

THE MOSQUITOES OF THE BANKS AND TORRES ISLAND GROUPS OF THE SOUTH PACIFIC (DIPTERA: CULICIDAE)

By **Mario Maffi¹** and **Brian Taylor²**

Abstract: In August 1971 a total of 1003 specimens of Culicidae were collected from 2 little known island groups of the New Hebrides, the Banks and the Torres, 637 (39 ♀♀, 12 ♂♂, 148 P, 13 p, 419 L, 6 1) and 366 (46 ♀♀, 3 ♂♂, 73 P, 13 p, 231 L), respectively. Of 9 species of Culicidae previously recorded, 6 are confirmed. 3 species are added: *Culex (Cux.) banksensis*, *Culex (Cux.) sitiens*, *Culex (Eum.) femineus*. The distribution (considerably wider than previously recorded) and the bionomics of the species are presented.

Located at the northern end of the territory of the New Hebrides Condominium, and administratively part of it, 2 island groups, the Banks and the Torres, rise from the New Hebrides submarine ridge and are dispersed over a wide area of the Southwest Pacific: 13°04' to 14°28' S, and 166°30' to 168°04' E. The Banks, the southern of the 2 groups, are more scattered and consist of 2 major islands (Gaua, Vanua Lava) and 6 minor islands (Merelava, Merig, Mota, Motalava, Parapara, Rowa) with a total land area of approximately 750 km². The Torres group is more compact and consists of 5 small islands (Toga, Loh, Tegua, Metoma, Hiu) with less than 100 km² of land area. There are a few off-shore islets. Except for the reef island of Rowa, the islands are of volcanic origin; however, on some of the smaller islands, particularly in the Torres, there are terraces of coral limestone.

The climate is typical of islands within the tradewinds belt, with prevailing southeasterly winds and alternating wet (October–May) and dry seasons. During the peak of the wet season, tropical cyclones are not uncommon. Rainfall, although variable, is high. However, because of the differences between the islands' morphologies, the main islands—which receive the highest rainfall (4000 mm/year at Sola, Vanua Lava)—are well watered, whereas on some of the smaller islands, and in particular in the Torres, there can be a marked or total absence of ground waters during the dry season. In general there is abundant natural vegetation; coconuts and subsistence crops are common where there is human influence.

The last census (1967) counted 3274 persons on the Banks and 200 on the Torres, all Melanesians.

Except for plane schedules twice a week between Espiritu Santo and Vanua Lava, which started in 1974, contacts with the rest of the Condominium are limited to infrequent visits by small administrative and missionary ships from Espiritu Santo.

1. Present address: 16030 Cavi (Genova), Italy.

2. Present address: 13 Ruskin Gardens, Kenton, Harrow, Middlesex, HA3 9PX, U.K.

COLLECTIONS

Prior to 1962 (Belkin 1962), only a few collections of mosquitoes had been reported from the Banks and Torres. Nine species had been recorded on 4 of the Banks Islands: *Anopheles (Cellia) farauti*, *Culex (Culex) quinquefasciatus*, *Culex (Culex) annulirostris*, *Aedes (Stegomyia) aobae*, *Aedes (Stegomyia) hebrideus*, *Aedes (Stegomyia)* sp. Vanua Lava form, and *Tripteroides (Rachionotomyia) melanesiensis* on Vanua Lava; *Anopheles (Cellia) farauti* and *Aedes (Verrallina) lineatus* on Pakea islet, off-shore of Vanua Lava; *Anopheles (Cellia) farauti* on Gaua; and *Culex (Culex) pacificus* on Merelava. A single species, *Aedes (Stegomyia) hebrideus*, from Toga had been recorded from the Torres. To our knowledge, this was still the situation as of August 1971.

The collections here reported were made during a malarimetric survey carried out by one of us (M. M.)³ in the Banks and Torres from 6 to 18 August 1971. All islands were visited except Merig, Tegua, Rowa and Metoma; heavy seas made landing impossible on the first; the others are considered uninhabited and were not included in the malaria study. Some stops were very brief (Maffi & Ratard 1974) and because the visits were primarily malarimetric, collections of the mosquito fauna were casual and rearing of adults was rarely carried out. Consequently, most of the specimens available are immature stages. The material was preserved in pill boxes (adults) and in MacGregor solution, and forwarded to the Bishop Museum, Honolulu, USA, for mounting and pinning. Before the end of 1972 preliminary identifications were done, which permitted a conspectus report (Maffi & Ratard 1974: 6). A single additional collection in 1975 (751011/1) yielded a few larvae and 1 female from a pupal rearing. All available material was reexamined recently.

All specimens are deposited in the Bishop Museum. Each collection is identified by a code number for the date, followed by the serial number of the specific collection during that day. E.g.: 710815/1. . . 2, identifies collection 1. . . 2, etc. made during 15 August 1971. Symbols (♀, ♂, L, l, P, p) are as in Belkin (1962).

Results are presented island-by-island, with a short description of each island followed by results of the collections, given chronologically.

BANKS ISLANDS

Merelava (visited 15 August 1971). This is a steep-sided volcanic cone, which rises abruptly to 833 m, and has a base less than 3 km across. It has no landing beaches. The villages are along a circular path running 150 m above sea level. The population is 812 (dens. 135/km²). Gardens and coconut groves cover the steep slopes.

Code 710815. At landing place, on the rocks of the western coast, below Tasmate Vill.: /1 & /7, in rainwater, brackish, highly polluted, filling fissures on basalt, *Cx. (Cux.) sitiens*, 1 ♀, 5 ♂♂, 16 L, 18 P, 5 p; /6, in rainwater, slightly brackish, in dugout canoe, *Cx. sitiens*, 2 L, *Ae. hebrideus*, 19 L; /2 near Copra storehouse, in rusty rainwater in drum,

3. As World Health Organization (Malaria) short term consultant.

Cx. pacificus, 5 L, 1 P, *Ae. hebrideus*, 1 L. Along island's circular path, between Tasmate and Auta Villages: /3, in small rainwater collection in step on coconut palm, in shade, *Tp. melanesiensis*, 4 L; /4, along steep gully, in rock pools on dry turrent, sunlit, leaves at bottom, *Ae. hebrideus*, 2 ♀♀ (rubbed), 1 L, 4 P, 2 p; /5, in cylindrical stump hole on mango tree, organic material at bottom, *Tp. melanesiensis*, 1 L.

Gaua (*Santa Maria, Lakon*) (visited 16–18 August 1971). Originally a low-angled complex volcanic cone, Gaua is a major island (336 km²). Roughly circular in shape, hilly-mountainous, Gaua has at the center, at 366 m, a crescent-shaped lake. There are hot springs on the island. The population is 432 (dens. 1.3 km²); people evacuated in 1973 because of impending volcanic activities have returned to the original villages, which are concentrated in 2 coastal areas, one in the northeast, the other in the southwest.

Code 710816. Northeastern part, coastal: /1 & /2, Namasari Vill., in clear rainwater in 170-liter drum, *Ae. hebrideus*, 3 L; /3, along Namasari-Lempot path, in clear rainwater, sunlit, in basin-shaped lava stone, *Cx. (Cux.) banksensis*, 2 L; /4, as above, in cylindrical hole at main branching of *Artocarpus* sp. tree, organic material at bottom, sun-shade, *Cx. banksensis*, 14 L, *Tp. melanesiensis*, 7 L, 1 P.

Code 710817. Southwestern part, coastal: /0, Ontar Vill., day-resting, indoors, *An. farauti*, 7 ♀♀; /3, along rocky dry bed of Qereton T., in rock pools with tufts of grass and decomposing leaves, sun-shade, *An. farauti*, 1 L, *Cx. annulirostris*, 4 L; /4, as above, same characteristics but more shaded, *Cx. annulirostris*, 5 L, *Cx. (Eum.) femineus*, 3 L, 10 P. Along Ontar-Qeteqavit path: /1, retrodunal swampy valley of Limatress R, in coastal light forest, with wild taro and floating material, sun-shade, *An. farauti*, 5 L, *Cx. annulirostris*, 3 L; /2, in open coastal woods, in treehole on *Laportea* sp., organic material at bottom, in shade, *Cx. banksensis*, 6 L, 2 P, *Ae. aobae*, 2 L, *Tp. melanesiensis*, 1 ♀ (reared), 28 L, 1 p; /5, near Doleb Vill., at the inner limit of beach, in small residual rainwater collection along drying creek, among rocks, in shade, *Cx. femineus*, 1 ♂ (reared), 2 P.

Code 710818. Qeteqavit Vill.: /9, resting in houses, at noon, *An. farauti*, 1 ♀, *Ae. hebrideus*, 12 ♀♀. Along the dry bed of nearby torrent, upstream: /1, in small lateral rock pools, with decomposing leaves, sun-shade, *Cx. annulirostris*, 8 L; /2, as above, in smaller collections, *Cx. annulirostris*, 14 P; /3, as above, in open rock pools, sunlit, *Cx. annulirostris*, 6 L; /4, in small collections on sandy-rocky ground, *Cx. annulirostris*, 1 L; /5, in large, shallow collections on flat rocks, in forest shade, *Cx. femineus*, 7 L, 1 l, 9 P; /6, on forested bank, in small treehole full of clear rainwater, organic material at bottom, *Cx. banksensis*, 23 L, 1 P, *Cx. annulirostris*, 1 L, *Ae. aobae*, 1 ♀ (attacking), 1 ♂ (resting), *Tp. melanesiensis*, 1 ♀ (reared), 12 L, 2 P, 1 p; /7, near village, in rainwater collection on coconut palm stump, *Cx. banksensis*, 7 L, 6 P, *Tp. melanesiensis*, 1 ♀ (resting), 4 P; /8, along dry bed of torrent, downstream, near rocks overhanging the beach, *Ae. aobae*, 1 ♀, attacking at 4 p.m.

Vanua Lava (visited 12–13 August 1971, and 11 October 1975). This is the 2nd major island (311 km²). It is of volcanic origin, and presents 2 rugged mountain ranges which rise above 900 m. On the western side the coast is rocky and abrupt; on the eastern side,

however, there is extensive flatland. Off the end of this coast, southeast, is the islet of Pakea. Most of the population (740, dens. 2.4/km²) is settled in the southern 1/2 of the island.

Code 710812. Southwestern quarter: /1, path between Vurias and Vetiboso Villages, near Vetiboso (approx. 100 m above sea), in rainwater collection in wide, cylindrical hole on stump of mango tree, abundant organic material at bottom, sun-shade, *Cx. banksensis*, 14 L, 1 p, *Ae. aobae*, 1 ♀ (reared, damaged), *Tp. melanesiensis*, 13 L, 6 P; /2, near Vetiboso, in 1/2 coconut shell, with foul contents, *Tp. melanesiensis*, 15 L, 1 P; /3, along path Vetiboso-Kerepeta Vill., in coconut plantation, in 1/2 coconut husk, *Ae. hebrideus*, 6 L; /4, as above, in swampy area at the crossing of the Darahiru Stream, in grassy edges of fast clear waters, *An. farauti*, 1 ♀ (reared), 1 p; /5, in small collection in step on coconut trunk, *Tp. melanesiensis*, 3 L, 2 P; /6, at the crossing of the Pedodol R, in rock pools on boulders, leaves at bottom, sun-shade, *Cx. femineus*, 5 L, 1 l, 11 P.

Code 710813. East coast, southern part: /1, Sola Plantation, in rat-gnawed coconut husk, slightly foul contents, *Ae. hebrideus*, 6 L, *Tp. melanesiensis*, 1 L; /3, as above, in clear rainwater in *Tridacna* shell, *Ae. hebrideus*, 1 L; /2, Sola, French Public School, playgrounds, in treehole on short stump, *Cx. banksensis*, 11 L, 1 P, *Ae. hebrideus*, 5 L, 4 P, *Tp. melanesiensis*, 7 L, 4 P; /5, Port Patteson Fisher Young School, compounds, in rainwater in 170-liter drum, *Ae. hebrideus*, 1 ♀ (reared), 12 L, 1 P; /4, just inland of preceding, in swampy area with fallen trees, in open, shallow collections of rain, with floating and submerged debris and mats of algae, *An. farauti*, 3 L, *Cx. annulirostris*, 1 L.

Code 751011. /1, at same breeding site as 710812/1, *Cx. banksensis*, 1 ♀ (reared), 5 L, 1 p (damaged). Collector: E. Wurvegqeat, National Malaria Service.

Mota (visited 14 August 1971). This is a small (10 km²), circular island surrounded by a narrow coastal peripheral plain of raised coral limestone, with a central sugarloaf-shaped peak (141 m). The population is 269 (dens. 27 km²).

Code 710814. /1, along path between Lotawan and Napqoi (western coast), in shallow rainpans on muddy soil, with floating debris, in sun-shade, *An. farauti*, 4 L, *Cx. annulirostris*, 12 L, 4 P. /2, near Tugetap Vill. (northern coast), in rat-gnawed coconut husk with foul contents, *Cx. banksensis*, 5 L, *Ae. hebrideus*, 1 L. /3, near Tasmate Vill. (southeastern coast), as in /1, *An. farauti*, 4 L, 2 P, *Cx. annulirostris*, 3 P. /4, along road between Veverau and Lotawan Vill. (southern coast), on dry bed of a creek, in a small collection among rocks, *Cx. annulirostris*, 1 L, *Cx. femineus*, 5 L. /5, near Lotawan Vill., at landing point, in small pit-like collections on coral limestone, sunlit, with brackish water, leaves at bottom, *Cx. sitiens*, 2 L, 3 P.

Motalava (visited 6-7 August 1971). This is an island of roughly rectangular shape (34 km²), with a central hilly spine rising to 411 m. At the southwestern end is a flat, narrow peninsula, where most of the villages are located; off of it is the islet of Rah. The population is 816 (dens. 24/km²).

Code 710806. Along the path which follows the uninhabited northwestern coast:

/1, in coconut plantation, in rat-gnawed coconut husk, foul contents, *Ae. hebrideus*, 1 L, *Tp. melanesiensis*, 7 L, 4 P; /2, at Ambit Cr., in small residual collection with turbid water and grassy edges, sunlit, *An. farauti*, 1 L; /3, at inner limit of the beach, in rat-gnawed coconut husk, clear contents, *Ae. hebrideus*, 1 P, 2 p, *Tp. melanesiensis*, 2 L, 9 P, 1 p. /5, near Avar Vill. (east coast), inland, in clear rainwater in 1/2 coconut shell, *Ae. hebrideus*, 2 L; /6, at beach of Avar Vill., in clear water in dugout canoe, *Cx. annulirostris*, 5 L, *Ae. hebrideus*, 1 L, 2 l. /7, near French Public School, attacking in the bush, at sunset, *Ae. hebrideus*, 1 ♀. /1, at Hospital, Female Ward, resting indoors, at sunrise, *Ae. hebrideus*, 3 ♀♀, 5 ♂♂. /2, on Rah Islet, in sunlit, clear water of stone-walled well, *Cx. annulirostris*, 2 L (fragments); /3, as above, in clear water in discarded stone-walled well, shaded by bush, *Cx. annulirostris*, 11 L; /4, as above, in rat-gnawed coconut husk, *Tp. melanesiensis*, 12 L, 1 P; /5, as above, slightly inland, attacking at 10 a.m. in coastal forest, near rainwater rock pools on boulders (no aquatic stages found), *Ae. hebrideus*, 2 ♀♀.

Parapara (*Ureparapara*, *Norbarbar*, *Vatgana*) (visited 11 August 1971). This horseshoe-shaped island is the sea-breached rim of a volcanic cone, the crater of which is the Big Bay. The mountain rim rises to 764 m. The surface of the island is 36 km², the population is 149 (dens. 4.1/km²) and is concentrated in 3 villages.

Code 710811. Western coast: /1, south of Lehale Vill., in coconut plantation, in clear rainwater in coconut spathe, *Ae. hebrideus*, 3 L, 3 P, *Tp. melanesiensis*, 4 L; /2, north of Lehale Vill., in 1/2 coconut shell, *Ae. hebrideus*, 6 L; /3, along the path Lehale-Lequanle Vill., on coastal boulders, in sunlit small rock pools with slightly brackish water and decomposing leaves, *Ae. hebrideus*, 9 L; /4, as above, on almost dry rocky bed of small creek, in limited collection of slow-moving, clear water among rocks, sun-shaded, *Ae. hebrideus*, 1 L; /5, south of Lequanle Vill., in shallow collection on a huge rock near sea, brackish water and decomposing leaves, *Ae. hebrideus*, 11 L, 1 P; /6, north of Lequanle Vill., on big, flat boulders at sea border, in ample, shallow, slightly brackish, sunlit collection, abundant leaves at bottom, *Cx. sitiens*, 7 L, 3 l, 6 P; /7, along the path between Lequanle Vill., and Big Bay, near crossing of the watershed (approx. elevation 150 m), in freshwater pool of Lakhahi Cr., on rocks, with dead leaves at bottom, in forest shade, *Cx. femineus*, 4 L, 2 P, *Ae. aobae*, 1 ♀ (attacking in forest, at noon), 3 P. In northeastern part of Big Bay: /8, in lightly wooded retrodunal depression, in large freshwater collection, shallow, with abundant submerged and floating leaves and branches, sun-shaded, *An. farauti*, 4 L, 2 P.

TORRES ISLANDS

Toga (visited 8–9 August 1971). A small island (16 km²), which is mostly a plateau, rising to 240 m, and a narrow coastal area. Except for a few persons in Likua, the entire population (88, dens. 5.5/km²) is in Litau.

Code 710808. /1, along the path crossing the island from Likua to Litau, in forested area, in treehole, organic material at bottom, *Tp. melanesiensis*, 5 L; /2, as above, in lightly

wooded forest, *Ae. aobae*, 1 ♀, attacking at 9 a.m.; /3, as above, before reaching Litau, on hill slopes, in taro garden, *Ae. aobae*, 3 ♀♀, attacking at 10 a.m. /4, at Litau Vill., in fresh 1/2 coconut husk, *Ae. hebrideus*, 1 L; /5, as above, at beach, in rainwater in dugout canoe, *Ae. hebrideus*, 6 L, 4 P, *Tp. melanesiensis*, 1 L; /6, as above, tree (local name: Nandau) in village square, treehole, organic material at bottom, *Tp. melanesiensis*, 20 L. /7, north of Litau, approx. 1 km, at inland limit of beach, in collection of brackish water in small pits on coral limestone, sun-shade, *Cx. sitiens*, 3 ♀♀ (reared), 2 ♂♂ (reared), 11 L, 1 p; /8, as above, more north, in similar breeding sites, *Cx. sitiens*, 10 L, 4 P, *Ae. aobae*, 1 L, 7 P, *Ae. hebrideus*, 5 L; /9, just inland of /8, in coastal forest, in treehole on *Barringtonia (asiatica)* (L.) Kurz (?), organic material at bottom, shade, *Ae. aobae*, 10 L, 7 P, 2 p, *Tp. melanesiensis*, 1 L. /10, west of Litau, inland, in forest, in small treehole, in shade, *Tp. melanesiensis*, 2 L; /11, as above, in hole on tree stump, dead leaves at bottom, *Ae. aobae*, 11 L, 6 P, *Tp. melanesiensis*, 1 L. /12, south of Litau, at the inland limit of beach, near a fisherman's hut, in rainwater in a small, pit-like depression on sandy-coral ground, *An. farauti*, 1 L, *Cx. annulirostris*, 1 L; /13, as above, at forested fringe of beach, *Ae. aobae*, 2 ♀♀, attacking, at 5 p.m.

Code 710809. /0, on the northern coast, at Likua Vill., in clear water in 170-liter drum, *Ae. aobae*, 1 L, *Ae. hebrideus*, 2 L, *Tp. melanesiensis*, 1 L; /A, as above, *Ae. aobae*, 2 ♀♀, attacking in the open. /6, as above in rainwater collection in buttresses of a big tree, *Ae. aobae*, 11 L, 5 P.

Loh (visited briefly on 8 and 10 August 1971). This is a crescent-shaped island (13 km²), with 2 hills rising just above 100 m. There are marshes and mangroves in the north; off-shore is a flat islet, Linua. The population of 74 (dens. 5.7/km²) is all at Lungarigi.

Code 710808. /1, at Lungarigi Vill., *Ae. aobae*, 2 ♀♀, attacking indoors, in early morning.

Code 710810. /1, at Lungarigi Vill., *Ae. hebrideus*, 11 ♀♀, resting or attacking indoors, in early morning. /2, along path from Lungarigi to landing place, in clear rainwater in cylindrical hole on tree stump, organic material at bottom, *Ae. aobae*, 1 L, *Tp. melanesiensis*, 23 L, 3 P.

Huu (visited 9 August 1971) is the biggest island of the Torres (43 km²). It is irregularly shaped, with a steep-edged plateau rising to 366 m at its center. The small population of 48 (dens. 1.3/km²) is at Yogawenamena, on the eastern coast.

Code 710809. /1, near Yogawenamena Vill., in rainwater in small treehole, *Tp. melanesiensis*, 4 L; /2, as above, in hole collection on big tree, *Ae. hebrideus*, 1 L, 10 P; /5, as above, at sea front, in small rainwater collection in groove on branch of *Inophyllum calophyllum* L., *Ae. hebrideus*, 7 L. /4, south of Yogawenamena, in retrodunal depression, in large, shallow water collection of dead branch of river, sun-shade, floating and submerged branches and leaves and algae, *An. farauti*, 5 L; /3, as above, farther south, in ample, sunlit, freshwater collection, with thick layers of green algae, and floating and submerged branches and leaves, *An. farauti*, 35 L, 4 P; /7, north of Yogawenamena, in rainwater in

small treehole, *Ae. aobae*, 9 L, *Tp. melanesiensis*, 4 L, 7 P; /8, as above, along the inland limit of the beach, in collections of rainwater sprinkled with sea moisture, in pitlike small depressions on coral limestone, sunshaded, algae, *An. farauti*, 8 L, *Cx. sitiens*, 9 ♀♀ (reared), 1 ♂ (reared), 46 L, 16 P, 10 p. /9, at Yogawenamena Vill., *An. farauti*, 14 ♀♀, indoors, resting, in nighttime and at sunrise.

NOTES ON THE SPECIES

Anopheles (Cellia) farauti Laveran, 1902

An. farauti has previously been reported from Vanua Lava, its off-shore islet Pakea, and Gaua. The collection on Gaua by Daggy (1945) consisted of adults captured near Steaming Hill Lake, at 366 m, a locality so far from man that the existence of a totally zoophilic *An. farauti* had to be implied by Daggy.

In August 1971—in spite of the dry season, which in the New Hebrides is a known handicap to the detection of the breeding sites of this species (Buxton & Hopkins 1927: 67–68)—we confirmed the presence of *An. farauti* on Vanua Lava and on Gaua; in addition, we found the species on Mota, Motalava, Parapara, Toga and Hiu. Pakea was not visited. Of all the islands visited, Merelava and Loh were the only ones where *An. farauti* was not found; epidemiological evidence of malaria, however, strongly suggests its presence on Loh (Maffi & Ratard 1974). The entomological results and the epidemiological data on malaria and bancroftian filariasis in the Banks and Torres indicate a close relation between these diseases and the distribution and densities of *An. farauti*.

Morphological characters of the immature stages agree with previous descriptions by Rageau & Vervent (1959), particularly, and by Belkin (1962). The inner clypeals (2-C) of the local larvae are usually simple or gently frayed. Adults, most of them captured resting indoors, at night and in daytime, show the reported characters. It is worth noting that one of the few reared specimens, a female (Vanua Lava, 710812/4), shows *An. (Cel.) koliensis* wings, i.e., without a separate sectoral dark spot on vein C between basal and median dark spots. The variety of the breeding sites in which the immature stages of *An. farauti* have been found confirms the adaptability that this species shows in the New Hebrides to a wide range of aquatic conditions (Daggy 1945, Laird 1956, Rageau & Vervent 1959). *An. farauti* has been occasionally associated with *Cx. annulirostris* in fresh water and with *Cx. sitiens* in brackish water.

Culex (Culex) pacificus Edwards, 1916

This species had been reported only once, from Merelava (Salaun in Rageau & Vervent 1958: 21). We found it again on Merelava, and only there: immature stages, associated with *Ae. hebrideus*, were collected from very rusty rainwater in a 170-liter drum (710815/2). It is worth noting that 2 of the 5 larvae collected, all undoubtedly *Cx. pacificus*, show morphological characters suggestive of *Cx. banksensis*. In one specimen 3-P is double on 1 side, in the other 4-P is triple on both sides. Such variations are extremely unusual in the specimens of *Cx. pacificus* collected in the New Hebrides group proper. The adults

of *Cx. pacificus* are reported not to attack man (Belkin 1962: 192); our experience confirms this statement.

Culex (Culex) banksensis Maffi & Tenorio, 1977

This species has been reported and figured in detail elsewhere (Maffi & Tenorio 1977). The species has been collected on Gaua, Vanua Lava and Mota, as immature stages. It is mainly a treehole-breeder, where it is frequently associated with *Tp. melanesiensis*, occasionally with *Ae. hebrideus* or *Ae. aobae*, and, once, with *Cx. annulirostris* (!). Twice, however, it has been found to breed elsewhere, once in a coconut husk, on another occasion in a basin-shaped block of lava, sunlit. In the latter case, the 2 larvae collected (3rd instar) show characters very similar to *Cx. pacificus*. Since no adults of this species were taken in biting collections, we presume that this species does not attack man. The species is not known elsewhere.

Culex (Culex) sitiens Wiedemann, 1828

Unreported previously from the 2 island groups, *Cx. sitiens* has been found by us on Merelava, Mota, Parapara, Toga and Hiu. Its breeding sites were never far from the sea and usually on solid ground (basalt, coral limestone) and in waters polluted and/or brackish to various degrees. On one occasion *Cx. sitiens* was found in a seagoing dugout canoe marooned near a ground-breeding site. On coral limestone, with brackish waters, *Cx. sitiens* can have *An. farauti*, *Ae. aobae*, and *Ae. hebrideus* as breeding associates.

Culex (Culex) annulirostris Skuse, 1889

Reported in the past only from Vanua Lava, this species has been found on Gaua, Vanua Lava, Mota, Motalava and Toga. This distribution is consistent with the preference shown by this species for ground water habitats. Indeed, whereas permanent or semipermanent breeding sites of this kind are available in the Banks, they are scarce or nil in the Torres, except for Hiu. This is confirmed by the fact that the only finding of *Cx. annulirostris* in the Torres is that of a single larva collected on Toga from a tiny rain-water site on sandy-coral soil, associated with 1 larva of *An. farauti*. The collection of a single larva from a treehole (on Gaua), an exception to the ground water habitat, is thought to represent an accidental invasion from a typical *Cx. annulirostris* breeding site found nearby. More numerous specimens of *Cx. banksensis*, *Ae. aobae* and *Tp. melanesiensis* were found in association.

Culex (Eumelanomyia) femineus Edwards, 1926

This species, known only from the New Hebrides group proper, but never reported from the Banks and Torres (Belkin 1962: 237), was collected on Gaua, Vanua Lava, Mota and Parapara. Immature stages were found in typical breeding sites, i.e., rock pools along streams, mostly in shade. The lack of similar environmental conditions may explain the apparent absence of *Cx. femineus* from the Torres.

The larvae agree with Belkin's description and illustration (1962: 181-182, 236-237, Fig. 140); some of the pupae, however, though undoubtedly *Cx. femineus* by most of their

morphological characters and by the genitalia of the developing males within the pupal pelt show hair 10-C to be 3–5 b. This is a possible variation to be remembered when identifications are made following Belkin (1962: 181, 236, Fig. 139).

***Aedes (Stegomyia) aobae* Belkin, 1962**

Originally found only on Aoba Island, at Crater Lake, by Bonnet in August 1956, this species was later (1959) captured as a single female by L. E. Cheesman on Vanua Lava (Belkin 1962: 452–453). We found *Ae. aobae* on 6 of the 9 islands visited: Gaua, Vanua Lava, Parapara, Toga, Loh and Hiu. A thorough search—as is necessary when treehole-breeders are investigated—may well show that this species is on all the islands of the 2 groups. In this context it is worth reporting that the casual collections made by one of us (M. M.) in the New Hebrides island group proper show *Ae. aobae* to be present also, and only, on the western coast of Pentecost: immature stages of this species have been collected from a treehole at Latano and from a dry coconut husk at Salap.

Ae. aobae, though mainly a treehole-breeder, shows considerable adaptability. Apart from its expected presence in a 170-liter drum, it was found in collections of brackish water, in pitlike small depressions on coral limestone, associated with *Cx. sitiens* and *Ae. hebrideus* (Toga, 710808/8). These findings confirm, though less strikingly, the adaptability of some members of the *scutellaris* group in the area to waters with high salt content (Maffi & Taylor 1974: 203, 208). Collecting adult females is easy: *Ae. aobae* is very aggressive, attacking at any time, in a variety of different environments in the open and in houses. Specimens of all stages agree with Belkin (1962: 452–453).

During the fall of 1975 the Banks and Torres experienced an epidemic strongly suggestive of dengue fever. Since *Ae. aegypti*, the typical vector of dengue, has never been reported from the 2 island groups and the epidemiological evidence dismisses *Ae. hebrideus* as a vector of the disease, the distribution and behavior of *Ae. aobae* suggests this species as the local vector of dengue fever.

***Aedes (Stegomyia) hebrideus* Edwards, 1926**

Reported in the past only from Toga (Salaun in Rageau & Vervent 1958) and Vanua Lava (Belkin 1962: 460), *Ae. hebrideus* was found on every island visited. Immature stages have been collected from a variety of breeding sites (rainwater in 170-liter drum, treehole, tree groove, palm spathe, coconut shell, coconut husk, freshwater rockhole, brackish water pool, dugout canoe, a *Tridacna* shell). Frequently alone, *Ae. hebrideus* may associate, in changing patterns, with *Cx. banksensis*, *Cx. pacificus*, *Cx. sitiens*, *Cx. annulirostris*, *Ae. aobae* and *Tp. melanesiensis*.

Adults were captured outside and indoors, resting and biting. Though a nuisance, *Ae. hebrideus* does not appear to have any vectorial importance.

***Tripteroides (Rachionotomyia) melanesiensis* Belkin, 1955**

In the past this species has been reported only from Vanua Lava (Belkin 1962: 517). We found *Tp. melanesiensis* on all the islands visited, except Mota; it is therefore second only to *Ae. hebrideus* in distribution in the 2 island groups. This species is normally found in

treeholes and in more than 1/2 of these findings has been associated with *Cx. banksensis* and/or *Ae. aobae*. It has also been collected from coconut husks, a palm spathe, a canoe and a 170-liter drum, and sometimes has been associated with *Ae. aobae* and/or *Ae. hebrideus*. A few adults have been captured resting near the breeding sites, and a few have been reared. This species does not attack man.

The larvae collected show the latitudinal and/or environmental variations noted by Belkin (1955: 233-243, 1962: 515-517) and are easily referred to *Tp. melanesiensis*. The pupae, however, by morphological characters, range from typical *Tp. melanesiensis* (Belkin 1962: 507-08, 515-16, Fig. 383) to specimens (Hiu, 710809/7) which, by key, description and illustration, are very close to *Tp. (Rah.) rotumanus* pupae (Belkin 1962: 513-14, Fig. 379).

CONCLUSIONS

In the long chain of scattered islands rising from a common ridge that characterizes the Santa Cruz-New Hebrides faunal area, the island groups of the Banks and Torres represent the link between the Santa Cruz subarea, located north, and the New Hebrides group proper, which lies south (Belkin 1962: 26-31). Prior to 1971 little was known about the mosquito fauna of these 2 island groups, which are remote and rarely visited (Belkin 1962: 29, Lee 1975: 477, 485). Since more data have been made available for the Santa Cruz faunal subarea in 1974 (Maffi & Taylor), it is reasonable to say that the Banks and Torres are the least known sector of the whole faunal area.

Therefore, in spite of the casual nature of the collections and the unequal time spent on the islands visited, the results obtained in the Banks and Torres during August 1971 have some significance. They have resulted in broader knowledge of the presence and

TABLE 1. Conspectus of the mosquito species of the Banks and the Torres island groups, by island.

SPECIES	BANKS							TORRES			No. OF ISLANDS ON WHICH SPECIES FOUND
	Mercilava	Gaua	Vanua Lava	Pakea	Mota	Motalava	Parapara	Toga	Loh	Hiu	
<i>An. (Cel.) farauti</i>	⊕*	⊕*	+	○	○	○	○	○	○	○	8
<i>Cx. (Cux.) pacificus</i>	⊕	○	○	○	○	○	○	○	○	○	1
<i>Cx. (Cux.) banksensis</i>	○	○	○	○	○	○	○	○	○	○	3
<i>Cx. (Cux.) quinquefasciatus</i>	○	○	+	○	○	○	○	○	○	○	1
<i>Cx. (Cux.) sitiens</i>	○	○	○	○	○	○	○	○	○	○	5
<i>Cx. (Cux.) annulirostris</i>	○	○	⊕	○	○	○	○	○	○	○	5
<i>Cx. (Eum.) femineus</i>	○	○	○	○	○	○	○	○	○	○	4
<i>Ae. (Ver.) lineatus</i>	○	○	○	+	○	○	○	○	○	○	1
<i>Ae. (Stg.) aobae</i>	○	○	⊕	○	○	○	○	○	○	○	6
<i>Ae. (Stg.) hebrideus</i>	○	○	⊕	○	○	○	○	⊕	○	○	9
<i>Ae. (Stg.)</i> sp., Vanua Lava form	○	○	+	○	○	○	○	○	○	○	1
<i>Tp. (Rah.) melanesiensis</i>	○	○	⊕	○	○	○	○	○	○	○	8
No. of species present on each island	4	7	9	2	6	4	6	6	3	5	

*+ = previous record; ⊕ = previous record confirmed; ○ = new record.

distribution of the local mosquito fauna (TABLE 1), in a better assessment of the behavior of some species and in a few still unanswered questions on systematics.

Prevailing environmental conditions play a decisive role in determining the presence, distribution, density and behavior of the mosquito fauna on each island, or even portion of an island. Because of their history and morphology, the Banks and Torres appear to favor those mosquito species which use plant-container habitats, a condition which, in areas that are subjected to considerable natural pressures on the environment, is known to offer some advantages (Belkin 1962: 47-48). In the Banks and Torres, the mosquitoes using plant-container habitats are mainly treehole-breeders; most of them, however, are able to utilize other containers, natural and/or artificial. The treehole-breeders are markedly more prevalent in the Torres, where, except for Hiu, permanent groundwaters are scarce or nonexistent. Of the species which utilize ground water habitats, only *An. farauti*, *Cx. sitiens* and *Cx. annulirostris* are found on both island groups; all of these have the ability to tolerate salt, and occasionally exhibit other breeding adaptabilities (e.g., *Cx. sitiens* in canoes, and *Cx. annulirostris* in canoes and even treeholes). On the other hand, those species which appear to be more strictly dependent on fresh water, as *Cx. quinquefasciatus*, *Cx. femineus* and *Ae. lineatus*, seem to be limited to the Banks, particularly the main islands, and to be absent from the Torres, where there are few freshwater habitats.

In practical terms, the entomological information on *An. farauti*, the local vector of malaria and bancroftian filariasis, coupled with the parasitological data gathered (Maffi & Ratard 1974), has resulted in more appropriate actions. These include a field trial of vector source reduction by introduction of *Gambusia* sp., a larvivorous fish, into the important *An. farauti* breeding sites on Hiu. The new data obtained on *Ae. aobae* have led to suspicions that this species may be the vector of dengue fever in the 2 island groups. All this confirms the importance of a solid entomological background when acting against mosquito-borne diseases.

Some questions arise from the collection in the Banks of a new species, *Culex* (*Culex*) *banksensis* (Maffi & Tenorio 1977), which presents morphological characters and bionomics relating it on one side with the *pipiens* group, *trifilatus* subgroup, and in particular with *Cx. pacificus*, and on the other side with the *atriceps* group, a likely relict group of species. Another question is posed by the finding on Hiu of pupae which on the basis of breeding site are related to typical larvae of *Tp. melanesiensis* but which by morphological features are suggestive of *Tp. rotumanus*. This evidence seems to substantiate the origin of *Tp. rotumanus* suggested by Belkin (1955: 225, 1962: 497, 514, 516).

Whatever their value, our findings stress the need for a more complete study of the mosquito fauna of the Banks and Torres. Since such a study seems to be forthcoming (Yonge 1975: 268, Lee 1975: 485), more valuable information on this subject may be available in a reasonably short time.

Acknowledgments: We are much indebted to Dr J. A. Tenorio and Dr W. A. Steffan of the Bishop Museum, and to their staff, for assistance in preparing the specimens and valuable advice given when

finalizing this paper. The senior author wishes to express his gratitude to the Condominium, British and French administrative and health authorities of the New Hebrides, as also to the World Health Organization, for their support during the visit to the Banks and Torres which made this paper possible. Thanks are given to Captain Kameli and to the crew of the "Navaka" for their friendly cooperation during the trip.

LITERATURE CITED

- Belkin, J. N.** 1955. The *Tripteroides caledonica* complex of Mosquitoes in Melanesia (Diptera: Culicidae). *Pacif. Sci.* **9**: 221-46.
1962. *The Mosquitoes of the South Pacific*. University of California Press, Berkeley. **1**: 608 p.; **2**: 412 p.
- Buxton, P. A. & G. H. E. Hopkins.** 1927. Researches in Polynesia and Melanesia. I-IV. *Mem. Lond. Sch. Hyg. Trop. Med.* **1**: 1-260.
- Daggy, R. H.** 1945. The biology and seasonal cycle of *Anopheles farauti* on Espiritu Santo, New Hebrides. *Ann. Ent. Soc. Amer.* **38**: 1-13.
- Laird, M.** 1956. Studies on mosquitoes and freshwater ecology in the South Pacific. *Bull. Roy. Soc. N.Z.* **6**: 1-123.
- Lee, K. E.** 1975. A discussion on the results of the 1971 Royal Society—Percy Sladen Expedition to the New Hebrides. Conclusions. *Phil. Trans. R. Soc. Ser. B.* **272**: 477-86.
- Maffi, M. & R. C. Ratard.** 1974. Le paludisme aux Banks et Torres, archipel des Nouvelles-Hébrides. *Parassitologia* **16**: 1-46.
- Maffi, M. & B. Taylor.** 1974. The mosquitoes of the Santa Cruz faunal subarea of the Southwest Pacific (Diptera: Culicidae). *J. Med. Ent.* **11**: 197-210.
- Maffi, M. & J. A. Tenorio.** 1977. *Culex (Culex) banksensis*, a new species of mosquito (Diptera: Culicidae) from the Banks Islands, New Hebrides. *Pacif. Ins.* **17**: 503-09.
- Rageau, J. & G. Vervent.** 1958. Arthropodes d' intérêt médical ou vétérinaire aux Nouvelles-Hébrides. Inst. Franc. Oceanie, Nouméa. Unpubl. report: 51 p.
1959. Enquête entomologique sur le paludisme aux Nouvelles-Hébrides. South Pacific Commission, Tech. Paper **119**: 34 p.
- Yonge, M. (Sir)** 1975. A discussion on the results of the 1971 Royal Society—Percy Sladen Expedition to the New Hebrides. Preface. *Phil. Trans. R. Soc. Ser. B.* **272**: 268.