Notes on the Mosquitoes of Nissan Island, Territory of New Guinea[1]

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NISSAN ISLAND, also known as Green Island, Sir Charles Hardy Island, or Los Caimanes, lies approximately halfway between the Solomon Islands and the Bismarck Archipelago. Some 50 miles east of southern New Ireland (Bismarck Archipelago) and 40 miles northwest of Buka (northern Solomons), it is in line with the main chain of the Solomons. The island is an elevated atoll, the seaward cliffs of the eastern side, in places upwards of 100 feet in height, owing their formation to gentle tilting associated with the elevation (Davis, 1928). An area of about 7 miles by 4 miles is enclosed by the atoll rim, which is never more than a mile, and often only a few hundred yards, in width. Before its military occupation Nissan was densely bushed, with the exception of two coconut plantations and a few native clearings. Some earlier accounts have overestimated the size of the island. Thus Schmiele (1891) speaks of it as being 15 miles in diameter with a rim 2 or 3 miles wide, and Hartert (1926) gives its dimensions as "about 27 km. long and 21 wide."

Nissan was held by the Japanese from 1942 to February, 1944, when an Allied force which included the Third New Zealand Division recaptured it. Two airstrips were laid down, and the island was used as an Allied air base until the middle of 1945. The local incidence of *Anopheles* and malaria being high, strict mosquito control was maintained throughout the military area during this period. Thus the initial malaria rate was low, only 46 cases being recorded among 6,922 New Zealand troops during the 3-month period from the landing until the departure of the Division in May, 1944. During the remainder of the Allied occupation, cases of primary malaria were infrequent and were usually traceable to infection outside the controlled area.

When Nissan was abandoned as an operational base, malaria control had been in force for almost a year and a half. The material discussed below was collected during a 10-day visit to the island in September, 1945. It was of particular interest to note how rapidly and completely *Anopheles* had reoccupied the abandoned base in the 2 months which had elapsed since the cessation of mosquito control activities.

Three species of mosquitoes have previously been recorded from Nissan: *Anopheles* (*Myzomyia*) *farauti* Laveran, recorded by Perry (1945); *Tripteroides* (*Tripteroides*) *nissanensis* Lee, described from material collected by L. J. Dumbleton; and *Aëdes* (*Finlaya*) *kochi* (Dönitz), recorded by Marks (1947) from material collected by L. J. Dumbleton. *T. nissanensis* was not recorded in the present survey. The other two species and the following four additional ones were collected: *Aëdes* (*Stegomyia*) *quasiscutellaris* Farner and Bohart, *Aëdes* (*Aëdes*) *carmenti* Edwards, *Armigeres breinli* (Taylor), and *Culex* (*Culex*) *annulirostris* Skuse.

THE BIOLOGY OF MOSQUITO LARVAL HABITATS

The vegetation of ground pools on the overgrown Tangalan plantation closely resembled that of similar pools in New Britain (Laird, 1947) and the Solomons. *Paspalum conjugatum* Berg., *Echinochloa colona* O. Kuntze, and *Eleusine indica* Gaerter were the

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usual marginal grasses. As at Jacquinot Bay, New Britain, clumps of *Pennisetum macrostachyum* (Brongn.), *Clitoria* sp. (Papilionaceae), and *Cucumis* sp. (Cucurbitaceae) were also commonly present. Algal mats were composed mainly of the green algae *Spirogyra* and *Hormidium* or the blue-greens *Oscillatoria*, *Anabaena*, and a member of the Chroococcaceae.

Hemipterans of the families Notonectidae, Gerridae, and Veliidae, a small dytiscid beetle of the genus *Bidessus*, nymphs of Odonata, and developmental stages of Chironomidae (Diptera) comprised the usual macrofauna associated with mosquitoes in long-established ground pools. There was insufficient time available for studying the significance of any of these arthropods as predators of developing mosquitoes. Webs of spiders belonging to the genera *Epeira* and *Carepalxis* often spanned portions of ground pools and such artificial larval habitats as oil drums. On several occasions remains of adult *Anopheles farauti* and *Culex annulirostris* were found in these webs.

NOTES ON THE BIONOMICS OF THE MOSQUITOES COLLECTED

Anopheles farauti Laveran, 1902, Soc. de Biol., Compt. Rend. 54: 908.

At the time of the survey there were 18 ground pools of a semipermanent nature in the abandoned RNZAF area in Tangalan plantation. Sixteen of these pools held developmental stages of *A. farauti*. Although many of them were exposed to direct sunlight and contained predaceous insects, shade and shelter were afforded the anophelines by marginal and emergent vegetation, floating masses of green and blue-green algae, and surface debris. The other two pools were without vegetation other than felted, bottom-dwelling algae. Although numerous other arthropods were present in these, mosquitoes were absent. The presence of predators together with the lack of sheltering vegetation probably explained the absence of anophelines from these two pools.

Larvae of *Culex annulirostris* were always associated with those of *A. farauti* in the ground pools examined. Estimates of the hydrogen-ion content of the water of these larval habitats made with nitrazine paper ranged from *p*H 5.5 to *p*H 7.0 and averaged *p*H 6.5. During the daytime the water temperature averaged about 33°C. and once was recorded as 41°C. in an exposed situation. In this last case, all the larvae of both *C. annulirostris* and *A. farauti* present were sheltering in the shade afforded by floating coconut husks and an oil drum half-submerged in the water. The average larval population of *A. farauti* per square foot of water surface (50 counts) was 75, early instars outnumbering fully developed larvae by about five to one.

On one occasion numerous anopheline larvae were found in association with those of *C. annulirostris* and *Aëdes quasiscutellaris* in a 44-gallon drum half-filled with water, shaded by the eaves of an abandoned hut. The water was cloudy and its hydrogen-ion content was *p*H 6.0. Many larvae and pupae of Chironomidae were associated with the mosquitoes. *A. farauti* was recorded from only one other artificial larval habitat on Nissan, when seven fully developed larvae and one pupa were found, together with 25 larvae and pupae of *A. quasiscutellaris*, in a tin can shaded by tall grasses and containing 300 cc. of rain water.

Numerous adult females of *A. farauti* were captured at the camp each evening. In addition, many specimens of both sexes were taken by sweeping the marginal grasses around larval habitats during the daytime with a hand net.

Aëdes (Finlaya) kochi (Dönitz, 1901), Insekten-Börse 18: 38.

Developmental stages were found in water held in the leaf axils of most of the taro plants (*Colocasia* sp.) examined. This water was always clear, the hydrogen-ion content ranging from *p*H 6.0 to *p*H 7.0, and the water temperature averaging 29°C. (some 2° less than the shade air temperature) during the daytime. The average population of *A. kochi* (50 counts) was five larvae and pupae per cubic centimetre of water. The largest number recorded in one leaf axil was 136 (81 early instar larvae, 43 late instars, and 12 pupae) in 15 cc. of water. Developmental stages of Chironomidae were commonly found in association with those of *A. kochi*. Large numbers of small ants were once noticed swarming over the leaf and stem surfaces down to the edge of a small pocket of water (about 2 cc.) in a taro leaf axil. The water held two early instar and three late instar larvae of *A. kochi*, which were promptly seized upon by the ants when the water was drained away by means of a knife cut.

A. kochi females were abundant at the camp during the evenings, and featured prominently in biting collections made from dusk until about 11:00 P.M.

Aëdes (Stegomyia) quasiscutellaris Farner and Bohart, 1944, Biol. Soc. Wash., Proc. 57: 120.

Like other members of the *scutellaris* group, *Aëdes quasiscutellaris* breeds readily in domestic situations. Developmental stages were collected from a variety of habitats, for the most part domestic in nature. These included 44-gallon drums, an old water tower, truck tyres lying flat on the ground, tin cans, coconut husks, and tree holes. In drums and tanks they were often associated with *Culex annulirostris*, and once with *Anopheles farauti* as well. Many larvae of *A. quasiscutellaris* and *C. annulirostris* were found in a flour drum full of water in the dark interior of a shed. *A. quasiscutellaris* was never found in association with other species of mosquitoes in such larval habitats as water held in truck tyres, coconut husks, and tree holes.

The water temperature in larval habitats of *A. quasiscutellaris* was generally some two or three degrees Centigrade above that of the shade air temperature at midday. In one such habitat, a 44-gallon drum standing in an exposed situation at the edge of one of the airstrips, the midday water temperature was found to be 36°C. The hydrogen-ion content of water holding developmental stages of this species ranged from *p*H 5.5 to *p*H 6.5.

Chironomidae were constantly associated with *A. quasiscutellaris* throughout its range of larval habitats, and adults and larvae of dytiscid beetles (*Bidessus* sp.) were sometimes plentiful. The presence of the latter insects did not appear to have any appreciable effect on the numbers of *Aëdes* present.

Adults of *A. quasiscutellaris* were not troublesome during the evenings, but bit constantly in shady places near larval habitats during the daytime.

Aëdes (Aëdes) carmenti Edwards, 1924, Bul. Ent. Res. 14: 388.

No breeding places were ever discovered. Adult females were common and bit readily in shady jungle during the daytime. A few were captured in a lighted room in the early evening.

Armigeres breinli (Taylor, 1914), Roy. Ent. Soc., London, Trans. 1914: 186 (*Neosquamomyia*).

Developmental stages were commonly found in coconut husks which had been pierced for drinking purposes. These husks had a small hole in one place only, and held water of a yellowish colour heavily charged with decomposing copra. They were usually shaded from direct sunlight by grasses, and the water within them attained an average midday temperature of 28°C., some 3° less than the prevailing shade air temperature. Water emptied from these husks frequently held a wriggling mass of larvae and pupae of *A. breinli*. In one case 363 early instar larvae, 119 late instars, and 41 pupae were counted in 250 cc. of water from a single husk. No other mosquitoes were associated with *A. breinli* in any of the larval habitats examined, but hover-fly larvae (Syrphidae) were sometimes present.

The species was troublesome in the shade of abandoned buildings and at the jungle's edge throughout the day, especially so in the late afternoon. On one occasion numerous *A. breinli* together with a few *Aëdes quasiscutellaris* were noticed biting two domestic cats resting in the shade of a wall at midday.

Culex (Culex) annulirostris Skuse, 1889, Linn. Soc. N. S. Wales, Proc. 13: 1737.

Collections were made from 26 larval habitats, 16 of these being the ground pools utilized by *Anopheles farauti*. *C. annulirostris* was recorded from water in 44-gallon drums four times: once alone, twice in association with developmental stages of *Aëdes quasiscutellaris*, and once with both this species and *Anopheles farauti*. Larvae were also found with those of *A. quasiscutellaris* in the flour drum indoors previously mentioned. The other larval habitats noted were truck tyres (twice), an exposed wheelbarrow holding a few inches of rain water (the midday temperature of which was recorded as 40°C.), a pool on the steel tray of an abandoned truck, and water held in the folds of a self-sealing rubber petrol tank. In the latter cases larval Chironomidae were the only other arthropods present.

C. annulirostris was the most abundant and most troublesome mosquito during the earlier part of the evening. Adults of both sexes were attracted in large numbers to lighted huts. They were also collected during the day, together with *Anopheles farauti*, by sweeping the vegetation bordering ground pools.

DISTRIBUTION

Four of the seven mosquito species now listed from Nissan are common to the Solomon Islands and the Bismarck Archipelago: *Anopheles farauti* occurs throughout both island chains (Lee and Woodhill, 1944; Belkin *et al.*, 1945; Laird, 1946*a*); *Aëdes carmenti* is common to the Solomons (Edwards, 1924; Paine and Edwards, 1929), New Ireland (Edwards, 1925), and New Britain (Laird, 1946); *Armigeres breinli* is known from the Solomons (Paine and Edwards, 1929) and New Britain (Laird, 1946); and *Culex annulirostris* occurs throughout the South Pacific. *C. annulirostris* is widespread in the Solomons (Edwards, 1924) and has been collected in New Britain (Laird, 1946).

Of the other three species, one is indigenous but closely related to a species found in both island groups, one has not been recorded with certainty from the Solomons, and one does not occur in the Bismarck Archipelago. Lee (1945) states that *Tripteroides nissanensis* is closely allied to *T. quasiornata* (Taylor), which occurs in the Solomons (Belkin, 1945) and New Britain (Hill, 1925; Laird, 1946). *Aëdes quasiscutellaris* occurs throughout the Solomons (Farner and Bohart, 1945), but in the Bismarck Archipelago its place is taken by *Aëdes scutellaris* (Walker) (Stone and Farner, 1945; Stone, 1947). *Aëdes kochi* is a common mosquito in the Bismarcks where it is known from New Ireland (Taylor, 1934) and New Britain (Hill, 1925; Laird, 1946). There is no certain record of this species from the Solomons, and Marks (1947) states that Nissan is probably near its eastern limit.

MEDICAL SIGNIFICANCE

Malaria: *Anopheles farauti* is the principal vector of *Plasmodium* in the Solomons (Perry, 1945) and an important vector in the Bismarck Archipelago (Heydon, in Lee and Woodhill, 1944).

Filariasis: *Anopheles farauti* is claimed to be the most important vector of *Wuchereria bancrofti* in the Solomons (Anon., 1944). *Aëdes kochi* (Marks, 1947) and *Culex annulirostris* (Anon., 1944) may also act as vectors for this parasite.

SUMMARY AND CONCLUSIONS

The mosquito control measures practised on Nissan Island throughout the period of

Allied military occupation included weekly larvicidal treatment of all ground pools within the camp areas. Over the latter (and major) part of the period, 5 per cent DDT in Diesel oil was used for this purpose. From the fact that the pools examined in the present survey already supported thriving populations of various arthropods two months after the cessation of mosquito control activities, it is apparent that the residual effect of this treatment was short-lived. This was probably largely due to tropical downpours flushing away the DDT-Diesel oil emulsion from the pools. The rapidity with which *Anopheles* may reoccupy an area from which it has been temporarily excluded by control measures is well illustrated by the fact that all suitable larval habitats for *Anopheles farauti* in the old camp areas held heavy populations of this species when the survey was conducted. It may be that the presence of such large numbers of anopheline larvae (average: 75 per square foot of water surface) represented a temporary population peak made possible by the fact that the normal biological balance between *A. farauti* and its natural enemies had not yet been restored, because of the longer time required for the rebuilding of sufficiently heavy populations of such predators as Zygoptera, Coleoptera, and Gerridae to keep breeding of the anopheline in check.

The following mosquitoes are recorded from Nissan Island for the first time: *Aëdes* (*Stegomyia*) *quasiscutellaris* Farner and Bohart, *Aëdes* (*Aëdes*) *carmenti* Edwards, *Armigeres breinli* (Taylor), and *Culex* (*Culex*) *annulirostris* Skuse.

Of the seven species of mosquitoes now known from Nissan, four are common to the Solomon Islands and the Bismarck Archipelago, one is indigenous, and two are otherwise restricted to the Solomons and the Bismarck Archipelago respectively.

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