A MOSQUITO SURVEY IN NEW CALEDONIA AND THE BELEP ISLANDS, WITH NEW LOCALITY RECORDS FOR TWO SPECIES OF *CULEX*.

BY

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A MOSQUITO SURVEY IN NEW CALEDONIA AND THE BELEP ISLANDS, WITH NEW LOCALITY RECORDS FOR TWO SPECIES OF *CULEX*.*

By MARSHALL LAIRD, M.Sc., Ph.D.†

The archipelago made up by New Caledonia, the Belep Islands to the north-west and the Isle of Pines to the south-east, is bounded by Latitudes 19°30′ and 22°40′ South and Longitudes 163°35′ and 167°35′ East. New Caledonia itself is 248 miles in length and averages 30 miles in breadth. Its northern tip and the off-lying island of Baaba are in the same latitude as Aneityum, the most southerly Pacific island known to be malarious (Laird, 1954), which is some 360 miles to the east. The Belep Islands are positioned within the barrier reefs which trend north-west from New Caledonia. They extend for 23 miles more or less in line with the mainland ridge, from which they are separated by some 30 miles of sea. Art, the largest island, rises to an altitude of 728 feet. The Belep group has no European settlements other than the Mission Station at Uala, on the western coast of Art Island, where virtually all of the 550 natives (Melanesians and part Melanesians) are congregated.

There is no evidence that *Anopheles* or autochthonous malaria have ever been encountered in any of the islands of the New Caledonian archipelago. Mumford (1942) and Perry (1950) have reviewed the relevant literature, the latter author asserting that this island was still free from *Anopheles* and malaria at the end of active military occupation in 1946.

Comprehensive anti-anopheline measures in the area ceased with the withdrawal of Allied entomological control units. At the same time, New Caledonia remained more exposed to airborne introductions of dangerous insects than it had been in pre-war days; for air links were developed with countries such as the New Hebrides, Indo-China and Australia, in which occur species of *Anopheles*. The present flying-boat link with the New Hebrides brings Noumea, the capital of New Caledonia, within a very few hours flying time of the malarious islands of Efate and Espiritu Santo.

Buxton (1926) stated that in general all the islands between the Equator and 20° S., and New Guinea and 170° E., are malarious, the only exceptions being the Belep Islands " and a very few minute islands such as Tucopia." However, there is no indication in the literature as to what mosquitos occur in the Belep group, no mention being made of these islands by Williams (1943) and Perry (1950) in their accounts of the Culicidae of New Caledonia.

It was with the objects of ascertaining whether Anophelines have appeared in New Caledonia since the end of the war, and of undertaking mosquito- and haematozoan-surveys in the Belep Islands, that the reconnaissance discussed hereunder was carried out during November and December 1952.

The Culicidae of the New Caledonian Mainland.

Our knowledge of this fauna has been most recently summarised by Williams (1943) and Perry (1950). The latter author's list of the species recorded during

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the wartime surveys includes all 13 of the mosquitos known from the island prior to the present investigation:—

Tripteroides (*Mimeteomyia*) *caledonica* (Edwards)
Mansonia (*Coquillettidia*) *crassipes* (van der Wulp)
Aëdes (*Mucidus*) *alternans* (Westwood)
Aëdes (*Mucidus*) *kermorganti* (Laveran)
Aëdes (*Ochlerotatus*) *vigilax* (Skuse)
Aëdes (*Finlaya*) *notoscriptus* (Skuse)
Aëdes (*Stegomyia*) *aegypti* (L.)
Aëdes (*Aëdimorphus*) *vexans* (Meigen)
Culex (*Culex*) *annulirostris* Skuse
Culex (*Culex*) *sitiens* Wiedemann
Culex (*Culex*) *pipiens fatigans* Wiedemann* = (*C. quinquefasciatus* Say)
Culex (*Culex*) *basicinctus* Edwards
Culex (*Neoculex*) *pseudomelanoconia* Theobald

All but three of these species, *M. crassipes*, *A. alternans* and *A. kermorganti*, were collected in the course of a larval survey extending from Noumea along the western coast to Poum in the far north, during the periods 15th–24th November and 3rd–11th December 1952. As regards *M. crassipes*, larval *Mansonia*, which attach themselves to plant tissues underwater, were not specially searched for. That *A. alternans* was not collected might be due to seasonal factors. Cooling (1924) indicated that this species is seldom found in Queensland outside the period of influence of the king tide (latter part of January —middle of March). *A. alternans* breeds in salt marshes, where its larvae prey upon those of *A. vigilax* and *C. sitiens* (Cooling, 1924); and both of these species were found in all the suitable larval habitats examined. Williams (1943), who worked in New Caledonia during the period August–November 1940, also failed to find *A. alternans*, although he too collected *A. vigilax* and *C. sitiens* on many occasions.

It should be noted that there is some doubt concerning the identity of *A. kermorganti*, the larvae of which have not been described (although Perry, 1950, included it among the mosquitos recorded in wartime larval surveys). Edwards (1922) was of the opinion that this species might merely be a form of *A. alternans*.

The following larval associations were noticed: *A. vigilax* and *C. sitiens* (four times), *A. vexans* and *C. annulirostris* (once), *C. annulirostris* and *C. pipiens fatigans* (once), *C. annulirostris* and *C. bitaeniorhynchus* (twice).

In all the coastal areas visited, *A. vigilax* was by far the most abundant and most troublesome day-biting mosquito. It readily bites through clothing, even when exposed to bright sunshine. On one occasion, while in the north of the country, my wife and I were bitten about the head and shoulders while swimming about fifteen yards from the banks of the Kone river on a hot, sunny afternoon. Fortunately, this species is very sensitive to dimethyl phthalate repellents. *C. annulirostris* was the most numerous and widely-distributed night-biter at the time of the survey. *C. sitiens* and *A. vexans* were sometimes locally abundant in the vicinity of their breeding places, the former species particularly so at Gatope village (on the coast near Voh) and the latter one at Tontouta Airport, where its larvae were common in ponded drainage ditches. Many adults of *C. pipiens fatigans* (both sexes) were collected in the passenger waiting room at Tontouta on 18th November 1952, although a prolonged search failed to reveal any larvae in the vicinity. No adults of either *A. notoscriptus* or *A. aegypti* were found outside of the Noumea area, but these mosquitos, particularly the latter one,

* See note on p. 293.

are said to be common domestic pests in the town itself. The only other species recognised in the field in the adult state was *T. caledonica*, a single female of which was captured at light at Anse Vata, Noumea, at 21.30 hrs. on 22.xi.1952.

Williams (1943) and Perry (1950) agreed as to the major importance of *A. vigilax* as a pest mosquito in New Caledonia. However, the latter author failed

TABLE I.

Synopsis of larval records.

Species	Localities	Habitats	No. of times collected*
T. caledonica	Noumea	Tree-hole	1
A. vigilax	Noumea, Tontouta, Voh, Koumac, Poum	Mangrove swamps, brackish and tidal pools	8
A. notoscriptus	Noumea	Tin can	1
A. aegypti	Noumea	Water tanks	2
A. vexans	Noumea, Tontouta	Ponded ditches	2
C. annulirostris	Noumea, Tontouta, Voh-Koumac-Poum	Ponded ditches, hoof-print pools, swamps, road ruts, etc.	9
C. sitiens	Noumea, Voh, Koumac	Mangrove swamps, brackish and tidal pools	4
C. pipiens fatigans	Poum	Water drum, swamp	2
C. basicinctus	Voh	In algae at edges of Temala river	2
C. pseudomelanoconia	Near Bouerabate, far north	At edges of a ponded, rocky creek	1
	First record from New Caledonia		
Culex (*Culex*) *bitaeniorhynchus* Giles	Anse Vata (Noumea)	In masses of *Spirogyra* in ponded ditches	2

* The total number of individual collections (26) was less than the sum of these figures indicates, as more than one species of mosquito sometimes utilised the same larval habitat. Each collection was a comprehensive one embracing all aspects of the biology of the water body concerned, an average of an hour being spent in the examination of each breeding place. Similar studies were made of a number of water bodies which altogether lacked CULICIDAE. A detailed consideration of the data gathered will be published at the conclusion of the studies at present in progress, as a contribution to Pacific mosquito ecology.

to comment on the prevalence of *C. annulirostris* adults, although he recorded larvae from fresh or stagnant water in ponds, road ruts and artificial catchments, while Williams, Theobald (1913) and Edwards (1922) did not record this species at all. The lack of earlier information concerning this mosquito in New Caledonia is surprising, for *C. annulirostris* was second only to *A. vigilax* in pest significance during the present survey. Its developmental stages were found in freshwater ground pools of various kinds both on the mainland (Table I) and in the Belep Islands (p. 291) more frequently than were those of any other mosquito.

With two exceptions, the larvae of the mosquitos previously known from the island correspond with the descriptions published by Lee (An atlas of the mosquito larvae of the Australasian region. Tribes Megarhinini and Culicini.—119 pp. Aust. milit. Forces H.Q., 1944). The siphonal detail of my examples

of *C. pseudomelanoconia* differs considerably from that of the Australian larvae described and figured by Lee, but agrees substantially with that of the New Caledonian material discussed by Williams (1943). The larvae figured by Lee (his Pl. 85) has a siphonal index of 4·7 : 1, the siphon having a medial dark band, whereas that illustrated by Williams (his fig. 12a) has a long and slender siphon (index 7·3 : 1) lacking such a band. As is shown in fig. 4, the siphon of the larvae which I collected near Bouerabate is of similar length-breadth ratio to that figured by Williams, but has a prominent dark band medially—although this band is darker in some larvae than in others, and may disappear altogether in alcohol-preserved specimens. The pecten teeth, which Lee illustrated as only slightly serrated, are, as Williams figured them, prominently multi-dentate (fig. 2). Williams failed to describe the characteristics of the head, but, according to Lee, head hair B is very long and single, while C and d are very short and branched. In the Bouerabate larvae head hair B is double, C is single and about half the length of B, while d is comparatively short and branched (fig. 1).

The second mosquito showing marked variance from Lee's account is *C. annulirostris*. Larvae of this species collected in New Caledonia, particularly those from natural swamps of a permanent nature, frequently have a much longer and more slender siphon than the ones described by Lee (his Pl. 75, siphonal index about 7 : 1). Their siphonal index reaches 10 : 1, and there are often seven instead of the customary six siphonal hairs; while the anal gills, normally about three-quarters the length of the saddle, may be appreciably longer than this structure. Adults reared from such larvae do not differ from typical *C. annulirostris*. Perry (1946) reported a similar variation of the larvae of this species in the New Hebrides, those from natural freshwater swamps having a siphonal index close to 8 : 1 in contrast to those from various ground pools of a temporary nature which possessed a short siphon having an index of from 4·5 : 1 to 6 : 1.

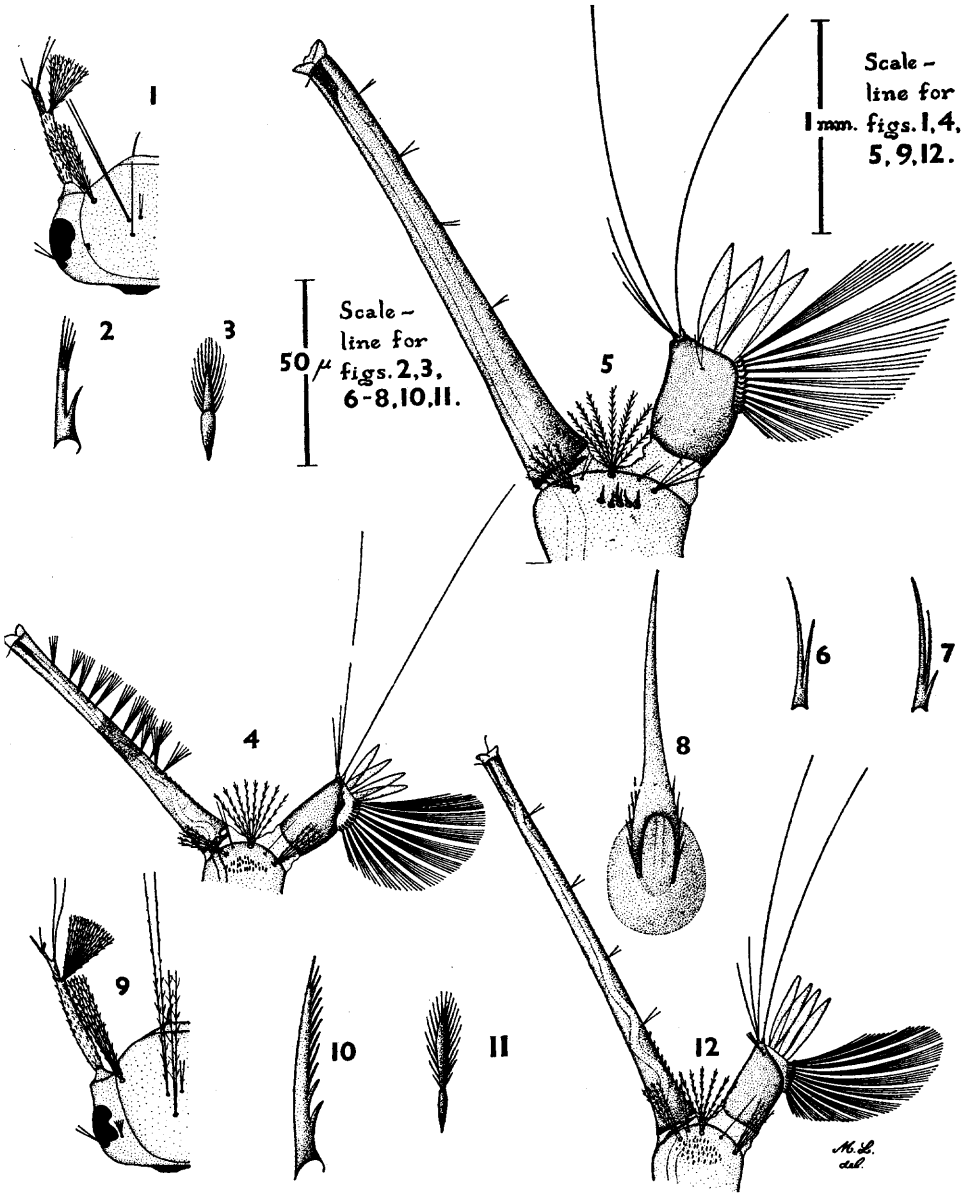
Culex (*Culex*) *bitaeniorhynchus* Giles has never before been reported from New Caledonia, nor indeed from any of the islands of the south-west Pacific. The distribution of this species was given by Lee (*loc. cit.*) as New South Wales, Northern Australia, the Oriental Region and Africa. The larvae of *C. bitaeniorhynchus* cannot be confused with those of any other Australasian mosquitos. According to Lee (*loc. cit.*) their diagnostic characters are as follows:—

> Siphon extremely long, with 4 pairs of ventro-lateral bifid hairs. Pecten inconspicuous. The most obvious character is the lateral comb, which consists of about 6 spines, each arising from a chitinous base.

All aquatic stages of *C. bitaeniorhynchus* were collected from ponded ditches at Anse Vata, Noumea, on 21.xi.1952. Larvae were abundant in clumps of *Spirogyra* at the bottom of the clear, fresh water in these ditches. The pH of the water was 8·2 (at 30°C.), and there was no overhanging vegetation at the surface, which was fully exposed to sunlight. The only other species of mosquito present was *C. annulirostris*.

As seen in the field the *bitaeniorhynchus* larvae had a very pale body with a jade green tinge. They differed from all the other species of *Culex* studied in New Caledonia in that they died instantly on immersion in 70 per cent. alcohol. Dissection revealed the gut to be crammed full with chewed-off lengths of *Spirogyra* filaments. The terminal segments, and the pecten and comb teeth, are illustrated in figs. 5–8. There are from three to seven irregularly arranged spines (fig. 8) in the lateral comb, the characteristic number being six. In all important respects the larvae from Anse Vata agree with Lee's description and figures.

C. bitaeniorhynchus was not found outside the Noumea area, although its larvae were specially searched for. The occurrence of this mosquito in the



Figs. 1–4.—*Culex* (*Neoculex*) *pseudomelanoconia* Theobald, fourth instar: (1) head, dorsal view (left side only); (2) pecten tooth; (3) lateral comb scale; (4) terminal segments, lateral view.

Figs. 5–8.—*Culex* (*Culex*) *bitaeniorhynchus* Giles, fourth instar: (5) terminal segments, lateral view; (6) and (7) pecten teeth; (8) lateral comb scale.

Figs. 9–12.—*Culex* (*Lophoceratomyia*) *fraudatrix* Theobald, fourth instar: (9) head, dorsal view (left side only); (10) pecten tooth; (11) lateral comb scale; (12) terminal segments, lateral view.

(All figures prepared with the aid of a Zeiss-Winkel drawing apparatus, from alcohol-preserved specimens mounted in Canada balsam.)

vicinity of the capital, which received prolonged attention by Allied mosquito control during the war years, is noteworthy. Indeed, the collection localities are within a few hundred yards of a former Naval headquarters, and abandoned drip-oilers nearby testify to the control activity which once went on there. Even if this species had been overlooked in the collections discussed by Edwards (1922) and Williams (1943), it is most unlikely that such conspicuous larvae would have gone unnoticed by the wartime entomological survey teams.

It is therefore considered very likely that *C. bitaeniorhynchus* has been introduced into New Caledonia since the cessation of mosquito control activities in 1946. Such an introduction could have been made from New South Wales, as regular shipping and flying-boat services are maintained between Sydney and Noumea.

This circumstance underlines the necessity for the maintenance of efficient entomological quarantines at the ports of entry for both ships and aircraft to New Caledonia. Although the island is as yet free from *Anopheles*, breeding conditions there appear suited both to the south-west Pacific *A. farauti* Laveran and to Oriental and Indonesian species which utilise mangrove swamps as larval habitats. In the latter connection, extensive mangrove swamps occur at certain seaports, particularly at Koumac in the north, and also at Tontouta, the only airport at present used by land-based aircraft from abroad. These swamps and the adjacent salt marshes are the breeding grounds of myriads of the two brackish-water mosquitos *Aëdes vigilax* and *Culex sitiens*. In Indonesia and south-east Asia these same mosquitos occur in mangrove areas, together with *Anopheles sundaicus* (Rodenwaldt). The latter species is an important malaria vector in Indonesia and Indo-China (Puri, 1949), and that it has not yet reached the limits of its distribution is shown by its recent invasion of eastern India (Muirhead Thomson, 1951). In view of this, and the frequent air and sea traffic between Indo-China and New Caledonia by way of Indonesia, it is considered that serious attention should be paid to the problems of entomological quarantine at the ports of entry in question.

Turning now to *Anopheles farauti*, this mosquito, the most widely distributed vector of the human malarial organisms in the south-west Pacific, is abundant in the New Hebrides. In this group, its larvae are found in the same range of habitats as are those of *C. annulirostris*. Comparisons being made during the present studies have so far failed to disclose any fundamental differences in the biology or chemistry of breeding places of the latter mosquito in the New Hebrides and New Caledonia, and there are *annulirostris* larval habitats throughout the area of Noumea, the port of entry for flying boats which maintain a weekly air service with the New Hebrides and also for shipping from this group. Here again, a definite hazard appears to exist and should be met with more comprehensive preventative measures than the (not always efficient) insecticidal spraying of aircraft alone.

Investigations in the Belep Islands.

Eight days (25.xi.52–2.xii.52) were spent at Art Island, which is largely of serpentine formation. The eastern end of this island has a very arid appearance; the ochreous-red colour of its soil, which is due to the presence of quantities of iron, showing everywhere through the sparse, drought-resistant scrub. Numerous very small streams run quite steeply down to the coast, more or less at right angles to the central ridge, and there are a few short creeks subject to tidal influence. At the time of the survey, which took place at the end of the dry season, the beds of most of the smaller streams were dry, containing only scattered pools in cavities excavated by cascades during the wet season. The central spine of the island carries stretches of forest composed chiefly of niaouli

(*Melaleuca leucadendron*). Above the Mission Station at Uala, at an altitude of some 300 feet, there is a permanent pond about 80 feet across in a marshy hollow surrounded by niaouli trees. Vegetation is somewhat denser on the eastern coast, and near an old village towards the north-eastern end of the island there are stretches of mangrove swamp and a few freshwater seepage pools.

Six species of mosquitos were collected during this visit:—*T. caledonica*, *A. vigilax*, *A. vexans*, *C. annulirostris*, *C. pipiens fatigans* and *Culex* (*Lophoceratomyia*) *fraudatrix* Theobald, of these the last being recorded from the New Caledonian area for the first time.

As in New Caledonia, *C. annulirostris* was the mosquito most commonly found breeding in freshwater ground pools. Its larvae were taken in ponded stream channels and ditches, in seepage pools on the north-eastern coast, and in the permanent pond in the hills above Uala. *C. pipiens fatigans* was also plentiful, its larvae being abundant in small pools rich in organic matter in the vicinity of native dwellings. Adults of these two Culicines made up the bulk of routine night catches. *A. vigilax* was not so abundant as on the mainland, although this species was troublesome in the vicinity of the mangrove swamps on the north-eastern coast. *A. vexans* was seldom collected, and its larvae were found once only, a few in the second instar being taken from the pond above Uala in which they were living in association with *C. annulirostris*.

Several hours were spent in a fruitless search for mosquito larvae in the water held in the leaf axils of *Pandanus*. Pitcher plants (*Nepenthes* spp.), which afford a favourite larval habitat for *Tripteroides caledonica* on the mainland, were never seen on the island. On one occasion, however, larvae of this species were found, quite fortuitously, together with those of *C. fraudatrix* and *C. fatigans*. Very heavy rain, the first for some time, fell on the evening of 29th November. During the following afternoon, a number of obviously discomforted larvae were noticed at the surface of a rock pool in the bed of a small stream about a mile and a half north of Uala. The water in this pool was coloured bright yellow with suspended mud. On collection, the larvae in question proved to be those of the three species mentioned above. Although adults could not be obtained, as all the larvae died soon after they were found, no hesitation was felt, other than in the case of *C. pipiens fatigans*, in assigning these mosquitos to the species indicated.

Three of the larvae agree with the diagnosis of *Culex* (*Lophoceratomyia*) *fraudatrix* Theobald as given by Lee (*loc. cit.*) in all respects other than in the presence of a dark band just beyond the mid-point of the siphon. Perry (1946), describing the larvae of *C. fraudatrix* in the New Hebrides, stated that the siphonal band is only occasionally present, and indicated that *Culex hilli* var. *buxtoni* Edwards (which was said to have a siphon resembling that of *C. fraudatrix* but lacking a dark band) is a synonym of the former species. I have myself collected *fraudatrix* larvae lacking a siphonal band, and similar in every respect to the one under discussion, in the New Hebrides; and therefore regard the Art Island larvae (figs. 9–12) as belonging to this species.

C. fraudatrix is widely distributed from Australia to south-east Asia (Lee, *loc. cit.*), and in Melanesia has been recorded from New Guinea and New Britain to the Solomons and New Hebrides (Perry, 1946). In New Britain (Laird, 1946) and the New Hebrides its larvae are frequently found in association with those of *Anopheles farauti*.

Nineteen of the larvae of the second species of *Culex* from this pool have a stout, straight-sided siphon (index 5:1) bearing three pairs of ventro-lateral hair tufts and one dorso-lateral pair. The maximum width of the siphon is at the base, this being the chief larval characteristic used in the separation of *Culex* (*Culex*) *pacificus* Edwards from *C. pipiens fatigans* by Lee (*loc. cit.*), who stated that in the latter species the siphon usually has curved sides, its greatest

width being about one-third from the base. On comparison of the Art Island material with *C. pacificus* larvae from the New Hebrides (the only known locality for this species), however, a point of difference is obvious. As indicated by Perry (1946) the larvae of the latter mosquito have stout and bluntly pointed setae on the basal two-thirds of the antennae, whereas in *C. pipiens fatigans* these spines are slender and tapered. As the setae concerned are in the latter condition in the Art Island larvae, it is considered that these are referable to *C. pipiens fatigans* despite the uncharacteristic shape of the siphon.

The larvae discussed above had presumably been flushed from their natural habitats further up the hillside as a result of the previous night's downpour, those of *Tripteroides caledonica* having probably been washed out of a rot-hole either in a branch overhanging the stream or in a fallen tree.

Once again no Anophelines were discovered. As a further check against the presence of such mosquitos, however, both thick and thin blood smears were taken from all the native children who had never left the Belep Islands—a total of 170, their ages ranging from a few months to seventeen years. A thorough microscopic examination of these preparations disclosed no haematozoa whatsoever (although as all the smears were made during the daytime, there is a possibility that periodic microfilariae occur but were overlooked). In view of the facts that so many children were found negative for *Plasmodium*—for at Aneityum, earlier in the 1952 dry season, 7 of 45 children examined were found to be positive (Laird, 1954)—and that no Anophelines were discovered even though all apparently suitable larval habitats encountered were thoroughly searched, it is felt that the Belep Islands, as New Caledonia itself, can be definitely considered as yet free from *Anopheles* and malaria.

Summary.

The mosquito fauna of New Caledonia and the Belep Islands is discussed, together with some features of the larval morphology of *Culex* (*Culex*) *pipiens fatigans* Wied., *C.* (*C.*) *annulirostris* Skuse and *C.* (*Neoculex*) *pseudomelanoconia* Theo. *Culex* (*C.*) *bitaeniorhynchus* Giles, herein recorded from New Caledonia for the first time, is probably a post-war introduction into the Noumea area from Australia. *Culex* (*Lophoceratomyia*) *fraudatrix* Theo., recorded from Art Island (Belep group), has not previously been known from the New Caledonian area. From the mosquito and blood-smear survey in the Belep Islands, it is concluded that these islands, like New Caledonia, are as yet free from *Anopheles* and malaria.

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Note.—The name *Culex pipiens fatigans* Wied. is adopted in this paper in preference to *Culex fatigans* Wied., the name by which this form has hitherto been known. The authority for this change is to be found in Mattingly and others (Trans. R. ent. Soc. Lond., **102,** pp. 331–382, 1951 (R.A.E., (B) **40,** pp. 62–67)).—Ed.
