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OBSERVATIONS ON MALARIA VECTORS OF THE *ANOPHELES PUNCTULATUS* COMPLEX IN THE BRITISH SOLOMON ISLANDS PROTECTORATE[1]

By **Brian Taylor**[2]

Abstract: All available information on malaria vector species of the *Anopheles* (*Cellia*) *punctulatus* complex in the British Solomon Islands Protectorate is presented. Particular emphasis is placed on the distribution of 3 species, *Anopheles punctulatus* Don., *A. farauti* Lav., and *A. koliensis* Owen, based on a comprehensive survey of all the inhabited islands of the Protectorate. Comments are provided on the apparent effects of DDT residual house spraying on the vector species.

The British Solomon Islands Protectorate (B.S.I.P.) comprises a scattered archipelago of mountainous islands and low-lying coral atolls stretching some 1450 km in a southeasterly direction between latitudes 5°S and 12°30′S and longitudes 155°30′E and 170°15′E. The total land area is approximately 29,500 km². The 6 major islands, Choiseul, New Georgia, Santa Isabel, Guadalcanal, Malaita and San Cristobal, are characterized by precipitous, thickly forested mountain ranges, intersected by deep narrow valleys. The coasts are frequently surrounded by extensive coral reefs and lagoons and there are extensive mangrove swamps in many areas. Guadalcanal is unique in having a large area of flat grassy plain on the north-central side of the island.

The climate is equatorial but modified by the surrounding ocean. The annual mean temperature is around 27°C at Honiara, the capital on Guadalcanal. The annual rainfall averages 3000 to 3600 mm but in some areas may be as much as 7600 mm.

The total population in 1970 was almost 161,000 with an overall density of 5.7 persons per km² (varying on the large islands from 11.50 per km² on Malaita to 2.16 per km² on Santa Isabel).

The islands have long been regarded as one of the most malarious regions in the world and since 1962 determined efforts have been under way to eradicate the disease (Macgregor 1968). This paper attempts to bring together the available information on the mosquito vectors of malaria in the B.S.I.P. particularly with regard to their distribution. Human malaria is solely transmitted by mosquitoes of the genus *Anopheles* Meigen and in the B.S.I.P. all 3 species that have been shown to be vectors belong to the *punctulatus* complex of the subgenus *Cellia*. They are *A. punctulatus* Dönitz, 1901, *A. farauti* Laveran, 1902 and *A. koliensis* Owen, 1945. Three other species of *Anopheles*, all belonging to the *A. lungae* complex, are found in the B.S.I.P. but these, although often abundant, rarely attack man and have never been implicated as vectors of malaria.

No attempt has been made to include or comment on findings from elsewhere in the range of the *punctulatus* complex (for example, New Guinea) as there is evidence, both behavioral and genetic, to support the view that the complex is as yet poorly understood and that comparisons would be unwise at this time.

Historical Background

1914 to 1942

The earliest recorded collection of a species of the *Anopheles* (*Cellia*) *punctulatus* complex in the British Solomon Islands appears to have been by G. C. H. Davies at Tulagi in 1914. This collection and others by A. G. Carment in 1923 at Tulagi and at Rere and Maravovo on Guadalcanal were reported by Edwards (1924).

Carment made numerous other collections of mosquitoes including 2 of anophelines in the Santa Cruz group; 1 on a schooner in Graciosa Bay in 1926, and the 2nd "near Tulagi Hospital, Santa Cruz" in January 1926 (Edwards 1926). The latter of these is somewhat puzzling as there was no hospital at Graciosa Bay in 1926. Other anopheline specimens from Vanikoro I., in the Santa Cruz group, were sent to S. M. Lambert and seen by P. A. Buxton (Buxton & Hopkins 1927).

An early specimen in the British Museum (Natural History) collection was collected at Suvana, Santa Isabel, in July 1925 by C. H. G. White.

In a comprehensive paper, Paine & Edwards (1929) reported on a series of mosquito collections Paine had made during the course of visits to coconut plantations throughout the Solomons. Anophelines were collected at Tenaru on Guadalcanal, at Banika in the Russell Is. and on Kolombangara I.

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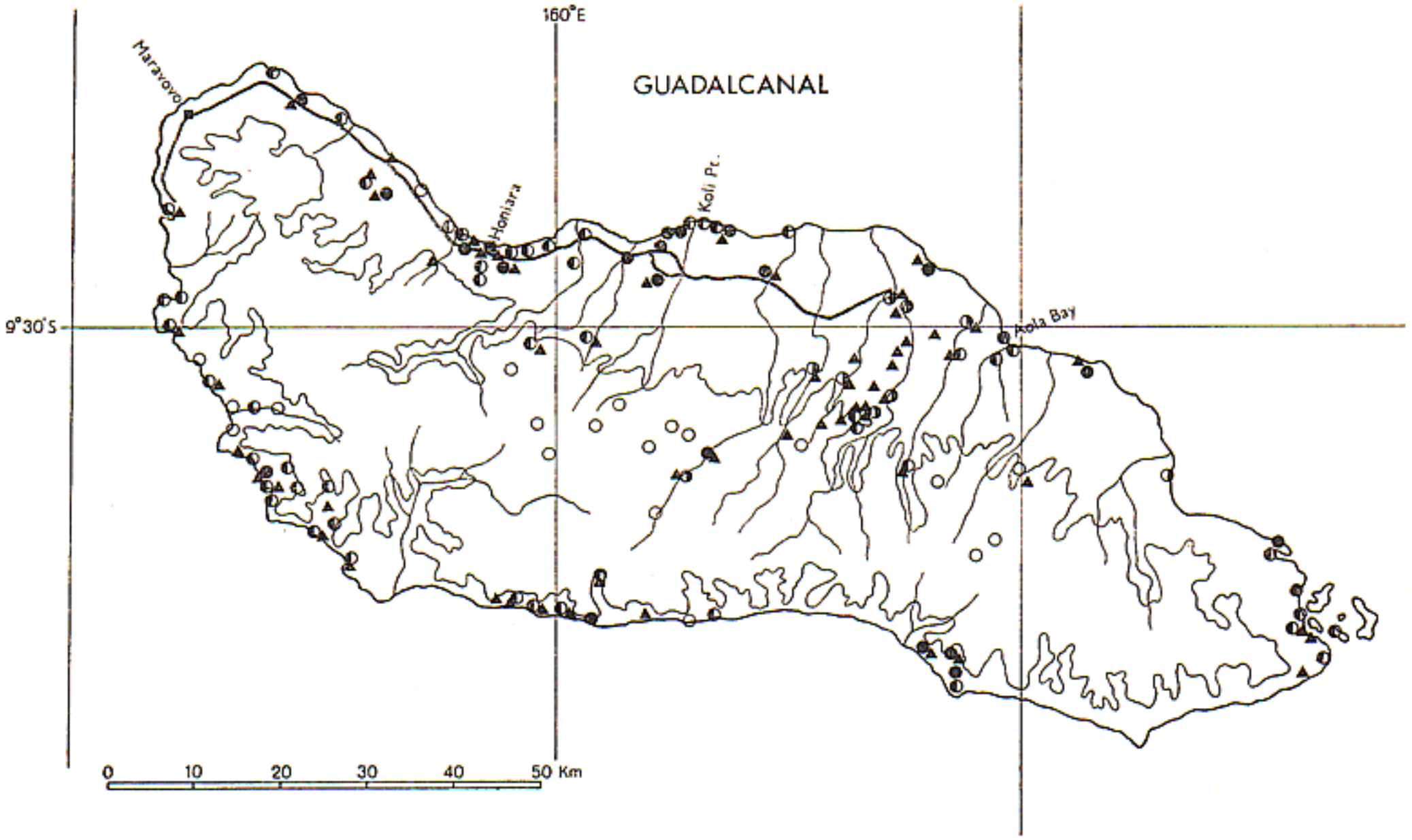

FIG. 1. Guadalcanal Island. The following symbols indicate the results obtained at the locations surveyed: ○ Anophelines not found; ◐ *A. farauti* alone found; ◑ *A. koliensis* alone found; ● *A. farauti* and *A. koliensis* found together; ▲ *A. punctulatus* found. The use of a relatively small scale for the maps has necessitated the omission of some results when closely neighboring villages gave similar findings. The *punctulatus* symbol closely adjacent to one of the other anopheline symbols usnally indicates findings at a single village. A 300 m contour line is shown, where appropriate, on all maps and the main road is shown on the Guadalcanal and Malaita maps.

From 1931 to 1936 R. J. A. W. Lever was agricultural entomologist in the Solomons. In a number of papers (1933, 1934, 1937) he gave notes on anophelines including a specific report of specimens from the Three Sisters Group (1937).

During visits to the Solomons in 1930 and 1933, S. M. Lambert collected mosquitoes, and his findings, which include the collection of anophelines on Sikaiana I., are listed most completely in an unpublished report made to the High Commissioner for the Western Pacific in 1933.

I have avoided indicating which of the species currently regarded as belonging to the *punctulatus* complex were collected, as there was much confusion among these early authors. In general, 2 forms, *A. punctulatus* Dönitz, 1901 and *A. punctulatus moluccensis* Swellengrebel & Swellengrebel de Graaf, 1920, were accepted but the taxonomic position and distribution of these forms was not clear. At the request of Lever, Edwards reexamined material from New Guinea, New Britain, the Solomons, the New Hebrides and other islands and expressed the opinion that both forms occurred in the Solomons (Lever 1945). Laveran (1902) had, however, described an anopheline species from the New Hebrides and named it *A. farauti*.

1942 to 1950

The onset of war on Guadalcanal in August 1942 involved very large numbers of troops and there were soon severe epidemics of malaria. Anti-malaria personnel including a number of entomologists were brought in by the United States Military Forces and one of the major results of the entomological work was the elucidation of the *punctulatus* complex.

The first publication was by Owen (1945) who described a species from North Guadalcanal and named it *A. koliensis*. Belkin et al. (1945) summarized the taxonomic status of the complex and concluded that there were 4 closely related species: *A. punctulatus*, *A. farauti*, *A. koliensis* and *A. moluccensis*. The first 3 were said to occur on Guadalcanal but *A. moluccensis* was thought to be restricted to New Guinea. The U. S. entomologists had collected only 1 form on Efaté in the New Hebrides and Rozeboom & Knight (1946) showed this to be synonymous with *A. moluccensis*. Reid (1947) located and examined Laveran's type material and

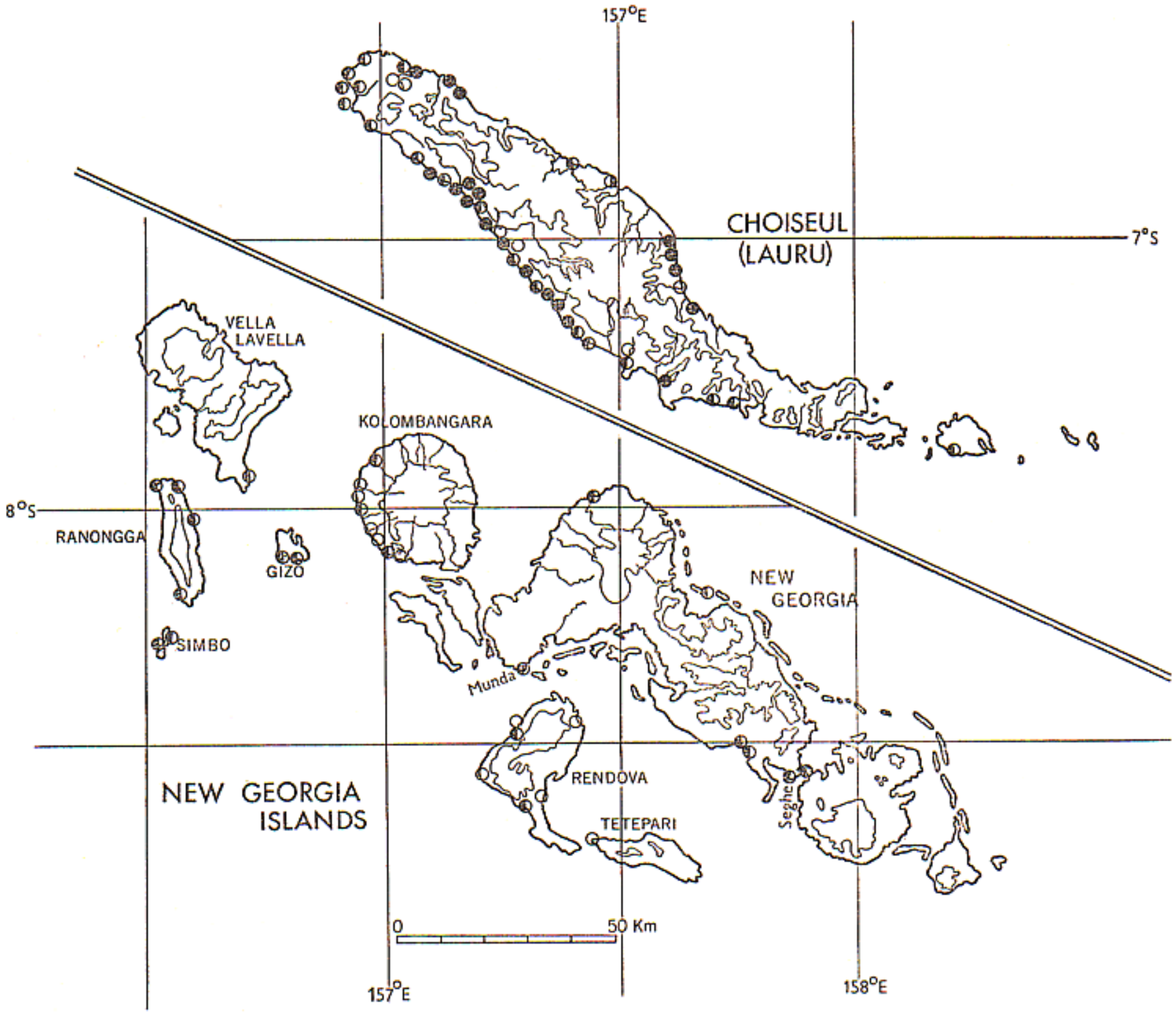

FIG. 2. Choiseul and New Georgia Islands. Symbols as in FIG. 1.

it became clear that the name *A. farauti* should be used for all material previously known as *A. moluccensis*. In their paper, Rozeboom & Knight (1946) had added a 4th species, *A. clowi*, to the complex but this was found only in New Guinea.

To return to the early records from the Solomons, it is clear that Lever (1934) (presumably reflecting the opinion of Edwards who had identified much of Lever's material) regarded his specimens as *A. punctulatus*. Belkin (1962), in preparing his monograph of the mosquitoes of the South Pacific, reexamined many of the early specimens and found most of those from the Solomons to be *A. farauti* although 1 specimen collected by Carment at Rere in 1923 was *A. koliensis*. Thus there are a relatively few but widely scattered pre-1942 records of *A. farauti* in the Solomons from Kolombangara in the west to Vanikoro in the east.

The collections made by the U. S. Forces' entomologists, although comprising a very large number of specimens [some 55,000 on Guadalcanal alone (Belkin 1962)], covered only a limited area of the Solomons. The distribution of members of the complex in this area was shown cartographically by Perry (1950) and was given by Belkin et al. (1945) as follows:

A. punctulatus: Guadalcanal—north coast, Tenamba to Tetere, and southwest coast at West Cape; usually in the vicinity of native villages away from the coast.

A. farauti: Guadalcanal—generally distributed along the entire coast, on the north coast from Maravovo to Aola Bay and at West Cape; Malaita; Tulagi; Florida; Savo; Russell Islands; New Georgia Group; and Treasury Islands (Mono).

A. koliensis: Guadalcanal—north coast from Malimbu River east to Aola Bay; absent from northwest coast.

Belkin (1950) gives a few more details of the collection areas. On Guadalcanal the area collected was extensively from sea level to about 200 m (a few hundred feet) and perhaps 6 km (4 miles) inland. The New Georgia collections were primarily from Munda Point with additional records from Arundel, Kolombangara, Rendova, Sasavele and Roviana Islands.

1950 to 1962

The first collector in this period was R. H. Black who visited mainly the outlying Polynesian islands in May and June 1952 and collected *A. farauti* on Avaha (Ontong Java), Sikaiana and Rennell. He was unable to find anophelines on Bellona. On Guadalcanal he collected *A. farauti* and *A. koliensis* at Suagi and Roroni (both within the collecting area of the U. S. Forces' entomologists) and on Savo I. collected *A. farauti* and *A. punctulatus* (Black 1952).

Laird (1955) was the first to collect in the mountainous interior of Guadalcanal. In August 1953 he found *A. punctulatus* at Tuturahitoko, about 26 km inland from the north coast and 580 m above sea level. In the same year he also found *A. farauti* on Rennell I. and Sikaiana I. (Laird 1956, Laird & Laird 1959).

J. S. Phillips in 1953–1954, E. S. Brown in 1954–1956 and J. de Beaux in 1956 made further collections of *A. farauti* within the collecting area of the U. S. Forces' entomologists on Guadalcanal; Brown also collected *A. koliensis*. On Rennell I. *A. farauti* was collected by Brown in 1955 and de Beaux in 1956. The first collection of *A. farauti* (a single female) on Bellona I. was made by Brown, also in 1955. Between 1954 and 1956 Brown collected *A. farauti* on Kolombangara, Russell Is., Malaita, San Cristobal and Malaupaina (Three Sisters Group). All of these collections were included, without any details, by Belkin (1962). M. V. Natuna and E. S. Brown collected *A. farauti* on Ontong Java in 1954–1955 (Hollins 1957) and S. Tabua found *A. farauti* in Lake Terota, Tikopia, in 1955 (B.S.I.P. Medical Department records).

The Eastern Outer Islands were visited by the Robinson-Peabody Museum of Salem Expedition in 1956 and D. B. Bonnet collected *A. farauti* on

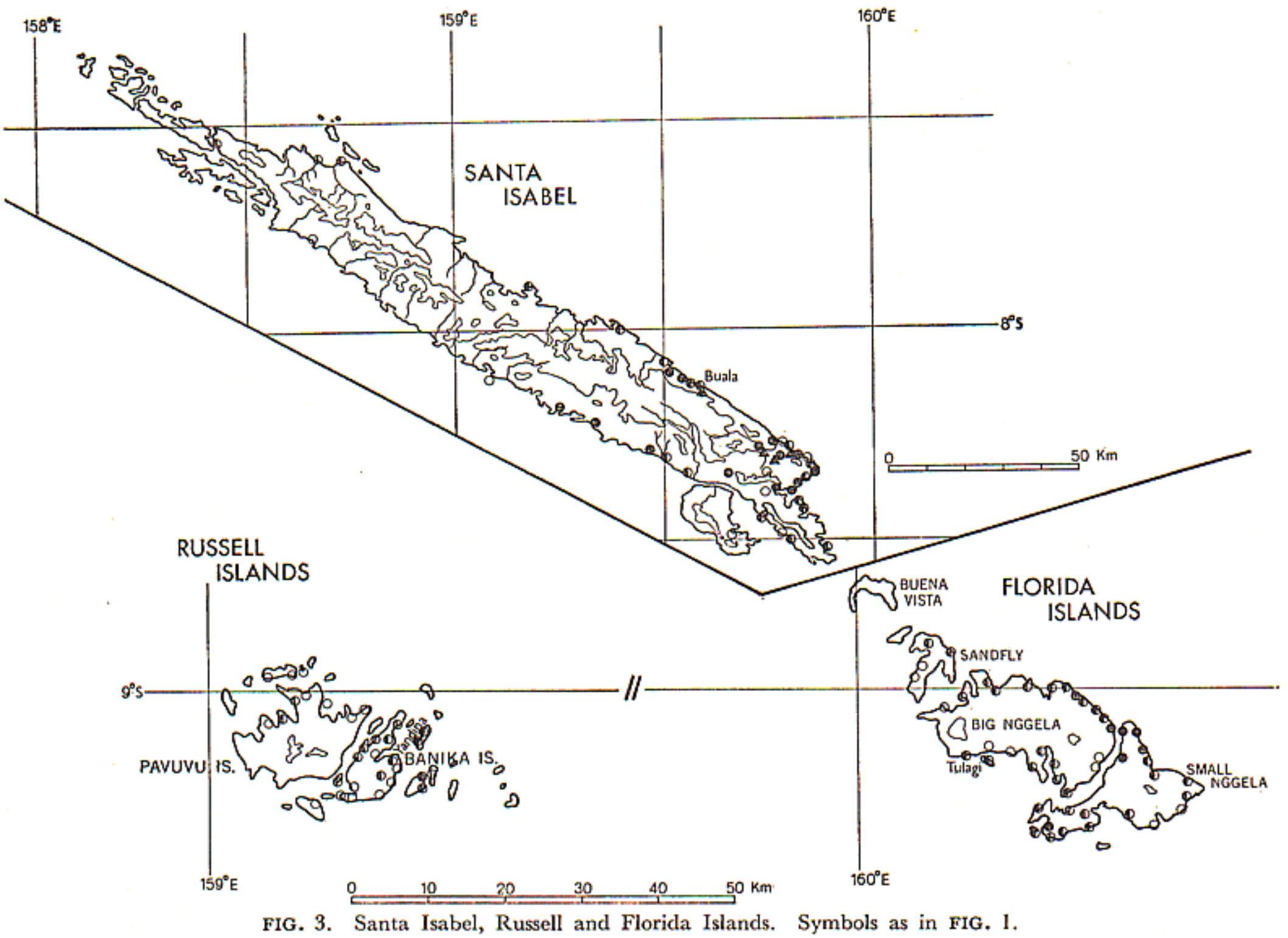

FIG. 3. Santa Isabel, Russell and Florida Islands. Symbols as in FIG. 1.

Tikopia, Vanikoro, Temotu and at Graciosa Bay, Santa Cruz (Belkin 1965).

The only other collections prior to the onset of the recent malaria eradication activities appear to be those of G. S. Parsonson who, in 1964, found *A. farauti* on Vanikoro, the Duff Islands and at Graciosa Bay, Santa Cruz (pers. commun.).

Surveys by malaria eradication staff of the B.S.I.P. Medical Department

Methods used

The limited road system on the islands has meant that nearly all the survey work has had to be carried out by 1 or 2 men traveling either by small inshore launch or, more often, on foot.

Adult anophelines were collected by means of daytime searches in houses for resting females or by nighttime man-biting catches and indoor resting searches. In most cases battery-powered aspirators were used for catching the adults. Identification of the species followed the keys of Belkin (1962). Adults were usually identified in the field on the basis of proboscis markings as seen under a 10 × handlens but from time to time specimens were pinned for laboratory identification. Larvae were preserved in MacGregor's solution and subsequently identified in the laboratory.

Surveys were carried out between 1962 and 1971. Nearly all the inhabited areas of the Protectorate were surveyed although in some areas, such as the New Georgia group and the inland areas of Choiseul and Santa Isabel, the coverage was poor. A limited amount of information on the work led by U. J. Mataika in 1962 to 1964 was given by Macgregor (1968). Slooff (1972) gave details of collections during the period of his assignment as W.H.O. entomologist with the malaria pre-eradication program from March 1964 to October 1968. Neither of these authors gave any maps of the distribution of the localities at which collections were made and, without access to the detailed operational maps produced by the malaria eradication staff, their results are not easy to interpret. Therefore, this paper reiterates the results prior to October 1968 and shows them on the maps (FIG. 1–6), together with the data collected between October 1968 and the end of 1971.

(1) *Guadalcanal:* Entomological activities associated with a malaria eradication pilot project commenced on this island in April 1962. The section, although small, managed to visit most areas of the island during 1962 and early 1963 and the results, especially in the inland, or bush, areas and on the south coast, added considerably to the findings of Belkin et al. (1945). The distribution of *A. koliensis*, in particular, was found to be much more general than the wartime findings indicated. A summary of the results from some 175 localities is shown in FIG. 1.

(2) *Western District:* The work in the New Georgia group was somewhat limited. In 1962 and early 1963, 20 localities were visited in an area comprising the Marovo lagoon, Munda and Vella Lavella, Ranongga, Simbo and Gizo Islands. A further 17 localities on Kolombangara, Rendova and Tetepari Islands were surveyed in June and July 1965. The only species found was *A. farauti*. Surveys were carried out on Choiseul I. in 1966 and 1968 and a total of 57 localities was visited. This island had not featured in any previous mosquito collections and *A. koliensis* was found to be almost as widely distributed as *A. farauti*. FIG. 2 summarizes the Western District work. No collections were made in the Shortlands Group as these islands had been under spray coverage by the Papua New Guinea Malaria Control Service since 1959.

(3) *Santa Isabel, Florida Islands and Russell Islands:* The results from these islands are all shown in FIG. 3. Between August 1966 and March 1969, 48 localities were visited on Santa Isabel. *A. punctulatus* was found at only 3 localities while both *A. koliensis* and *A. farauti* were widely distributed. Fifty-nine localities were visited on the Florida Group during March and April 1965. Surprisingly, in comparison with the wartime records when only *A. farauti* was collected, *A. koliensis* was quite abundant along the north coasts of Big and Small Nggela Islands. *A. farauti* was the only species collected on the Russell Islands during visits to 31 localities in surveys during November 1965, March 1966 and February 1970.

(4) *Eastern Outer Islands:* These islands were visited several times between 1966 and 1969 but were not systematically surveyed until July and September 1970 when all the inhabited islands were visited. FIG. 4 shows that *A. farauti* was readily found on Santa Cruz (Ndende), Utupua, Vanikoro and the Duff Islands. On the Reef Group islands, which are slightly raised coral formations with little surface water, *A. farauti* appeared to be restricted to a small area near Mohawk Bay. Anophelines were not found on the 2 easternmost islands, Tikopia and Anuta, and, as these islands are traditionally free from malaria, it

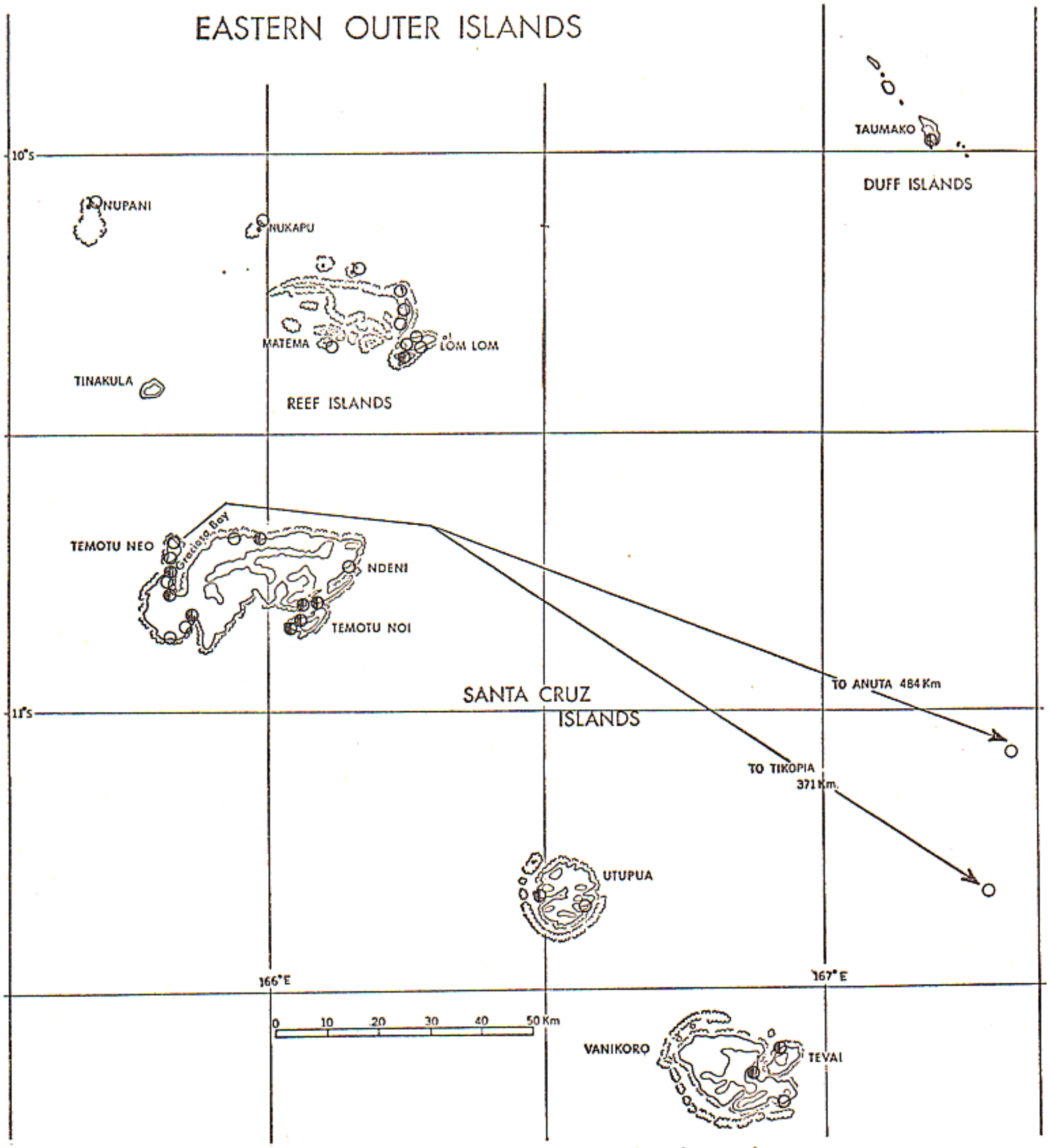

FIG. 4. Eastern Outer Islands. Symbols as in FIG. 1.

seems the presence of *A. farauti* on Tikopia in 1955–1956 was of a temporary nature. A more detailed account of the collections in the Eastern Outer Islands is given by Maffi & Taylor (1974).

(5) *Malaita:* Survey work on Malaita and its sister island, Maramasike or Small Malaita, started in 1967 and was intensified in late 1969 and early 1970 to cover as many areas as possible including inland, bush areas. These are the most densely populated of the major islands and some 320 localities were visited (nearly 1/5 of all villages reported in the records of spraying operations). *A. farauti* and *A. koliensis* were shown to be widely distributed but *A. punctulatus* was found in relatively few places (FIG. 5).

(6) *Outlying islands:* Ontong Java, Sikaiana and

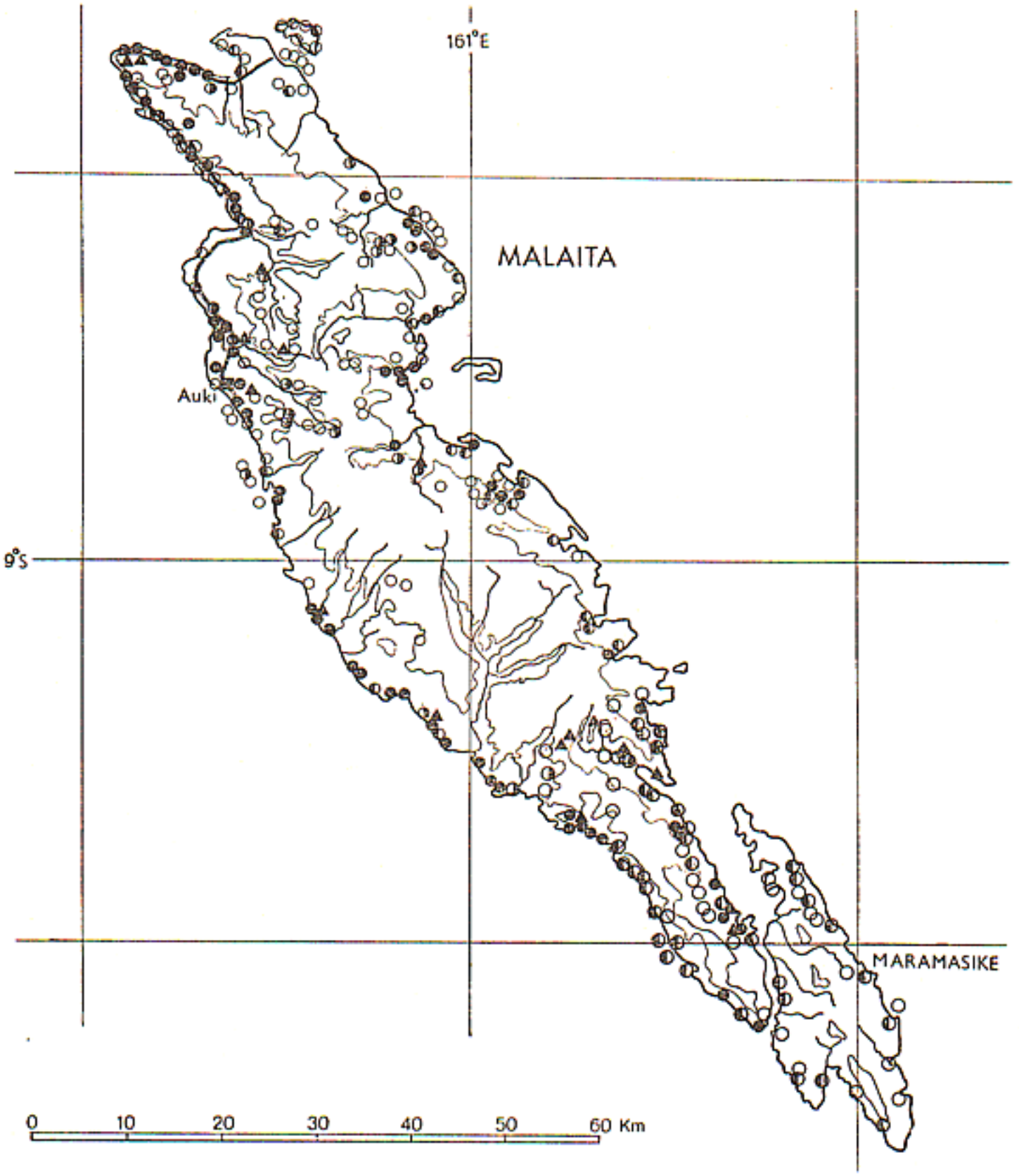

FIG. 5. Malaita Island. Symbols as in FIG. 1.

Ndai Island were visited in September 1969 and June 1970. On the 2 permanently inhabited islands of Ontong Java, *A. farauti* was found at Luaniua but not at Pelau. At Taini on Sikaiana, *A. farauti* was collected. *A. farauti* was found in the vicinity of the only village on Ndai Island. The island of Ulawa was visited in September 1969 and *A. farauti* was found at 6 of the 8 localities surveyed. Rennell and Bellona, both raised coral islands with Polynesian inhabitants, were surveyed in April 1966 when *A. farauti* was found on Rennell. Subsequently, in July 1969 and January and February 1970, *A.* cf *koliensis* was found on Rennell. Details of the collections on Rennell and Bellona are given by Maffi (1973a, b).

(7) *San Cristobal:* This was the last of the major islands to be surveyed. Very limited work took place in late 1967 but it was not until November 1970 that a survey program aimed at covering all inhabited areas of the island was started. The work, which also covered the adjacent small islands of Ugi, Santa Ana and Santa Catalina, but not, unfortunately, the Three Sisters Group, was completed at the end of 1971 and some 250 of the 280 known villages were visited. As was found on most of the other major islands, *A. farauti* and *A. koliensis* were widely distributed but *A. punctulatus* was relatively uncommon (FIG. 6).

Comments on distribution

General notes

Most of the results obtained from the malaria eradication project surveys were considered in preparing the species notes but particular use was made of the results obtained on Malaita. The fairly comprehensive survey of this island with its relatively numerous inland, or bush, population (around 7000 people) made it possible to analyze

TABLE 1. Altitudinal distribution of *Anopheles punctulatus* group on Malaita Island, September 1968 to September 1970.

Locality	Total no. localities visited	Anopheline free	*A. farauti*	*A. koliensis*	*A. punctulatus*
Artificial or offshore island	22	16	6	0	0
Coastal	145	41	91	61	5
Inland 0–100 m	49	10	27	29	5
100–200 m	17	9	5	10	2
200–300 m	10	6	2	0	2
300–400 m	9	5	2	1	2
400–500 m	11	7	1	3	0
500–600 m	8	5	2	1	0
600–700 m	5	4	0	1	0
700–800 m	4	2	2	1	0
800 + m	3	3	0	0	0
Unlocated on map*	37	24	9	6	2
Total	320	132	147	113	18

*Since frequent relocation of villages is common, some villages visited during surveys were no longer inhabited at the time of the 1st cycle of spraying operations.

the altitudinal distribution of the 3 species, *A. farauti*, *A. punctulatus* and *A. koliensis*. By using the 1 : 50,000 scale operational maps produced by the geographical reconnaissance staff of the malaria eradication program in conjunction with a B.S.I.P. Department of Lands and Surveys contour series, the altitude of each of the villages surveyed was estimated. Although the contour mapping was of an uncontrolled type, personal random checks of the altitudes of a few villages by means of an altimeter gave results in close agreement with the contour map. TABLE 1 shows the number of localities surveyed and the anopheline species found in arbitary altitudinal categories ranging from sea level to over 800 m. At a number of localities more than 1 species was collected (not necessarily sharing the same breeding site) and the association of species was as follows: *A. farauti* and *A. koliensis* together at 69 localities; *A. koliensis* and *A. punctulatus* together at 6 localities; and all 3 species together at 8 localities.

The maximum altitude at which both *A. farauti* and *A. koliensis* have been found in the Solomons was on Malaita at around 800 m. Laird (1955) found *A. punctulatus* at about 600 m on Guadalcanal whereas on Malaita it was not found above 400 m.

Temperature readings taken during one of the surveys on Malaita showed that although midday temperatures at an altitude of over 500 m were similar to those at sea level, the night temperatures dropped more rapidly and to a lower level. The daily temperature range at 500 m was over 10 °C compared with only 6 °C at sea level. It is possible that this greater daily temperature range is a factor in limiting the vertical distribution of the *A. punctulatus* complex in the Solomons although both *A. farauti* and *A. koliensis* were collected at altitudes over 500 m.

Species notes

Anopheles farauti: This species is widely distributed throughout the Solomons. Bellona, Anuta, Tinakula and certain of the outer islands in the Reef Group (e.g., Nupani and Nukapu) are the only inhabited islands on which *A. farauti* has not been found.

This species is not commonly found far from the coast and would seem to be most abundant in coastal swamp and low-lying riverine areas. Daggy (1945) commented that *A. farauti* could be said to surpass *Anopheles gambiae* in the variety of its breeding sites. In the Solomons, *A. farauti* has been found breeding in most kinds of water collection including rock pools with a salinity in excess of that of sea water (Maffi & Taylor 1974), stream edges, fresh and brackish swamps, permanent and temporary ground pools, small natural containers such as coconut shells, and rainwater collections on fallen trees. The only water collections not used are those in leaf axils and treeholes and where there is a high organic content. Daggy's comment is indeed justified when one considers that *A. gambiae* is now regarded as a complex of several species (with some, as *A. melas* and *A. merus*, breeding in salt water and others in fresh water) but so far there is no positive indication of any subspecific variation in the Solomons *A. farauti*. Bryan (1973) has, however, demonstrated 2 definite groups of *A. farauti* which, although apparently morphologically identical, when crossmated give sterile offspring. The 1st group comprised colonies from Rabaul (New Britain) and Tambea and Lunga on

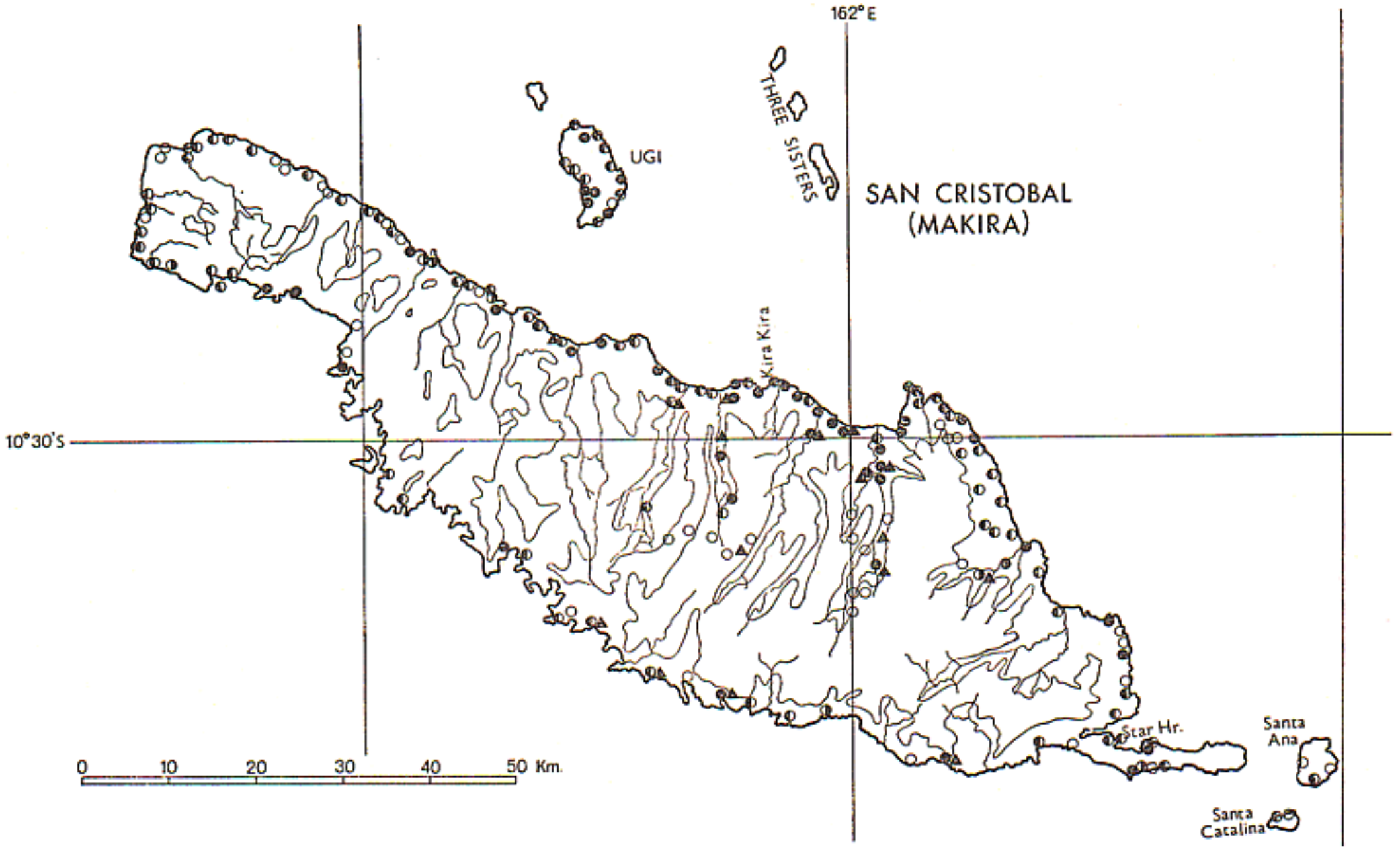

FIG. 6. San Cristobal and adjacent islands. Symbols as in FIG. 1.

Guadalcanal and the 2nd group was of colonies from the Eubenangee Swamps in Queensland, Australia (given as Eubenengie by Bryan). Recent unpublished work has shown *A. farauti* from San Cristobal to be genetically compatible with the Guadalcanal colonies (Bryan, pers. commun.).

Anopheles punctulatus: At first sight the distribution of this species is curious, with a relative abundance on Guadalcanal but only a very limited distribution on the islands of Santa Isabel, Malaita and San Cristobal. Comparison of the distribution data with a B.S.I.P. Department of Geological 1: 1,000,000 "Geological Map of the British Solomon Islands" shows the majority of the occurrences to be at places where the underlying rock is of an alluvium or reef limestone type laid down in the Recent Period of the Quaternary era. The inland records are mostly from riverine areas where alluvial deposits are found. Guadalcanal is the only island with widespread deposits of this type, especially on the north-central Guadalcanal Plains area, and thus it is the only island where the species is at all abundant.

The breeding sites of *A. punctulatus* are almost exclusively temporary rainwater pools and, although it is usually restricted to the valleys of larger streams and rivers, it can become extremely abundant following a period of heavy rain (Belkin et al. 1945, Slooff 1972). Observations carried out on a regular basis at Koli, North Guadalcanal, prior to the start of DDT house-spraying operations there in May 1963, showed no *A. punctulatus* between October 1962 and March 1963 but in April 1963 large numbers of the species were collected.

Anopheles koliensis: This species is now known to be widespread on all the major islands and island groups other than those of New Georgia and the Russell Islands. The distribution of *A. koliensis* is not as even as that of *A. farauti* and this may well be due to the closer association of *A. koliensis* with man. Owen (1945) found that, whereas only 10% of the total population of *Anopheles* he collected were *A. koliensis*, 90% of the indoor (tent) resting females were *A. koliensis* (5.8% of the remainder were *A. farauti* and 4.2% *A. punctulatus*). More recently, the results of precipitin tests on blood smears from engorged females, the relatively high numbers found resting in houses, and the late night, predominantly indoor, feeding habits have further underlined the anthropophilic nature of the species. The preferred breeding sites are temporary pools in grasslands and pools at the edge of the jungle (Owen 1945). In the Solomons, pools of this type are usually found only in the vicinity of larger, more

permanent human settlements and, both at the coast and inland, these most commonly have a riverine location. Studies of the pre-spraying malaria parasite rates in the human population indicate that the highest endemicity of the disease was often in areas where *A. koliensis* was abundant. The larvae collected on Rennell I. by Maffi in 1969 and reported as *A. koliensis* by Slooff (1972) have now been carefully examined by Maffi together with further specimens of female adults, pupae and larvae he collected in 1970, and they appear to constitute a population which is morphologically distinct from any of the recognized species within the *A. punctulatus* complex (Maffi 1973a).

The effect on the punctulatus complex of DDT residual house-spraying operations

Operations aimed at treating all places of human habitation with DDT residual spray (applied at a rate of 2.0 g per square m, repeated at 6-month intervals) were launched on Guadalcanal in October 1962 and extended to Savo and part of the New Georgia group by the end of the following 6-month period (Macgregor 1968). These operations have continued since that time and were gradually extended until, with the start of operations on San Cristobal in October 1971, the whole Protectorate came under spray coverage. The vector-free islands of Bellona, Tikopia and Anuta are the only exceptions. Spraying operations have recently ceased on Rennell I. and certain of the higher inland areas of Guadalcanal and Malaita. These latter areas have always been relatively non-malarious and malariometric and entomological surveys in 1971 and 1972 showed no evidence of transmission.

The population densities of all 3 species have usually fallen to a very low level in the months following the 1st cycle of spraying operations. *A. punctulatus* and *A. koliensis* have, in general, remained rare or absent thereafter. For instance, since spraying started in 1962, the first time that any significant numbers of these species were collected on Guadalcanal was in late 1972 when a resurgence of *A. punctulatus* was detected in low riverine areas of the north-central part of the land. In view of the fact that both *A. koliensis* and *A. punctulatus* displayed a high degree of endophily and endophagy prior to the onset of spraying and it was this that probably led to the pronounced effect of DDT on the species, the resurgence of *A. punctulatus*, and, to a lesser extent, *A. koliensis* is of some concern. It was not possible, unfortunately, to obtain enough specimens to carry out insecticide susceptibility tests nor was it possible to establish a laboratory colony.

A. farauti, however, appears to be much more adaptable. It is more ubiquitous in its breeding habits and before spraying showed equal tendencies towards exophily and endophily and exophagy and endophagy. Although during the first few months following the onset of spraying operations the population falls to a low level, it often recovers and in a number of areas has regained the original level after 18 months. This resurgence, coupled with an apparent shift and concentration of the time of peak biting activity towards the early night and the capacity to live and feed without entering houses, has reduced the effectiveness of DDT in those areas where the human population does not enter its houses until well after sunset. In areas where the species was not so well established before spraying or where the human population goes indoors at sunset, or both, the density of *A. farauti* has remained low. Consequently the problem of continuing transmission of malaria does not apply throughout the islands.

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