Observations on *Aedes (Stegomyia)* Mosquitoes in Micronesia and Melanesia

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ABSTRACT. Observations from a mosquito collecting trip to the Marshall, Caroline, and Mariana Islands of Micronesia and the Solomon Islands and Vanuatu of Melanesia are summarized. *Aedes albopictus* has expanded its range to Truk, and is now firmly established on northern Guadalcanal. The presence of *Ae. aobae* on Pentecost was confirmed. New colonies have been established of 2 populations of *Ae. albopictus*, 3 of *Ae. hebrideus*, and 1 each of *Ae. marshallensis* and *Ae. pernotatus*. Eggs from *Ae. saipanensis*, *Ae. pandani* and *Ae. quasiscutellaris* did not hatch in response to established procedures, and adults of *Ae. hakansonni*, *Ae. albolineatus* and *Ae. guamensis* could not be induced to feed in captivity. The literature for all *Aedes (Stegomyia)* species and their involvement in dengue transmission is summarized for the areas visited.

INTRODUCTION

The subgenus *Stegomyia* Theobald is one of the most important elements of the Central and South Pacific mosquito fauna. It is composed of 36 species that display a high level of single island or island group endemism. These mosquitoes are container breeders that may occur in great abundance in the vicinity of humans, to whom they are often a troublesome day-biting pest. A number of species are confirmed and several others suspected vectors of dengue or filariasis, both serious health problems in the Pacific. Due to their significance, they have been the focus of numerous studies (see Rai et al. 1982, for a review of the genetic and systematic literature). However, many species have not been colonized, ranges are unclear, and vectorial capacities are largely unknown.

Between February and April, 1982, the authors traveled to various areas of Micronesia and Melanesia for the purpose of collecting mosquitoes in this

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subgenus. Collections were made for electrophoretic studies of evolutionary relationships and to establish colonies for viral vector capacity investigations.

The following report is a compilation of notes concerning the distribution of *Aedes (Stegomyia)* and their role in the transmission of dengue. Information is presented on the Marshall, Caroline, and Mariana Islands in Micronesia and the Solomon Islands and Vanuatu (formerly the New Hebrides) in Melanesia. Specimens collected will be deposited at the Smithsonian Institution.

MARSHALL ISLANDS

In his overview of Micronesian mosquitoes, Bohart (1956) listed 4 species from the Marshall Islands. *Aedes aegypti* (L.), reported from many atolls in the island group (Suzuki and Hirshman 1977), was found to be the most common species in Rita and Dalap villages on Majuro (Ando 1982). We found that it was common throughout the Darrit-Uliga-Dalap urban area. However, in thickly vegetated areas, man-baiting resulted in the capture of numerous *Ae. (Stg.) marshallensis* Stone and Bohart. A vigorous colony of this species has been established at the University of Notre Dame.

CAROLINE ISLANDS

Three *Aedes* and 3 *Culex* species were found in a survey of Ponape by Knight and Hurlbut (1949). They originally described *Ae. (Stg.) hakanssoni* Knight and Hurlbut, which has been found in all subsequent surveys (Bohart 1956, Ando 1982). Larvae of this species have been collected in a wide variety of natural and artificial containers, but the adults have not been recorded biting humans. To obtain specimens, we placed leaves in an abandoned 55 gal. drum containing *Ae. hakanssoni* larvae. Several days later, the leaves were covered with many eggs, which were incubated, dried, and sent to Notre Dame. Hatching, emergence of adults, and mating were successful in the laboratory, but adults could not be induced to feed on humans, mice, or chicks, and a colony was not established. They do not appear to be autogenous, as no signs of ovarian development were found (J. Freier, pers. comm.).

Knight and Hurlbut (1949) suggested that *Aedes aegypti* was the vector for epidemics of dengue on Ponape during the Japanese occupation in World War II. Bohart (1956) also reported its presence, but subsequent searches by Suzuki and Hirshman (1975), Ando (1982), and ourselves were not successful. *Aedes hakanssoni* may be capable of vectoring dengue but it is not known to feed on man. *Aedes (Aedimorphus) senyavinensis* Knight and Hurlbut, the only other *Aedes* on Ponape, is in a subgenus which has never been implicated in dengue transmission. Nonetheless, there have been recent isolations of dengue type I from humans on Ponape (Rosen, pers. comm.), an event for which there is no current explanation.

Truk, also in the Carolines, was dry during February, and few mosquitoes were observed. Only limited numbers of blood-fed *Ae. (Stg.) hensilli* Farner were collected and colonization was not feasible. We also collected adult female *Ae. (Stg.) albopictus* (Skuse), the first record of this species from Truk, near the main road on the north side of Moen Island.

MARIANA ISLANDS

Because of the American military presence on Guam since World War II, the mosquito fauna of the Mariana Islands has been extensively studied. Bailey and Bohart (1952) reported an outbreak of dengue in 1944-1945, and suggested that earlier fever epidemics in 1911, 1932 and 1937 were also of dengue. Although Hammon et al. (1958) stated that *Ae. aegypti* had been considered the sole vector on Guam, Bailey and Bohart (1952) commented that the species was not recorded there before 1936. In any case, an intense eradication program after the World War II outbreak was successful, as there has been only 1 record of *Aedes aegypti* since 1948 (Teisen et al. 1972). Meanwhile, *Ae. albopictus* was introduced in 1944 (Rozeboom and Bridges 1972, first reported in Reeves and Rudnick 1951), and was abundant on all parts of the island by 1952 (Hu 1953). This was 1 of a series of inadvertent introductions (and 2 intentional introductions of *Toxorhynchites* species for control of other mosquitoes) that increased the number of mosquitoes present from 7 indigenous species to 12 in 1948, and then to 41 species by 1980 (Nowell 1976, 1980).

This is a striking example of how increasing human movement has altered the distributions of mosquitoes. These changes are not entirely recent phenomena, as the extensive ranges of container breeding species such as *Ae. albopictus*, *Ae. polynesiensis* Marks, and *Ae. hebrideus* Edwards are presumed to be due to transport centuries ago by ocean-going people (Belkin 1962, Taylor and Maffi 1978). *Ae. albopictus*, a species which will not normally travel more than 200 yards in its lifetime (Bonnet and Worchester 1946) and for which oceanic barriers would normally be insurmountable, now extends from Madagascar to Hawaii. Eads (1972) noted that *Ae. albopictus* individuals were found in surplus equipment shipped to Los Angeles from Vietnam. Because of regular commerce between islands, movements of mosquitoes and the disease organisms they transmit are extremely difficult to control.

The mosquito fauna of Guam and the other major islands in the Marianas, Saipan, Tinian, and Rota, has been summarized by Nowell (1980). He lists 12 species on Saipan, 13 on Tinian (only 8 were noted in Valder et al. 1976), and 9 on Rota (2 more than in Nowell and Sutton 1977). The totals include *Ae. aegypti*, which has apparently been eradicated from all of these islands.

We collected eggs from man-biting *Ae. saipanensis* Stone and *Ae. pandani* Stone, members of the Pandani Group of *Stegomyia* which is limited in distribution to the Marianas. Unfortunately, even though other *Stegomyia* eggs collected at the same time and treated identically hatched well, none of the Pandani Group eggs hatched. The peculiar hatching requirements of these species are unknown.

The only Scutellaris Subgroup species in the Marianas is *Ae. guamensis* Farner and Bohart. Bohart (1956) reported that they do not bite man, but will alight on shoes and trousers and are easily captured. In areas where both *Ae. guamensis* and Pandani Group species were abundant, we were able to induce a few individuals to take human blood meals. The small number of *Ae. guamensis* eggs that hatched at Notre Dame would not blood feed and a colony could not be established. Rozeboom and Bridges (1972) noted that *Ae. guamensis* density was declining, partially due to competition from *Ae. albopictus*. A colony has been established of *Ae. albopictus* collected on Saipan.

SOLOMON ISLANDS

Early mosquito surveys in the Solomons are summarized in Belkin (1962), and updated by Slooff (1972). In the 1970's, a series of papers greatly increased published information on the Solomons proper (Taylor and Maffi 1978), the southern outlying islands of Rennell and Bellona (Maffi 1973, Taylor 1973), and the eastern Santa Cruz group (Maffi and Taylor 1974).

Elliott (1980) first reported *Ae. albopictus* on Guadalcanal and on Ndeni in the Santa Cruz Islands. We observed that it has extended its range and is now established on the north coast of Guadalcanal. We collected them from water-filled cans at a small dump site near Ndondo Creek, 13 km east of Honiara in the Red Beach area. Larvae from these cans were reared to adults, and *Ae. (Stg.) quasiscutellaris* Farner and Bohart and *Ae. albopictus* were equally abundant, along with a smaller number of *Ae. (Stg.) albolineatus* (Theobald). *Aedes albopictus* was the only species observed biting humans in this area. Therefore, Belkin's statement (1962) that *Ae. albopictus* is unlikely to become well established in the South Pacific "for it does not seem to be able to compete successfully with other members of the *scutellaris* group" does not apply to the Solomons.

Ovitraps were placed in the cans at Ndondo, eggs collected, and *Ae. albopictus* and *Ae. albolineatus* hatched. If, as seemed likely, eggs of *Ae. quasiscutellaris* were present, their failure to hatch may indicate that they require special treatment. Although *Ae. albolineatus* were easily reared to adults, they would not blood-feed on either man, chicks, mice, or blood-filled capillary tubes, and a colony was not established. A population of *Ae. albopictus* from Ndondo Creek was easily colonized.

VANUATU

The mosquito fauna of Vanuatu was reviewed by Perry (1946) for the island of Espiritu Santo, summarized in Belkin (1962), and discussed in depth by Maffi (1977) for the main island group and by Maffi and Taylor (1977) for the more northerly Banks and Torres Islands. There were outbreaks of dengue in World War II on Efate and Espiritu Santo that Perry (1948) suggested were vectored by *Ae. aegypti*. Both *Ae. aegypti* and dengue continue to exist on Efate, but the mosquito seems to have been eradicated while the virus persists on Santo. This has lead to serious speculation that other Scutellaris Group mosquitoes, notably *Ae. hebrideus*, act as vectors (Daggy 1944, Rhodain and Fauran 1975, Maffi 1977). *Aedes hebrideus* is widespread through the island group, particularly in areas of moderate human disturbance such as isolated buildings or small dump sites, and was colonized from Santo, Pentecost and Efate.

Aedes pernotatus Farner and Bohart, also in the Scutellaris Subgroup, is not known to bite man in nature, and has only rarely taken a blood meal in the laboratory (Perry 1950, Belkin 1962). On Efate *Ae. pernotatus* was not observed feeding in the wild but field-collected larvae were raised, and captive adult females were coaxed to feed on humans. A colony of this species is now established at Notre Dame.

Aedes aobae Belkin, originally described from Aoba and subsequently from Vanua Lava (Belkin 1962) and other islands in the Banks and Torres (Maffi and Taylor 1977), was recently found on Pentecost (Maffi 1977). Our collections of this species from treeholes on the western coast of Pentecost confirm this finding. Dengue on Aoba has been attributed to *Ae. aobae*, but it is not known whether *Ae. aegypti* is present on that island (P. Fauran, pers. comm.).

SUMMARY AND CONCLUSIONS

As elsewhere, *Ae. aegypti* is the primary vector of dengue in the South Pacific. The distribution and density of this species was reviewed most recently by Suzuki and Hirshman (1977). We found it on Majuro, though there have been no reports of dengue there since a few cases in 1974 (B. Jacob, Department of Health Services, Majuro, pers. comm.), and also on Efate in Vanuatu, where epidemics of dengue are regular.

Aedes albopictus was first confirmed as a dengue vector in the laboratory by Simmons et al. (1930). Subsequently, it has been incriminated as the vector responsible for epidemics in Honolulu (Usinger 1944), Japan (Sabin 1952), the Seychelles (Metselaar et al. 1980), and partially involved, with *Ae. aegypti*, in outbreaks marked by dengue hemorrhagic fever in Thailand (on Koh Samui, Gould et al. 1968) and in Singapore (Chan et al. 1971). Its presence on Truk and the firmly established population on northern Guadalcanal should be considered serious public health threats. Indeed, there are reports of numerous cases of dengue in Honiara in 1982 (D. Roe, Cultural Centre, Honiara, pers. comm.).

Other Scutellaris Group species that have been implicated include *Ae. polynesiensis*, which Rosen et al. (1954) found to be an efficient vector, almost surely responsible for an epidemic on Tahiti in 1944, and suspected as a vector in American Samoa and the Cook Islands (Rosen, pers. comm.). MacKerras (1946) showed *Ae. scutellaris* (Walker) capable of vectoring dengue in New Guinea. The possible involvement of *Ae. hebrideus* and *Ae. aobae* in Vanuatu has been mentioned.

Though they may support virus, some species, including *Ae. hakanssoni*, *Ae. quasiscutellaris*, and *Ae. pernotatus*, are unlikely to act as important vectors because they do not normally bite man. The possibility exists, however, that there is an alternate maintenance cycle of the virus. For example, O'Gower (1960) suggested that the flying fox, one of the few large native mammals in much of the South Pacific, acts as a reservoir in northern Australia.

All species in this group should be tested for efficiency in transmitting dengue virus. This information combined with information on the abundance and distribution of these mosquitoes may lead to a better means of controlling dengue outbreaks. It is hoped that the material collected in our study will be of aid in this effort.

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