivary glands from a total of 483 individuals. Rozeboom (1938) also found a naturally infected *An. punctimacula* among 75 specimens at Las Guacas on the Rio Chagres, Panama. Kumm & Ruiz (1939) noted that both malaria and

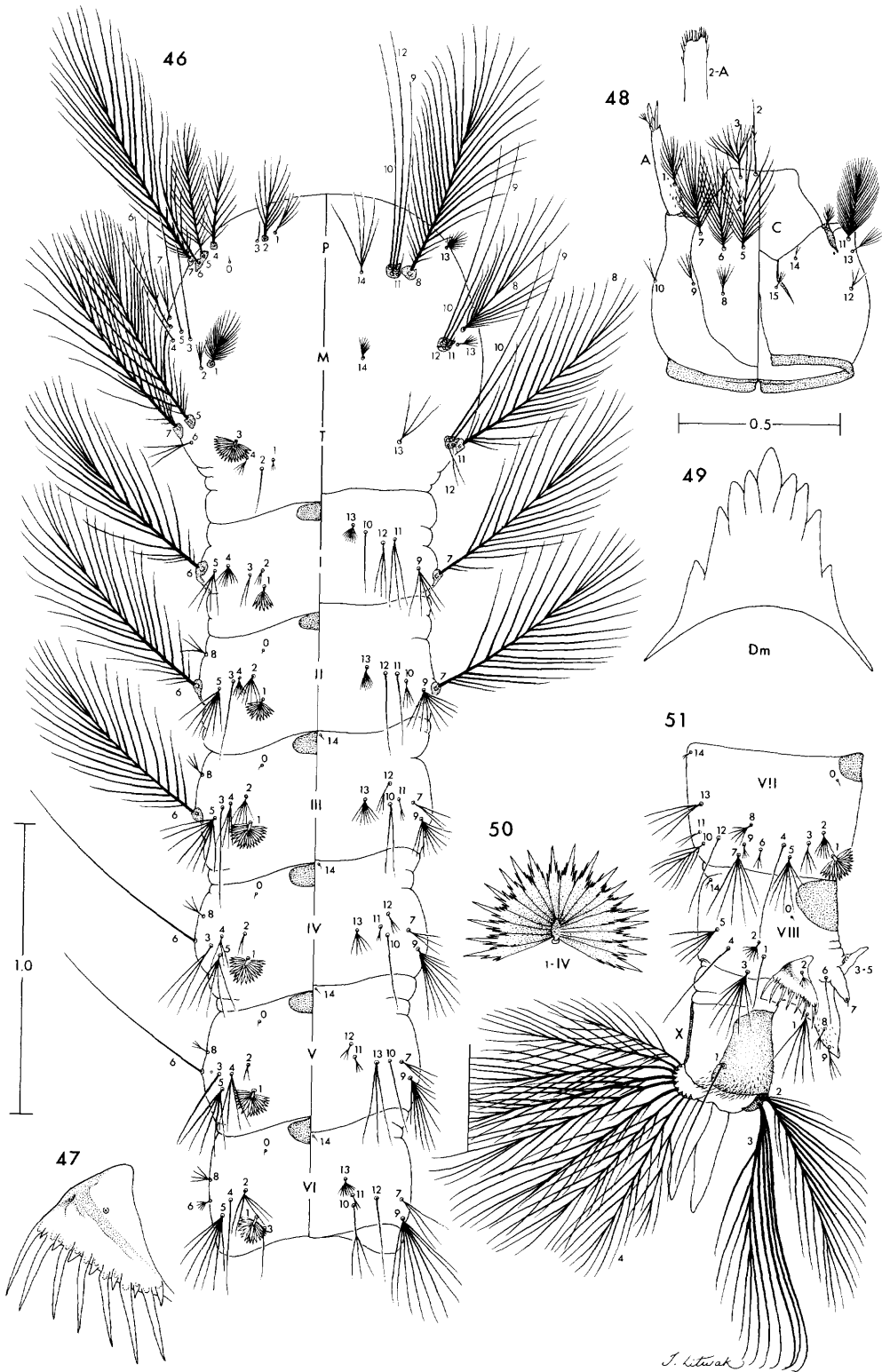


Fig. 46-51. *An. malefactor* larva. (46) Thorax and abdominal segments I-VI, left side dorsal, right side ventral. (47) Pecten and pecten plate. (48) Head, left side dorsal, right side ventral, antennal seta 2 above. (49) Dorsosentum. (50) Seta 1-IV. (51) Abdominal segments VII-X, side view.



*An. punctimacula* are found at elevations of less than 303 m in Costa Rica.

Other references to malaria infection in *An. punctimacula* merit special note. An anopheline found in the western coastal zone of Colombia, Ecuador, and Peru is undescribed (Villalobos & Valderrama 1944, Levi-Castillo 1949, Calderon et al. 1974) and will be treated elsewhere. In addition, it is possible that the *An. punctimacula* vector of malaria parasites of higher elevations in Colombia is also another species because all other records of *An. punctimacula* are from much lower elevations (Fig. 20, Kumm & Ruiz 1939). Pinzon (1945), in a very careful work, found *An. punctimacula* to be the third most commonly captured anopheline in houses at Puerto Salgar, Cundinamarca (elev. 1,773 m) and concluded that it was one of the two most likely species to transmit malaria parasites in the area. Rey et al. (1945) found oocysts in one of 177 *An. punctimacula* and found it to comprise 98% of anophelines caught in houses. They concluded that it was the vector of malaria parasites in Medellin, Colombia (elev. 1,540 m). Huffaker et al. (1945) found 4 of 208 females from houses and 1 of 118 from stable traps positive for oocysts from sites near Medellin. Ronnefeldt (1957), studying the effect of DDT on populations of *An. punctimacula* and resultant malaria rates, stated that *An. punctimacula* was the only vector in certain parts of the hill regions of Colombia between 800 and 1,100 m.

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