

A SURVEY OF THE MOSQUITO FAUNA (DIPTERA: CULICIDAE) OF THE IRIAN JAYA PROVINCE, NEW GUINEA, INDONESIA¹

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Abstract. A survey of mosquitoes was conducted in the highlands of Irian Jaya (New Guinea); additional collections were made on the north coast of Irian Jaya, on Biak I and on Ambon I in the Mollucas. The following genera (followed by the number of species) were represented in the collections: *Anopheles* (3), *Aedes* (14), *Armigeres* (3), *Culex* (18), *Mansonia* (1), *Tripteroides* (5), *Uranotaenia* (3) and *Toxorhynchites* (1).

The mosquito fauna of the western half of New Guinea (Irian Jaya) is poorly known. To increase our knowledge of the fauna of this area, a mosquito survey was conducted in the highlands of Irian Jaya. Collections of immatures were stressed and some specimens were link-bred. A total of 1338 specimens of mosquitoes was collected, consisting of 29 males, 107 females, 198 pupae, 79 pupal skins, 907 larvae, and 18 larval skins, representing 48 species in 8 genera.

The collections were made from December 1973 to February 1974 during a visit to Irian Jaya (FIG. 1) by M. M., accompanied during part of the time by P. S. Most specimens were collected in the highlands and particularly in the areas around Wamena (Balim Valley), Kelila, Bokondini and Karubaga, all in Djajawidjaja Regency (FIG. 2). Limited additional material was collected along the northern coast of Irian Jaya at Jayapura, Sentani and Manokwari, on Biak I, and on Ambon I in the Mollucas.

Except for a few anopheline adults captured indoors and identified by P. S., specimens were preserved in pill boxes (adults) or in MacGregor solution or alcohol (aquatic stages) and forwarded to the Bishop Museum, Honolulu, USA, for pinning, mounting and examination. Identifications were completed by us in May 1976.

The specimens were deposited in equal parts in Museum Bogoriense, Bogor, Indonesia, and the Bishop Museum.

HISTORICAL REVIEW

The anopheline mosquito fauna of Irian Jaya has been reviewed by Bonne-Wepster & Swellengrebel (1953), the nonanophelines by Bonne-Wepster (1954), and the vec-

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tors, pests and common species by Assem⁴ & Bonne-Wepster (1964). Steffan (1966) presented a checklist of the mosquitoes of the Papuan Subregion. Most literature references have dealt chiefly with the fauna of the coastal areas of Irian Jaya, and investigations of the highland mosquito fauna have stressed primarily the anophelines. The collections from the highlands reported in this paper are especially significant, since they include results of a more comprehensive survey.

COLLECTION RECORDS

Each specimen is identified by a numerical code consisting of 2-digit indicators of the year, month, and day, respectively, followed by a slash and a 1-digit lot number which refers to a specific collection from a particular habitat. For example, the first collection made on December 25, 1973 is labeled 731225/1. Collections are grouped to geographical area, i.e., Ambon I, Biak I and Irian Jaya (the western ½ of the island of New Guinea). The collections from Irian Jaya were made in the northern coastal areas (Jayapura, Lake Sentani and Manokwari) and in the highlands (Djajawidjaja Regency). In the collection records below, each specific locality is followed by modifiers which relate to all lot numbers in that paragraph. Any differences in a specific collection follow that particular lot number. Arrangement of genera and subgenera follow Steffan (1966). Generic and subgeneric abbreviations follow Reinert (1975). The following symbols are used to indicate stages collected: ♀, ♂, L = whole larva, L = larval skin, P = whole pupa, P = pupal skin.

Ambon Island (3.43 S, 128.12 E) Indonesia, Maluku Prov.; an important island of the Moluccas off the SW coast of Ceram I; 50 km long by 16 km wide, 505 km²; formed by 2 long strips of land connected by a narrow isthmus; with high peaks (Mt Salhutu, 1225 m) which are active volcanoes.

Gunong Nona, on rocky, grass-covered slopes, 300 m: 731225/1, rat-gnawed coconut husk, foul water, *Ar. (Arm.) malayi* (Theobald), 53L; 731225/2, broken bottle, polluted water, shaded, *Ae. (Stg.) paullesi*, 2L.

Biak (1.00 S, 136.00 E) Indonesia, Schouten Is; largest of the Schouten Is, off N coast of Irian Jaya; 72 km long by 37 km wide, 1525 km²; northwestern part of island is hilly.

Biak Town, at beach, thick vegetation in shade: 731229/1, pail, clear water, *Ae. (Stg.) scutellaris*, 3L, unidentified, 4P; 731229/2, sardine can, water with organic debris on bottom, *Ae. (Stg.) scutellaris*, 1♀, 1♂, 1L, 12P, 3P; 731229/3, nr fisherman's hut, 55-gal. [.946 litre] drum, water clear, *Ae. (Stg.) aegypti*, 5L.

Biak Town (W of, nr Naval Base), in coastal forest: 740210/1, fallen leaf, water clear, shaded, *Ur. obscura*, 10L; 740210/2, deeper into forest, metal biscuit box, water with abundant leaves on bottom, shaded, *Ar. (Arm.) breinli*, 2♀, *Ar. (Arm.) papuensis*, 3♀, *Cx. (Lop.) kuhnsi*, 3L; 740210/3, open terrain, natural pool (4×2×0.4 m), water clear, with abundant floating and submerged vegetal material, shaded, *Ae. (Edw.) imprimens*, 1L.

4. We cite van den Assem as Assem, J. van den, following Assem & Bonne-Wepster (1964).

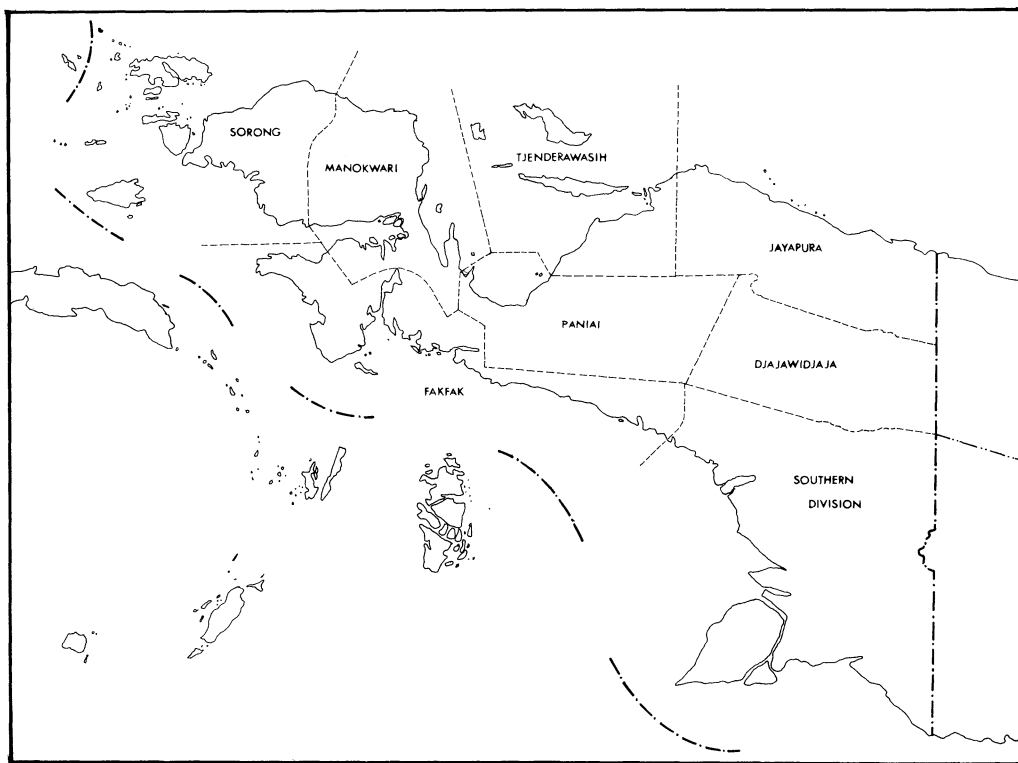


FIG. 1. Irian Jaya and nearby islands.

Biak Town, Airport Hotel, 740213/1, in garden, nr big tree, adults attacking at sunset, *Ae. (Stg.) scutellaris*, 1 ♀.

Irian Jaya is the Indonesian portion (the western ½) of the island of New Guinea (see FIG. 1).

1. *Coastal areas.* Most collections made during World War II were restricted to the coastal areas, so the following collections are interesting from a comparative viewpoint.

Jayapura (formerly known as Sukarnapura and Hollandia), on forested slope above Angkasapura Guest House, 300 m: 731231/1, *Nepenthes* sp. lying on ground, in shade, *Tp. (Rac.) filipes*, 2L; 731231/2, *Nepenthes* sp. just above ground level, *Tx. (Tox.) splendens*, 1L, *Tp. (Rac.)* sp. nr *mathesoni*, 1L; 731231/3, along forest path, fallen leaf, water clear, *Ur. diagonalis*?, 1L, *Ur. obscura*, 2L, 1P.

Jayapura, on forested slope above Angkasapura Guest House, nr logging camp: 731231/4, 300 m, biscuit box, water foul, *Cx. (Cux.) quinquefasciatus*, 1L; 731231/5, in coconut shell half, water foul, *Ar. (Arm.) breinli*, 6L; 731231/6, groove of fallen tree, water with organic material, *Cx. (Cux.) quinquefasciatus*, 5L, 4L.

Jayapura, Angkasapura Guest House, 250 m: 740101/4, indoors, resting on wall,

Cx. (Cux.) quinquefasciatus, 2 ♀, 1 ♂; 740103/1, captured biting indoors and resting indoors, *Tr. (Rac.)* sp.

Jayapura, along town water pipe, upstream the Anafri Val, nr source, 400 m: 740101/1, at edge of the Anafri Trail, in almost still water, among rocks, grassy edges, dead leaves, sunny, *Cx. (Cui.) pullus*, 1L; just below the highest dam, attacking or resting at 1500 h, *Tp. (Trp.) littlechildi*, 1 ♀, *Tp. (Rac.) fuscipleura*, 2 ♀; 740101/2, nr next dam downstream, small (40×5×4) rockhole, water yellowish, dead leaves on bottom, *Ae. (Stg.) albolineatus*, 1L; attacking or resting at 1500 h, *Tp. (Trp.) littlechildi*, 2 ♀, *Tp. (Rac.) fuscipleura*, 1 ♀.

Jayapura, on slope leading from Angkasapura to the sea, E: 740101/3, 200 m, below Angkasapur Guest House, at forest edge, pail, water shaded, *Ae. (Stg.) scutellaris*, 1L; 740104/1+1, 200 m, at abandoned logging camp in cleared forest, tin, water with organic material on bottom, *Ae. (Stg.) scutellaris*, 13L, *Tx. (Tox.) splendens*, 1L; 740104/2, along small torrent near Dock II, almost at sea level, clear shaded waters on flat meadow with grassy edges, *An. (Cel.) farauti*, 1 ♀, 1L, 1P; 740104/3, slightly downstream of /2, as above, but more thick grass, semifloating, in deep waters, *An. (Cel.) farauti*, 1 ♂, 10L, 1P, 4P; 740104/4, downstream of /3, *An. (Cel.) farauti*, 1 ♂, 10L, 1L, 3P, 1P; 740104/5, downstream of /4, sunlit and shallow, *An. (Cel.) farauti*, 4L.

Jayapura, Argapura Vill, sea level: 740102/1, seagoing canoe, water slightly polluted, *An. (Cel.) farauti*, 10L, 5P, *Cx. (Cux.) sitiens*, 1L, 2P; 740102/2, sardine tin, water clean, *Ae. (Stg.) scutellaris*, 3L, 1P; 740102/3, seagoing canoe, water slightly polluted, *An. (Cel.) farauti*, 17L, *Cx. (Cux.) sitiens*, 9L, 4P; 740102/9, *An. (Cel.) farauti*, 1L, *Cx. (Cux.) sitiens*, 1L, *Cx. (Cux.) annulirostris*, 4L, 3L, 5P; 740102/10, *An. (Cel.) farauti*, 3 ♀, 1L, 1L, 1P, 3P, *Cx. (Cux.) sitiens*, 1 ♀, 2P, 1P.

Jayapura, Hamadi Vill: 740102/4, pond, grassy edges, water dark brackish, wide swampy area, with peaty soil, covered by ferns, *An. (Cel.) farauti*, 4L, 1P; 740102/5, drains under the houses, water foul, with sewage debris, *Cx. (Cux.) quinquefasciatus*, 3L, 3L, 1P; 740102/11, *Cx. (Cux.) quinquefasciatus*, 2 ♀, 1 ♂, 3P; 740102/6, nr beach, in garden, flooded ditch, water foul, covered with vertical vegetation and pistia, with muddy bottom, *Cx. (Cux.) quinquefasciatus*, 4L, 4P, 1P, *Cx. (Lut.) halifaxii*, 1P; 740102/7, small pond, stone-walled, water clear, shaded, *An. (Cel.) farauti*, 8L, 3P, *An. (Cel.) koliensis*?, 1L.

Jayapura, Hamadi Pantai Vill: 740102/0, on beach, seagoing canoe, water clear, *Cx. (Cux.) quinquefasciatus*, 5L; 740102/8, in small estuary blocked by sandbars, grassy edges and floating debris, full sun, *An. (Cel.) farauti*, 2L.

Dasai Vill, W of Sentani Lakes: 740106/1, fishpond, grassy edges, water shallow and vertical vegetation, *An. (Cel.) farauti*, 10L, 1P, *Ur. solomonis*, 1L, *Cx. (Cui.) pullus*, 2L, *Ae. (Ver.) lineatus*, 3P; 740106/2, on marshy meadow, slowly moving shallow rivulets, small rainpans and seepage collections, *Cx. (Cux.) omani*, 1L; 740106/3, more extensive collections, grassy, sunlit, water still, *An. (Cel.) farauti*, 8L; 740106/4, meadows bordering ricefields, grassy edges and floating debris, open, sunlit collections,

An. (Cel.) farauti, 7L, *Ur. solomonis*, 1L, *Cx. (Cui.) pullus*, 1L; 740106/5, small sago forest, partially flooded, fairly large collections of still, yellowish waters, fully shaded, with submerged branches, and bottom with dead leaves, *An. (Cel.) farauti*, 1P, *Cx. (Lop.) fraudatrix*, 3L, 1P, *Ae. (Muc.) aurantius*, 1L, *Cx. (Lop.) christiani*, 1L; 740106/6, in sunlit collections, fringe of sago forest, abundant vertical vegetation, *Cx. (Lop.) christiani*, 7L.

Manokwari Town: 740212/1, backyard of Negara Hotel, taro (*Colocasia*) axil, water clear, *Ae. (Fin.) josephinae*, 5L; 740212/2, along road from hotel to Gunong (=Hill) Meja, 40 m, buttresses of Poinciana tree, small collection of water, organic material at bottom, sunshade, adults attacking at sunset, *Ae. (Stg.) albolineatus*, 20L, 1L, *Ae. (Stg.) scutellaris*, 4L, 2P, *Ar. (Arm.) breinli*, 3♀; 740212/3, 130 m, in inland forest, buttress of large tree, small rainwater collection, organic material at bottom, shade, adults attacking along nearby path at 1100 h, *Ae. (Stg.) albolineatus*, 8L, *Ar. (Arm.) breinli*, 1♀; 740212/4, in area of flooded forest, ground pool, temporary, shallow, shaded, abundant submerged and floating material, adults landing at 1100 h, *Ae. (Ver.) parasimilis*, 18L, *Ar. (Arm.) breinli*, 5♂.

2. *Highlands.* The Djajawidjaja Regency is at the northeastern end of the highlands of Irian Jaya. Collections were made mainly in 2 areas: the Balim Valley (main center Wamena) at about 1600 m altitude and the rural zones which are around the important centers of Kelila, Bokondini and Karubaga, all along the northern edge of the highlands, at altitudes between 1200 and 1800 m. The topography is that of high valleys, divided and surrounded by mountain chains rising to, and often above, 3000 m (and farther to above 4500 m). Rainfall (calculated as means for the period 1966–1971) is about 3000 mm/year, over $\frac{3}{5}$ of which occurs during the wet period, October–March. Average rainy days are 19 per month, with extremes in January (22) and August (10).

Wamena Town, Balim Val, 1600 m, house of medical officer, in garden: 740109/0, ditch, water slightly polluted, with dense vertical vegetation, shaded, *An. (Cel.) punctulatus* complex, 4L, unidentified, 1P; 740109/1, ditch, water polluted, shallow, floating material, green algae, sunlit, unidentified, 1L, 1P; 740115/5, resting indoors on window, *Ma. (Mnd.) uniformis*, 1♀; 740110/1, nr mosque, ditch, water clear, slowly floating, grassy edges, shaded, *An. (Cel.) punctulatus* complex, 4L; 740110/2, ditch, water almost still, *An. (Cel.) punctulatus* complex, 6L.

Wamena Airstrip, SE, 1600 m: 740111/3, wide flooded area, on peaty soil, covered with thick grass, ferns and reeds, water, shaded, adults attacking in open at 1500 h, *An. (Cel.) punctulatus* complex, 2♂, 8L, 1P, 2P, *Ae. (Och.) inexpectatus*, 2♀, *Ma. (Mnd.) uniformis*, 3♀; 740113/1, on rainy day, at 1000 h, *An. (Cel.) punctulatus* complex, 12L; 740111/4, open grassland, deep ditches, water clear, with abundant vertical and submerged grass, partially shaded, *Cx. (Cux.) bailyi*, 2L, 1P, Dixinae, 17L, 1P; 740111/5, as above but more sunlit, Dixinae, 5L, unidentified, 1L.

Wesagaput Vill, approx. 2 km E of Wamena, on the left bank of Balim Riv: 740109/3, ditches of sweet potato beds, water stagnant, open, shaded, with vertical vegetation

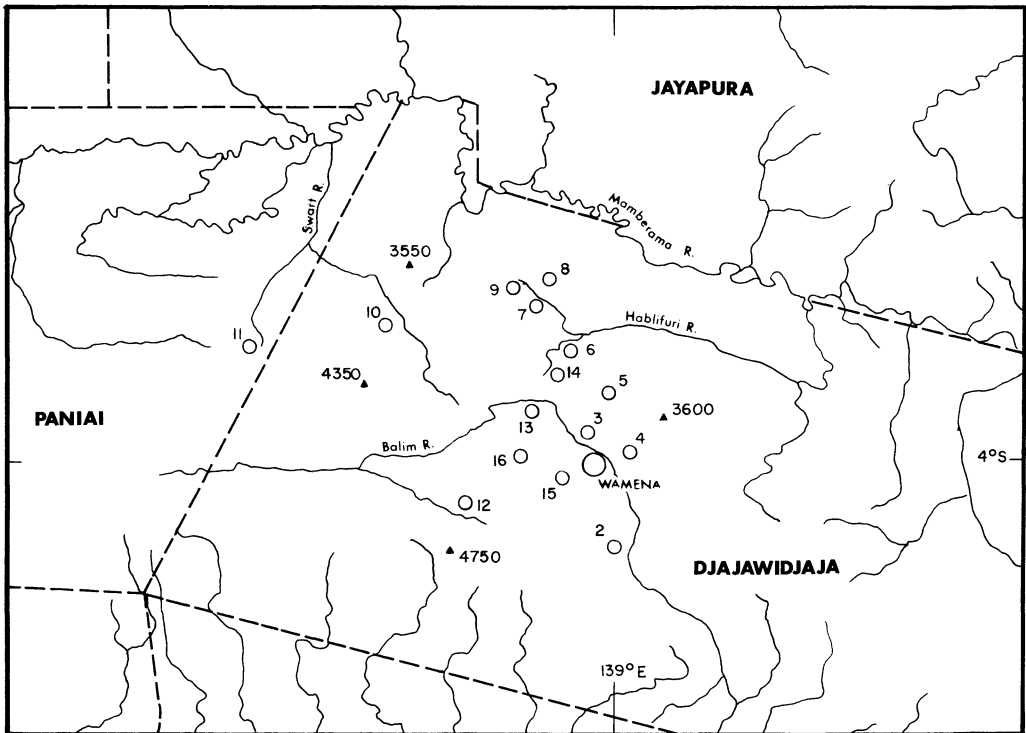


FIG. 2. Collection localities in Djajawidjaja and Paniai: 2 = Hitegima; 3 = Pikhe; 4 = Pugima; 5 = Jiwika; 6 = Kelila; 7 = Bokondini; 8 = Bilubaga; 9 = Abimbak; 10 = Karubaga; 11 = Mulia; 12 = Hebbema Lake; 13 = Pyramide; 14 = Tikka; 15 = Napua; 16 = Ibele.

and *Pistia*, *Cx. (Cux.) miraculosus*, 9L,7P; 740109/4, as above, but more open and less shaded, *Cx. (Cux.) miraculosus*, 3L; 740109/2, on right bank of Balim Riv, in open, shallow collection of clear water, with abundant vertical vegetation, *An. (Cel.) punctulatus* complex, 2L; 740109/6, big river canoe, water slightly polluted, with leaves at bottom, *An. (Cel.) punctulatus* complex, 5L, *Cx. (Cux.) miraculosus*, 5L,2P,1P; 740114/1, *An. (Cel.) punctulatus* complex, 3L, *Cx. (Cux.) miraculosus*, 4L,2P.

Minom Kato (along the path Wesagaput-Pugima), 1650 m, 740109/5, small rock-holes, under trees, water clear, cool, yellowish, leaves at bottom, adults attacking in the open at 1600 h, *Ae. (Fin.) notoscriptus*, 3♀,14L,2P, *Ae. (Och.) inexpectatus*, 3♀.

Pugima Vill, approx. 4 km E of Wamena, 1600 m: 740114/2, open ditch, water slightly muddy, sunny, with vertical vegetation, *Cx. (Cux.) bitaeniorhynchus*, 2L; 740114/3, same, but more vertical vegetation and green algae, *An. (Cel.) punctulatus* complex, 2L, *Cx. (Cux.) bitaeniorhynchus*, 1L, *Cx. (Cux.) pseudovishnui*, 6L; 740114/4, same, shallow, water clear, strongly shaded by vertical and horizontal grass, located in a depression of a grassy meadow, *An. (Cel.) punctulatus* complex, 7L, *Cx. (Cux.) miraculosus*, 1♀,1♂,9L,2P,2P; 740114/5, just N of same, on Bulnagait, a rocky slope,

at 1700 m; rockholes, approx. 30 cm diam, clear, fully sunlit, with organic material at bottom, *Ae. (Fin.) novalbitarsis*, 5♀, 7♂, 17L, 3P, 16P.

Megapura (=Sinata) Vill, approx. 7 km S of Wamena, W of Balim Riv, 1600 m: 740111/1, nr the school, in open collection in meadow, water clear, vertical vegetation, sunny, *An. (Cel.) punctulatus* complex, 5L; 740111/2, N of village, ditch, with limited vegetation, *An. (Cel.) punctulatus* complex, 9L, 1P, *Cx. (Cux.) pseudovishnui*, 4L.

Hitegima Mission, approx. 9 km S of Wamena, W of the Balim Riv, 1650 m: 740116/1, small creek above the mission, small, residual rainwater collection, Chironomidae, 1P; 740116/2, along small rivulet, among trees, limited stillwater lateral collection, adults attacking in the open at 0900 h, *Ae. (Och.) inexpectatus*, 3♀, Chironomidae, 1P; 740116/3, on grassy slope near mission, muddy, small ground pool, partially shaded, *Cx. (Cux.) quinquefasciatus*, 2L; 740116/4, on flat part of meadow above the mission, ground cooking pits lined with stone, water with dense cut tall grass, full sun, *Cx. (Cux.) quinquefasciatus*, 8L, 3P, *Cx. (Cux.) miraculosus*, 3L, 1L, 1P.

Hepoba Vill, along Hitegima-Wamena path, on right bank of the Balim Riv, 740116/5, ditch, water clear, still, grassy edges, full sun, *An. (Cel.) punctulatus* complex, 4L.

Napua Vill, approx. 5 km SW of Wamena, 1800 m: 740112/1, ground pool (15 m diam), bottom muddy, grassy, partially shaded, *Cx. (Cux.) pseudovishnui*, 3L; 740112/2, ground pool, water slightly muddy, full sun, *Cx. (Cux.) pseudovishnui*, 1♂, 2L, *Ae. (Fin.) novalbitarsis*, 1P; 740112/3, ground pool, large and shallow, sunny, *Cx. (Cux.) pseudovishnui*, 6L; 740112/4, along Wamena Trail, right effluent of Balim Riv, between Iluema Vill and Eiaima Vill, 1800 m, along a dry small torrent, residual pool among rocks, water still and sunny with abundant green algae, *Cx. (Cux.) solitarius*, 1♂, 14L, 3P, 1P; 740112/5, along path Napua-Wamena, just below Napua Bawa, 1750 m, in light forest, on muddy slope, small rain seepage, water clear, shaded, *Cx. (Cui.) bailyi*, 5L; 740112/6, same as /5, except 1730 m, along small creek with muddy bottom, shaded, margin water still with floating material, leaves at bottom, partial shade, adults attacking in the open, at 1500 h, *Cx. (Cui.) bailyi*, 2L, *Ae. (Fin.) notoscriptus*, 1♀ (biting); 740112/7, downstream of /5, 1700 m, margin, water reddish (clay), flowing slowly on muddy bottom, green algae, *Cx. (Cux.) solitarius*, 6L; 740112/8, nearing Wamena (nr 740110/2), ditch, water clean, gently flowing with abundant vertical vegetation and grassy edges, shaded, *An. (Cel.) punctulatus* complex, 6L.

Pikhe Vill, 4 km N of Wamena, on left bank of Balim Riv, 1600 m: 740115/1, ditch, water shallow, muddy, full sun, with abundant vegetation on edges, *An. (Cel.) punctulatus* complex, 7L, 1P, *Cx. (Cux.) miraculosus*, 5L, 1P; 740115/2, along rocky slope NE of the Mission, 1650 m, in small rockholes, water with organic material at bottom; partially shaded, *Ae. (Fin.) notoscriptus*, 4♀, 1♂, 13L, 1L, 18P, 6P, *Ae. (Fin.) novalbitarsis*, 3L, 3P; 740115/3, approx. 500 m downstream from the bridge on left bank of Balim Riv, in forest of *Casuarina* trees, water clear, still, with abundant submerged and floating material, and blue and gray algae, partially shaded, adults attacking in the open at noon, *An. (Cel.) punctulatus* complex, 1♀, 6L, 1L, 2P; *Ma. (Mnd.) uniformis*, 1♀,

Ae. (Och.) inexpectatus, 2♀; 740115/4, on path Pikhe-Hom Hom-Wamena, 1600 m, shallow rainpans, water slightly muddy with vertical vegetation, full sun, *An. (Cel.) punctulatus* complex, 10L, Dixinae, 1L, Chironomidae, 1P; 740117/1, along right bank of Balim Riv, 500 m inland W, 2 km N of Wamena, small rockhole, water slightly polluted, full sun, *Ae. (Fin.) novalbitarsis*, 22L, 1P.

Jiwika Vill, approx. 10 km N of Wamena, 1650 m, 740118/2, ground pool with grassy edges, *An. (Cel.) punctulatus* complex, 5L; 740118/3, small creek with gently flowing water, vertical and submerged vegetation and green algae, *An. (Cel.) punctulatus* complex, 1L, *Cx. (Cux.) bitaeniorhynchus*, 4L,5P; 740118/1, path in forest from Jiwika to the salt waters of Hilugaimo, 1750 m, small rockholes, water with limited organic material, partially shaded, *Ae. (Fin.) novalbitarsis*, 1♀,5L,5P, Chironomidae, 1P.

Bokondini area, path Bokondini-Marini, 740119/1, 1330 m at edge of small stream gently flowing, water clear, shaded, unidentified, 1P.

Bokondini Vill, lower end, 1250 m: 740119/2, abandoned fishponds, water turbid with vertical vegetation on the edges, full sun, *An. (Cel.) punctulatus* complex, 7L, *Cx. (Cux.) bitaeniorhynchus*, 2L,1P; 740126/1, lowest fishpond, water shallow with vertical vegetation, submerged dead grass, green algae, full sun, *An. (Cel.) punctulatus* complex, 21L,1P, *Cx. (Cux.) pseudovishnui*, 2L, *Ae. (Fin.)* sp., 1P, Ceratopogonidae, 1P.

Umaga Vill, 2 km E of Bokondini: 740120/4, large ground pool, water subturbid with abundant grass and reeds at edges, partially shaded, *An. (Cel.) punctulatus* complex, 3L, *Cx. (Cux.) squamosus*, 3♀,4♂,6L,6P,4P, unidentified, 1L; 740131/1, fishponds, water still, clear, with vertical vegetation, full sun, *An. (Cel.) punctulatus* complex, 1♀,1♂,3L,1P.

Nokobumbo Vill, on the slopes across the Boko Riv, N of Bokondini, 1350 m, 740121/1, small shallow ground pool, water muddy with some grass, full sun, *Cx. (Lop.) fraudatrix*?, 1♀,1L.

Boko Riv, at the bridge of the Bokondini-Bilubaga path, 1100 m, on the left bank, 740121/2, rockhole, water with some leaves at bottom, full sun, *Ae. (Fin.) novalbitarsis*, 2♂,14L,10P,3P, *Cx. (Cux.) quinquefasciatus*, 1♀.

Bilandaga Vill, on the right bank of the Boko Riv, 1200 m, 740123/2, indoor-resting at 900-1000 h, *An. (Cel.) punctulatus* complex, 20♀.

Abimbak Vill, approx. 3 km W of Bokondini, 1450 m: 740122/2, in taro (*Colocasia*) garden, small ground pool on muddy soil, with seeping water, slowly moving, *Cx. (Lop.) fraudatrix*, 5L; 740122/2, cooking pits, water yellowish, full sun, *Cx. (Cux.) pseudovishnui*, 1L; 740122/3, cooking pits, shallow water with dead leaves and sticks at bottom, *Cx. (Cux.) quinquefasciatus*, 21L,2P, *Cx. (Cux.) gelidus*, 6L,3P, *Cx. (Lut.) halifaxii*, 4L,2P, *Cx. (Cui.) bailyi*, 3L,3P, *Cx. (Cui.) fragilis*, 1L,1P; 740122/4, small swampy area, small pools, water clear, still with vertical vegetation and green algae, *Cx. (Cux.) pseudovishnui*, 4♀,3♂,19L,5P,5P.

Bilubaga Vill, N of Bokondini, across the Boko Riv, above Nokobumbo Vill, 1450 m, 740123/1, abandoned fishpond, water clear-turbid with abundant vertical vege-

tation at edges, full sun, adults indoor-resting, at 900–1000 h, *An. (Cel.) punctulatus* complex, 10♀, 12L, *Cx. (Cux.) omani*, 1L, 1P, *Cx. (Cux.) squamosus*, 5L, Ceratopogonidae, 1P.

Karubaga Mission, 20 km SE of Bokondini, above the Kuonda Riv, 1480 m, in garden, abandoned fishpond, water shallow with abundant submerged dried grass, dense vertical vegetation, bottom muddy, partially shaded: 740129/1, *Cx. (Cux.) pseudovishnui*, 1♀, 3♂, 7L, 10P, 5P, unidentified, 1P; 740129/2, *Cx. (Cux.) pseudovishnui*, 20L, *Cx. (Cux.) miraculosus*, 2L; 740129/3, *Cx. (Cux.) pseudovishnui*, 1L, *Cx. (Lut.) halifaxii*, 15L, *Ae. (Stg.)* sp., 1L.

Kelila Vill, 4 km W of Bokondini, W above the Kamba Riv, 1230 m, in front of dispensary: 740120/1, pond, water turbid with grassy edges and green algae, full sun, *An. (Cel.) punctulatus* complex, 3L, Ceratopogonidae, 1P; 740120/3, same as /1 with more vegetation and shade, *An. (Cel.) punctulatus* complex, 1L, Ceratopogonidae, 3♂♀, 2P, 2P; 740120/2, ditch, water shallow, still with submerged branches, *Cx. (Lop.) fraudatrix*, 1L, 1L, 1P; 740201/1, pond, as 740120/1, *An. (Cel.) punctulatus* complex, 4L, 4P, *Cx. (Cux.) pseudovishnui*, 3L, *Cx. (Cux.) omani*, 1L, *Cx. (Cux.) bitaeniorhynchus*, 1P, *Cx. (Cux.) squamosus*, 1L, Chironomidae, 2P.

Dibuggen Vill, SE of Kelila, 1500 m: 740202/1, small pond, water stagnant with mats of green algae, full sun, *Cx. (Cux.) squamosus*, 1L, 1P; 740202/2, small pond, water sub-turbid with vertical grass at edges, partial shade, *An. (Cel.) punctulatus* complex, 2L.

Worleme-Wirggelebur Trail, E of Dibuggen Vill, 1450 m, 740202/3, shallow large pool, water turbid with muddy bottom, grassy edges, floating and submerged vegetal material and debris, full sun, *An. (Cel.) punctulatus* complex, 16L, Psychodidae, 1L, Chironomidae, 1P.

Kelila-Pyramide Trail, on the watershed between Kelila and Tika villages, 2050 m: 740204/1, wide ditch, water clear with abundant vertical and submerged vegetation and dead leaves at bottom, *Cx. (Cux.) miraculosus*, 1L, *Cx. (Lop.) christiani*, 5L, 2P, *Cx. (Cux.) solitarius*, 1L; 740204/2+3, Tika Vill, 1850 m, ditch, water still with grassy edges, full sun, *An. (Cel.) punctulatus* complex, 36L, 5P; 740204/4, below Tika, along Nuu Riv, at 1700 m, large pool, margin of river, water still with muddy-sandy bottom and with floating leaves and debris, shaded, *Cx. (Cui.) bailyi*, 1L, *Ae. (Fin.) novalbitarsis*, 8L; 740204/5, 300 m downstream of /4, small rockhole, water shallow with vegetal decayed vegetation at bottom, full sun, *Ae. (Fin.) novalbitarsis*, 14L; 740204/6, in Balim Val, inland and N of the river, 1600 m, wide ground pool, flooded and covered with reeds, water shallow, semistagnant, on marshy soil, with debris and green algae, *An. (Cel.) punctulatus* complex, 3L, *Cx. (Cux.) bitaeniorhynchus*, 1L.

DISCUSSION

Anopheles (Celia) punctulatus complex

The 3 members of this complex, *An. (Cel.) punctulatus* Doenitz, *An. (Cel.) farauti* Laveran and *An. (Cel.) koliensis* Owen all occur in the Irian Jaya area and, as adults,

are easily distinguished. The larvae of *An. (Cel.) punctulatus* can usually be distinguished from those of the other 2 species; however, the larvae of *An. (Cel.) farauti* and *An. (Cel.) koliensis* are difficult to distinguish. In part, this is due to variation found in specimens collected in the Irian Jaya area (Bonne-Wepster & Swellengrebel 1953, Assem & Bonne-Wepster 1964). Therefore, the identifications of *An. (Cel.) farauti* larvae from the Jayapura and Lake Sentani areas are questionable, especially since many of the larval specimens were early instars.

Lee (1946) was the first to report the "intermediate type" of *An. (Cel.) farauti* from high altitudes in New Guinea (1900 m, Mt Hagen area, Papua New Guinea). Lee noted that the specimens "were far larger than is at all common in specimens taken from coastal areas." Bonne-Wepster (1948) confirmed the "distinctly larger size" typical of specimens of *An. (Cel.) farauti* and *An. (Cel.) koliensis* collected by Toxopeus in the western highlands in 1939. She also revised the upper altitudinal limits of both species: 2250 m (Ibele Camp) for *An. (Cel.) farauti* and 1700 m (Balim Camp) for *An. (Cel.) koliensis*; and she stated that *An. (Cel.) punctulatus* was restricted to coastal areas. These altitudinal limits were confirmed for *An. (Cel.) farauti* and *An. (Cel.) koliensis* by Assem & Dijk (1958), who stated that these specimens were also larger and "slightly—but consistently—different from the typical lowland *An. farauti*." They mentioned that "the typical *An. farauti* might be lacking in mountainous regions, if there is a real difference between specimens from the lowlands and the mountains." The larger size of the highland specimens was reported also by Bonne-Wepster & Swellengrebel (1953) and Assem & Bonne-Wepster (1964).

Since we were unable to obtain a significant number of individual rearings and examination of larval and pupal specimens showed variations in the relevant morphological characters, it was considered preferable to identify the immature stages collected in the highlands as *An. (Cel.) punctulatus* complex. More thorough field collections, especially individual and progeny rearings and genetic studies, are needed to clarify these interspecific relationships.

Several larvae of *An. (Cel.) punctulatus* complex were collected in a swampy area near Wamena (740111/3) at 1600 m. Two of these larvae were found to be parasitized by *Coelomomyces lairdi* Maffi & Nolan (1977). This is the first report of *Coelomomyces* from Irian Jaya.

***Aedes (Edwardsaedes) imprimens* (Walker)**

One larval specimen of this species was found on Biak I in a shaded pool with floating and submerged vegetation. This species was previously reported from Manokwari, Kaimana and Hollandia (Jayapura) (Assem & Bonne-Wepster 1964).

***Aedes (Finlaya) josephinae* Marks**

This species belongs to the *Aedes (Finlaya) kochi* group which is being revised by E. N. Marks & N. Dobrotworsky. Identifications should, therefore, be considered tentative. The larvae collected in a *Colocasia* axil at Manokwari Town correspond to

those described by Assem & Bonne-Wepster (1964), who reported this species from Irian Jaya.

Aedes (Finlaya) notoscriptus (Skuse)

Many larvae and pupae of this species were collected from rockholes in the Balim Valley, at altitudes above 1600 m, and some adults reared, or captured attacking in daytime, in the open. Except for 1 report from Ayamaru Lake in the Kepala Burung area, *Ae. notoscriptus* has been reported primarily from lowland areas (Assem & Bonne-Wepster 1964).

Aedes (Finlaya) novalbitarsis King & Hoogstraal

Immature specimens were collected from rockholes or along streams both in the Balim Valley and around Bokondini at altitudes between 1100 and 1700 m. Though common and widespread in the lowlands, *Ae. novalbitarsis* has also been reported from altitudes above 2000 m (Assem & Bonne-Wepster 1964).

Aedes (Mucidus) aurantius (Theobald)

The single larva collected in a flooded sago forest near the Sentani Lakes was associated with *An. (Cel.) farauti*, *Cx. (Lop.) fraudatrix* and *Cx. (Lop.) christiani*.

Aedes (Ochlerotatus) inexpectatus Bonne-Wepster

Adults of this species were collected biting in the open at noon and 1500–1600 h in the Balim Valley.

Aedes (Stegomyia) aegypti (Linnaeus)

Larvae of *Ae. aegypti* were collected in a 55-gallon [.946 litre] drum near a fisherman's hut on Biak I. The distribution of this species was previously restricted to some localities of Kepala Burung and of Kaimana District, at the western end of New Guinea, and the species was absent from all larger settlements (Assem & Bonne-Wepster 1964).

Aedes (Stegomyia) albolineatus (Theobald)

Our collections were from rockholes and tree buttresses in the Jayapura and Manokwari areas and confirm the bionomics and behavior of this species as given by Assem & Bonne-Wepster (1964). The larvae fall into type A (variant) and type D by morphological characters, and both types occur in the same breeding sites (Knight & Rozeboom 1946). Associated species in the tree buttresses were *Ae. (Stg.) scutellaris* and *Ar. (Arm.) breinli*.

Aedes (Stegomyia) paullusi Stone & Farner

This species is known to be present on Ambon I and, in Malaysia, has been found

breeding in small artificial containers (Huang 1972). Our collection was from an artificial container on Ambon.

Aedes (Stegomyia) scutellaris (Walker)

The presence of the few specimens collected (biting catches and larval collections in the coastal areas) and their bionomics and behavior are in accordance with previous records (Bonne-Wepster 1954, Assem & Bonne-Wepster 1964).

Aedes (Verrallina) lineatus (Taylor)

This species is restricted to the lowlands in Irian Jaya. Our collections of pupae from a fishpond W of Sentani Lakes correspond with previous records (Assem & Bonne-Wepster 1964). Associated species were *An. (Cel.) farauti*, *Ur. solomonis*, and *Cx. (Cui.) pullus*.

Aedes (Verrallina) parasimilis King and Hoogstraal

Larva and pupa of *Ae. parasimilis* are apparently indistinguishable from those of *Aedes (Verrallina) similis* (Theobald), according to Huang (1968). We consider, however, our specimens to be *Ae. parasimilis*, since this is the only one of the 2 species reported as present in Irian Jaya by Assem & Bonne-Wepster (1964). Our single collection was in the coastal area, near Manokwari.

Armigeres (Armigeres) breinli (Taylor)

Our larval collections (artificial containers) and adult biting catches (1100 h and sunset) were from Biak I and Jayapura and agree with records reported by Assem & Bonne-Wepster (1964).

Armigeres (Armigeres) malayi (Theobald)

The single larval collection from Ambon I (coconut husk) corresponds with records reported by Steffan (1968).

Armigeres (Armigeres) papuensis Peters

Adults were collected on Biak I. As reported by Steffan (1968), the specimens from Hollandia (Jayapura) identified as *Ar. obturbans* (Walker) by King & Hoogstraal and referred to in Knight, Bohart & Bohart (1944) were *Ar. papuensis*.

Culex (Culex) annulirostris Skuse

This species was found only once near Jayapura, in rainwater in a seagoing canoe pulled ashore, associated with *An. (Cel.) farauti* and *Cx. (Cux.) sitiens*.

Culex (Culex) bitaeniorhynchus Giles

According to the localities given by Assem & Bonne-Wepster (1964), this species has been recorded only in coastal areas. We found it present both in Balim Valley and in Bokondini.

Culex (Culex) gelidus Theobald

This species was not previously reported from Irian Jaya. Its distribution is given as "Greater and Lesser Sunda Islands and a few surrounding islands" by Bonne-Wepster (1954), and Assem & Bonne-Wepster (1964) state that *Cx. gelidus* is "not occurring in New Guinea." More recent statements of its presence in "New Guinea" (Steffan 1966, Bram 1967) do not necessarily imply its presence in Irian Jaya. Our collections could, therefore, possibly be a new record for the area visited.

Though the adults of *Cx. gelidus* appear to be very similar to those of *Cx. (Cux.) whitmorei* (Giles), the 2 species are said to be distinctly different at the larval stage (Assem & Bonne-Wepster 1964, Bram 1967).

We found *Cx. gelidus* once in the highlands at 1450 m (Abimbak), associated with *Cx. (Cux.) quinquefasciatus*, *Cx. (Lut.) halifaxii*, *Cx. (Cui.) bailyi* and *Cx. (Cui.) fragilis*. There are previous reports of *Cx. gelidus* at similar altitudes in Thailand (Bram 1967).

Culex (Culex) miraculosus Bonne-Wepster

This was considered a typical highland species, and has been reported from the Anggi Lakes (Kepala Burung), Enarotali—where it is common—and native villages near Homejo (Central Highlands), between 1800 and 2300 m. We collected it along the Balim Valley, in breeding sites similar (artificial pools and ditches) to those reported by Assem & Bonne-Wepster (1964) and once in a canoe filled with rainwater; it was often associated with immature stages of the *An. (Cel.) punctulatus* complex.

Culex (Culex) omani Belkin

The specimens were collected in the highlands at Kelila and Bilubaga (1230–1450 m) and in the lowlands near Lake Sentani. This would be a new record since this species previously was reported only from the Solomon Is. Belkin (1962) indicates that it is occasionally found with *Cx. squamosus*. In our collections, it was associated with the *An. (Cel.) punctulatus* complex, *Cx. (Cux.) squamosus*, *Cx. (Cux.) pseudovishnui* and *Cx. (Cux.) bitaeniorhynchus*.

Culex (Culex) pseudovishnui Colless

This is a common species in the highlands; we collected it in the Balim Valley as high as 1880 m (Napua), in the Bokondini area and in Karubaga. Bionomics of the larvae are as reported by Bonne-Wepster (1954), under *Cx. vishnui*. The larvae collected consistently show a bifid 4-P and only 1 pair of lateral siphonal tufts; they are, therefore, similar to *Cx. neovishnui* described by Lien (1968), which Sirivanakarn (1976) considers synonymous with *Cx. pseudovishnui*.

Culex (Culex) quinquefasciatus Say

This species, widely distributed in New Guinea, is said to have reached the highlands just before 1964 (Assem & Bonne-Wepster 1964). We collected it in the lowlands

(around Jayapura) and in the highlands (Hitegima in the Balim Valley, Abimbak in Bokondini area).

Culex (Culex) sitiens Wiedemann

Collected in seagoing canoes pulled ashore, filled with rainwater, polluted, associated with *An. farauti*.

Culex (Culex) solitarius Bonne-Wepster

The immature stages—from which a ♀ was reared—were collected from still and slow-flowing waters, with vertical, floating, and submerged vegetation and algae, at altitudes from 1700 to 2050 m. This is consistent with former records (Bonne-Wepster 1954).

Culex (Culex) squamosus (Taylor)

This species was reported to be widespread but no highland localities were listed (Assem & Bonne-Wepster 1964). We found this species up to 1600 m altitude, in the Balim Valley and in Bokondini and Kelila areas, in its typical breeding sites (fishponds, mostly out of use, with vertical and floating vegetation, and mats of algae).

Culex (Culiciomyia) bailyi Barraud

Specimens that we collected, on a few occasions, in the highlands appear closest to *Cx. bailyi*, an Oriental species. In Ceylon, *Cx. bailyi* has been collected at a height of 5600 ft [1700 m] (Bram 1967).

This species has never previously been reported from this area. We found it on the slopes of the Balim Valley, up to 1750 m, and in the area of Bokondini at Abimbak (1450 m) in cooking pits and associated with *Cx. (Cux.) gelidus*, *Cx. (Cux.) quinquefasciatus*, *Cx. (Cui.) fragilis* and *Cx. (Lut.) halifaxii*, and in a ground pool associated with *Ae. (Fin.) novalbitarsis*.

Culex (Culiciomyia) fragilis Ludlow

The presence of this species at Abimbak (1450 m alt.) is not surprising, since it was reported from Wissel Lakes, at 1800 m (Assem & Bonne-Wepster 1964).

Culex (Culiciomyia) pullus Theobald

This is one of the most common mosquito species in New Guinea (Assem & Bonne-Wepster 1964).

Culex (Lophoceraomyia) christiani Colless

This species is common in the highlands of Papua New Guinea and was collected there at altitudes between 1200 and 1700 m. In addition to specimens collected in the Balim Valley at about 1600 m, 1 specimen found in the coastal area, near Sentani Lake, is near *Cx. christiani*.

Culex (Lophoceraomyia) fraudatrix (Theobald)

In the lowlands, this species was collected in the Sentani Lake area, at the margin of flooded forest; in the highlands, it was found in the Kelila and Bokondini areas, between 1250 and 1450 m, in small pools and puddles shaded by grasses. Previous records from Irian Jaya indicate the species was not found above 300 m (Assem 1961).

Culex (Lophoceraomyia) kuhnsi King & Hoogstraal

Larvae of this species were collected from an artificial container on Biak I and were associated with *Ar. (Arm.) breinli* and *Ar. (Arm.) papuensis*.

Culex (Lutzia) halifaxii Theobald

This species is reported as widespread in New Guinea (Assem & Bonne-Wepster 1964) and we collected larvae, in typical breeding sites (semipermanent ground pools), both in the lowlands near Jayapura and the highlands in Bokondini and Karubaga areas. The species was associated with *Cx. quinquefasciatus* and *Cx. pseudo-vishnui* and, in 1 case, with *Cx. (Lop.) bailyi* and *Cx. (Lop.) christiani*.

Mansonia (Mansoniodes) uniformis (Theobald)

The few adults were captured either attacking in swampy areas, in shade, or resting indoors. This species has been reported in the past from the Balim Valley up to 2100 m (Assem & Bonne-Wepster 1964).

Tripteroides (Rachisoura) filipes (Walker)

This species was collected by Assem (1959) from *Nepenthes* pitchers associated with *Tx. splendens* on the grassy slopes of the foothills of the Cyclops Mts at Ifar. We collected it from *Nepenthes* near Jayapura.

Tripteroides (Rachisoura) fuscipleura Lee

We collected this species from the same area in which the specimens described by Lee were collected.

Tripteroides (Rachisoura) sp. nr mathesoni Belkin

One larva was collected from *Nepenthes* near Jayapura and was associated with *Tx. (Tox.) splendens*.

Tripteroides (Tripteroides) littlechildi (Edwards)

A few females (landing or resting) were collected at 1300 h near Jayapura. This species was previously known only from the southern portion of Papua New Guinea.

Uranotaenia (Pseudoficalbia) diagonalis? Brug

One larva tentatively identified as *Ur. diagonalis* ? was collected from a fallen leaf

near Jayapura. It was associated with another larva fitting the description of *Ur. (Pfc.) obscura* Edwards.

Uranotaenia (Pseudoficalbia) obscura Edwards

This species was collected at Biak I in a fallen leaf and near Jayapura (see *Ur. diagonalis*).

Uranotaenia (Uranotaenia) solomonis ? Belkin

Larvae tentatively identified as *Ur. solomonis* were collected in ground pools in the Jayapura area.

Toxorhynchites (Toxorhynchites) splendens Wiedemann

Larvae of *Tx. splendens* were collected near Jayapura in *Nepenthes* associated with *Tp. sp.* near *mathesoni* and in an artificial container associated with *Ae. scutellaris*.

LIST OF SPECIES

- An. (Cel.) farauti*: 740102/1, /3-4, /7-8, /9-10; 740104/2-5; 740106/1, /3-5.
An. (Cel.) koliensis ? : 740102/7.
An. (Cel.) punctulatus complex: 740109/0, /2, /6; 740110/1-2; 740111/1-3; 740112/8; 740113/1; 740114/1, /3-4; 740115/1, /3-4; 740116/5; 740118/2-3; 740119/2; 740120/1, /3-4; 740123/1-2; 740126/1; 740131/1; 740201/1; 740202/2-3; 740204/2-3, /6.
Ae. (Edw.) imprimens: 740210/3.
Ae. (Fin.) josephinae: 740212/1.
Ae. (Fin.) notoscriptus: 740109/5; 740112/6; 740115/2.
Ae. (Fin.) novalbitarsis: 740112/2; 740114/5; 740115/2; 740117/1; 740118/1; 740121/2; 740204/4-5.
Ae. (Fin.) sp.: 740126/1.
Ae. (Mus.) aurantius: 740106/5.
Ae. (Och.) inexpectatus: 740109/5; 740111/3; 740115/3; 740116/2.
Ae. (Stg.) aegypti: 731229/3.
Ae. (Stg.) albolineatus: 740101/2; 740212/2-3.
Ae. (Stg.) paullusi: 731225/2.
Ae. (Stg.) scutellaris: 731229/1-2; 740101/3; 740102/2; 740104/1; 740212/2; 740213/1.
Ae. (Stg.) sp.: 740129/3.
Ae. (Ver.) lineatus: 740106/1.
Ae. (Ver.) parasimilis: 740212/4.
Ar. (Arm.) breinli: 731231/5; 740210/2; 740212/2-4.
Ar. (Arm.) malayi: 731225/1.
Ar. (Arm.) papuensis: 740210/2.
Cx. (Cux.) annulirostris: 740102/9.

- Cx. (Cux.) bailyi*: 740111/4; 740112/5–6; 740122/3; 740204/4.
Cx. (Cux.) bitaeniorhynchus: 740114/2–3; 740118/3; 740119/2; 740201/1; 740204/6.
Cx. (Cux.) gelidus: 740122/3.
Cx. (Cux.) inexpectatus: 740111/3; 740116/2.
Cx. (Cux.) miraculosus: 740109/3–4, /6; 740114/1, /4; 740115/1; 740116/4; 740129/2; 740204/1.
Cx. (Cux.) omani: 740106/2; 740120/1; 740123/1.
Cx. (Cux.) pseudovishnui: 740111/2; 740112/1–3; 740114/3; 740122/2, /4; 740126/1; 740129/1–3; 740201/1.
Cx. (Cux.) quinquefasciatus: 731231/4, /6; 740101/4; 740102/0, /5–6, /11; 740116/3–4; 740121/2; 740122/3.
Cx. (Cux.) sitiens: 740102/1, /3, /9–10.
Cx. (Cux.) solitarius: 740112/4, /7; 740204/1.
Cx. (Cux.) squamosus: 740120/4; 740123/1; 740201/1; 740202/1.
Cx. (Cui.) fragilis: 740122/3.
Cx. (Cui.) pullus: 740101/1; 740106/1, /4.
Cx. (Lop.) christiani: 740106/5–6; 740204/1.
Cx. (Lop.) fraudatrix: 740106/5; 740120/2; 740121/1; 740122/1.
Cx. (Lop.) kuhnsi: 740210/2.
Cx. (Lut.) halifaxi: 740102/6; 740122/3; 740129/3.
Ma. (Mnd.) uniformis: 740111/3; 740115/3, /5.
Tp. (Rac.) filipes: 731231/1.
Tp. (Rac.) fuscipleura: 740101/1–2.
Tp. (Rac.) sp. nr *mathesoni*: 731231/2.
Tp. (Rac.) sp.: 740103/1.
Tp. (Trp.) littlechildi: 740101/1–2.
Ur. diagonalis ? : 731231/3.
Ur. obscura: 731231/3; 740210/1.
Ur. solomonis: 740106/1, /4.
Tx. (Tox.) splendens: 731231/2; 740104/1.

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