

An Annotated Bibliography
of the Mosquitoes and Mosquito-Borne Diseases
of Guam (Diptera: Culicidae)^{1/}

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ABSTRACT. The literature concerning the mosquitoes and mosquito-transmitted diseases on Guam, Mariana Islands, is presented in the form of an annotated bibliography. It reflects the emphasis on mosquito surveys during World War II, and the continuing mosquito surveillance with new species collection records which has resulted from the island's current importance as a U.S. military center and port for both aerial and surface trans-Pacific commerce.

The earliest scientific references to mosquitoes on the island of Guam are comments by J.F. Leys (1905) and F.E. McCullough (1908), Surgeons, U.S. Naval Station, Guam. The initial entomological survey of the island was accomplished in 1911 by Mr. D.T. Fullaway (1912), and the first definitive study of the mosquito fauna of Guam made during 1936 was reported on by Mr. O.H. Swezey (1942). U.S. Navy activities on Guam dating from August 1899, combined with U.S. military actions during World War II, stimulated entomological surveys and produced numerous reviews of the local mosquitoes and the diseases they can transmit to man. The severe outbreaks of dengue fever in 1944 and Japanese B encephalitis in 1947-1948 made continued mosquito surveys on Guam desirable.

The post World War II buildup of U.S. military facilities, and the role of Guam as both an aerial and surface port for trans-Pacific traffic during the Korean and Vietnamese conflicts, sustained interest in the mosquito surveillance. Incidence of autochthonous malaria in 1966 initiated a series of surveys that resulted in the reporting of 9 species of *Anopheles* on Guam. It also redirected attention to the probability of introduction of new mosquito species into Guam via airplanes and ships.

The steady increase in the number of species of mosquitoes collected on Guam between 1948 and 1972 was documented by Nowell (1975) with the number rising from 12 to 37. Subsequent discoveries have brought this total to 40 species, including the two *Toxorhynchites* species purposely introduced during 1954 in an attempt to control the day-biting mosquito, *Aedes albopictus*.

^{1/} The views expressed herein are those of the author and do not necessarily reflect the views of the United States Air Force or the Department of Defense.

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The following bibliography is an annotated account of the studies and review of the collections and records that have been published on the mosquitoes and the diseases they can transmit to man on the Island of Guam. Those entries marked with an asterisk (*) were not seen by the author.

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Knight, K.L. and H.S. Hurlburt. 1949. The mosquitoes of Ponape Island, eastern Carolines. J. Wash. Acad. Sci. 39(1):20-34. Comparison of *Aedes senyavinensis* with *A. oakleyi*, a species known only from Guam, p. 30; *Culex annulirostris marianae* Bohart & Ingram, from the Marianas, is subspecifically distinct from *C. annulirostris*, p. 31.

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Lauret, T. 1975a. Personal communication. Adult *Culex fuscocephalus* were collected in a light trap at Apra Harbor, Guam, by U.S. Navy Public Works Center personnel during Aug-Sep 1969. Larvae of this species were found at the same time breeding in a sewer break, 50 to 60 feet from where the light trap was set up. The larvae were feeding on *Culex quinquefasciatus* immatures. This was the initial collection record for this species on Guam. It was recorded on a local mosquito identification form, and the species was included by Holway and Bridges (1970) in their key to the mosquitoes of the Mariana Islands.

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- Reid, J.A. 1968. Anopheline mosquitoes of Malaya and Borneo. Studies Inst. Med. Res., Malaysia 31:1-520. *Anopheles indefinitus*, a valid species, became established on Guam sometime between 1945 and 1948, p. 337.
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- Rosen, L. 1971. Infectious disease research activities of the National Institutes of Health in the Pacific, in Proc. Commander in Chief Pacific First Conference on Preventive Medicine, Oahu, Hawaii, 18-22 January 1971, pp. 14-17. Notes that after *Aedes albopictus* was introduced accidentally on the island of Guam during World War II, it eventually displaced the endemic *scutellaris* species from the peridomestic habitat, p. 16.

- Rozeboom, L.E. 1975. Our society - an entomologist's perspective. *Am. J. Trop. Med. Hyg.* 24(3):375-382. Cites the eradication of *Aedes aegypti* from Guam as an outstanding achievement in species sanitation, p. 377.
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- Russell, P.F. 1959. Insects and epidemiology of malaria. *Ann. Rev. Ent., Annual Reviews, Inc., Palo Alto, Calif.* 4:415-434. Reviews introduction of *Anopheles subpiotus indefinitus* on Guam in 1948, p. 420. Malaria is not endemic on Guam, p. 427.
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- U.S. Dept. Health, Education, and Welfare. 1975. Health status of Vietnamese refugees. Morbidity and Mortality Wkly Rept. 24(18):157-158, 163. Public Health Service, Center for Disease Control, Atlanta, Georgia. Hospitalization rates for refugees arriving on Guam are listed. Only 2 cases of malaria (1 *Plasmodium vivax*, 1 *P. falciparum*) have been reported. 5 cases of a syndrome clinically compatible with dengue fever have been diagnosed in arriving refugees. Comprehensive malaria assessment, including transmission potential and case occurrence, is given, p. 158.
- U.S. Dept. Health, Education, and Welfare. 1975. Update on Vietnamese refugee health status. Morbidity and Mortality Wkly Rept. 24(19): 172. Public Health Service, Center for Disease Control, Atlanta, Georgia. 20 cases of malaria have been reported for a total of 22; no additional cases of dengue fever, leaving the total at 5.
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- U.S. Dept. Health, Education, and Welfare. 1975. Update on Vietnamese refugee health status. Morbidity and Mortality Wkly Rept. 24(21):188. Public Health Service, Center for Disease Control, Atlanta, Georgia. 5 additional cases of malaria reported from Guam and Wake islands for a total of 30. 2 additional cases of dengue fever reported from Guam.
- U.S. Dept. Health, Education, and Welfare. 1975. Update on Vietnamese refugee health status. Morbidity and Mortality Wkly Rept. 24(22):189-190. Public Health Service, Center for Disease Control, Atlanta, Georgia. No new cases of dengue fever. Vector control activities included aerial ultra-low volume spraying with malathion. No transmission of the infection on Guam has been verified. A total of 90 cases of malaria has been reported to date from all refugees. 50 of these cases were reported from Guam and Wake islands. No transmission of malaria has been reported on Guam since the arrival of the refugees.
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|-------------------------|---------|----------|----------------|
| Ann. Suppl. 1953 (1954) | Malaria | 7 Cases | Table 5, p. 9 |
| Ann. Suppl. 1954 (1955) | Malaria | 5 Cases | Table 5, p. 9 |
| Ann. Suppl. 1955 (1956) | Malaria | 3 Cases | Table 6, p. 12 |
| Ann. Suppl. 1956 (1957) | Malaria | 6 Cases | Table 7, p. 14 |
| Ann. Suppl. 1957 (1958) | Malaria | 3 Cases | Table 7, p. 14 |
| Ann. Suppl. 1961 (1962) | Dengue | 1 Case | Table 7, p. 12 |
| | Malaria | 5 Cases | Table 7, p. 12 |
| Ann. Suppl. 1970 (1971) | Malaria | 54 Cases | Table 6, p. 9 |
| Ann. Suppl. 1972 (1973) | Malaria | 2 Cases | Table 6, p. 9 |

These cases may have been acquired outside or on the island. There is no distinction in the reported cases. The disease data from Guam were not published each year. Since the years and numbers of cases of malaria reported do not include the 1966 and 1969 outbreaks on Guam, it is likely that they represent those cases diagnosed, treated or hospitalized in military personnel returning from assignments in the Far East or in Southeast Asia.

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- U.S. Navy. 1945. Tropical and exotic diseases of naval importance. U.S. Naval Medical School, Bethesda, Maryland. 107 pp. Guam is included in a malaria-free zone (map and island list), p. 2; dengue fever distribution map, p. 42; filariasis distribution map, p. 66.
- U.S. Navy. 1967a. Entomology, in Preventive Medicine Activities (RCS MED 6200-1). Semiannual report for period ending 31 Dec 1966, pp. 13-14, Enclosure 1. U.S. Navy Preventive Medicine Unit No. 6. (mimeographed). Reviews 6 cases of malaria occurring on Guam during 1966. There is evidence that introduced autochthonous malaria occurred, with 2 cases of *falciparum* malaria diagnosed at the U.S. Navy Hospital.
- U.S. Navy. 1967b. Marianas, in Proc. Commander in Chief Pacific Conference on Quarantine and Control Measures to Prevent Dissemination of Vectors of Disease, Oahu, Hawaii, p. 13. Points out that vector mosquito control is conducted by limited aerial spraying on Guam.
- U.S. Navy. 1967c. Mosquitoes of Guam. Enclosure to Letter: Conference of Military Entomologists, from U.S. Navy Public Works Center, Guam, to Pacific Division, Naval Facilities Engineering Command, 24 Jul 67. 5 pp. (mimeographed). Comprehensive review of the mosquitoes on Guam with collection sequence of the species, bionomic data, and control information.
- U.S. Navy. 1971. Guam, in PACOM Intelligence, Proc. Commander in Chief Pacific First Conference on Preventive Medicine, Oahu, Hawaii, 18-22 January 1971, p. 28. States the intelligence for this area of study (Marianas) is minimal. The possibility of a major vector-borne disease outbreak such as dengue fever, encephalitis, malaria or plague exists and constitutes an area of major concern to preventive medicine officials.
- U.S. Navy. Consultant and other reports published by the Preventive Medicine Unit No. 6. See individual authors.
- U.S. War Dept. 1944a. Medical and sanitary data on Guam. War Dept. Tech. Bull. (TB MED) 57:1-16. No *Anopheles* mosquitoes or malaria in Guam. *Aedes aegypti*, *A. oakleyi*, *A. pandani*, *A. scutellaris pseudoscutellaris*, and *Culex fatigans* are reported, with notes on vector abilities. Dengue fever and endemic filariasis are reported as occurring.

- U.S. War Dept. 1944b. Medical and sanitary data on the Mariana Islands. War Dept. Tech. Bull. (TB MED) 20:1-18. No anopheline mosquitoes in the Marianas, and malaria does not occur. *Aedes oakleyi*, *A. pandani* and *A. pseudoscutellaris* are recorded from Guam, p. 3; dengue fever occurs on Guam, p. 9.
- U.S. War Dept. 1945. Dengue on Guam. Epidemic Disease Control and Sanitation 1(3):1-5. Publ. by Medical Section, Island Command, Guam. (mimeographed). Reviews the incidence, treatment, vectors and their control on Guam.
- Usinger, R.L. 1944. Entomological phases of the recent dengue epidemic in Honolulu. U.S. Pub. Hlth. Rept. 59(13):423-430. Notes the presence of *Aedes (Stegomyia) scutellaris* (Walker) dengue virus vector, on Guam, p. 427. (This species was subsequently redesignated *Aedes (Stegomyia) guamensis* by D.S. Farner and R.M. Bohart in 1944).
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- Ward, R.A., B. Jordan, A.R. Gillogly and F.J. Harrison. 1976. *Anopheles litoralis* King and *A. baribostris* group on the island of Guam. Mosq. News 36(1):99-100. Reviews the collection records for anopheline mosquitoes on Guam and reports the finding of two new species, *Anopheles litoralis* and a member of the *A. (A.) barbirostris* species group.
- *Wester, W.H., Jr. 1918. Control of the disease situation, in Guam Agric. Exper. Sta. Rept. for 1917, pp. 58-62.
- Wheeler, N.H. 1948. Contribution of the United States Naval Medical School to zoological science in World War II. Ann. Ent. Soc. Am. 41(1):41-47. *Aedes aegypti* and *Culex quinquefasciatus* were collected on Guam, pp. 43-44.

- Williams, F.X. 1944. Biological studies in Hawaiian waterloving insects. Part III. Diptera or flies. D. Culicidae, Chironomidae and Ceratopogonidae. Proc. Hawaiian Ent. Soc. 12(1):149-197. Guam has 6 species of mosquitoes, p. 149.
- Wissemann, C.L. and B.H. Sweet. 1961. The ecology of dengue, in J.M. May (Ed.), Studies in Disease Ecology, Chapt. 2, pp. 15-44. Hafner Publ. Co., New York. Dengue neutralizing antibodies in dengue fever patients from Guam, p. 21. *Aedes albopictus* is replacing *A. aegypti* on Guam, p. 34; distribution of the vector (includes Guam), pp. 42-43.
- World Health Organization. 1955. Control of insect vectors in international air traffic. WHO Int. Dig. Hlth. Leg. 6(3):379-435. Cites three species of mosquitoes brought into Guam since World War II which have acclimatized themselves there, p. 388. Refers to the introduction of *Anopheles subpictus* into Guam, probably by insufficiently disinfected aircraft coming from the Celebes, p. 391, and *Aedes albopictus*, by aircraft from the Philippines, p. 392.
- World Health Organization. 1969. Japanese encephalitis, in Report on the Second Regional Seminar on Virus Diseases: Mosquito-Borne Virus Diseases (Arboviruses). WHO Regional Off. for the Western Pacific, Manila, Philippines, 6-11 October 1969. WPR/416/69, 58 pp. A single epidemic of Japanese encephalitis occurred in Guam in 1947. The virus was apparently introduced, was not reported previously, and has not reappeared since, p. 2. *Gulex annulirostris marianae* was considered to be the vector, p. 6.
- World Health Organization. 1970. Status of malaria eradication during the year 1969. WHO Wkly. Epidem. Rec. 45(40):429-452. Guam is included in the list of malaria-free areas.
- World Health Organization. 1971. Status of malaria eradication during the first semester of the year 1970. WHO Wkly. Epidem. Rec. 46(11):97, 100-109. Guam is included in the list of malaria-free areas with November 1963 as the date of notification.
- World Health Organization. 1972. Vector control in international health. Wld. Hlth. Org., Geneva. 144 pp. *Anopheles subpictus indefinitus* was first reported on Guam in 1948; until that time the island was believed to be free from anophelines. In 1969, 6 cases of malaria were reported from Guam, and at least one of these cases was transmitted locally on this previously malaria-free island, p. 32.
- World Health Organization. 1973. Status of malaria eradication during the year 1972. WHO Wkly. Epidem. Rec. 48(34):329-340. Guam is included in the Supplementary List of Malaria-free Areas, Table 4, with notification date of 14 November 1963.

- World Health Organization. 1975. Dengue fever surveillance in some countries of Asia and the South-west Pacific. WHO Wkly. Epidem. Rec. 50(30):269-272. *Aedes aegypti* was detected during a survey carried out on Guam in 1971. *A. scutellaris* and *A. albopictus* were also identified, p. 271.
- *Yamada, S. 1932. Family Culicidae, in Esaki, et al, Nippon Konchu Zukan (Iconographia Insectorum Japonicorum), pp. 210-235, Tokyo. (in Japanese). Reports *Aedes aegypti* from Guam.
- Yamaguti, S. and W.J. LaCasse. 1950. Mosquito fauna of Guam. Off. of the Surgeon, Hdqtrs. U.S. Eighth Army, APO 343. 101 pp. Report of a comprehensive mosquito survey made on Guam during Feb-Mar 1948. A total of 10 species was collected. *Aedes albopictus* and *Anopheles subpictus indefinitus* are recorded for the first time from Guam. Keys to the larvae and adults of the 11 species of mosquitoes known to occur on Guam are provided.
- *Yoshioka, K., C. Tsuji and H. Sawa. 1941. [Report on insects collected on the South Sea islands.] Hakubutsu-zasshi [J. Nat. Hist.] 38(72): 15-24. (in Japanese).

ADDENDUM

- Esaki, T. 1939. Injurious Arthropoda to man in Mandated South Sea Islands of Japan (First Report), in Osaka Hakubutsu Gakkai, Volumen Tubilare pro Professore Sadao Yoshida, Vol. 1, pp. 230-252. Osaka Natural History Society, Institute for Research in Microbic Diseases, Osaka Imperial University, Japan (title in English, text in Japanese). Cites the mosquitoes collected by Fullaway (1912) on Guam, p. 252.
- Guam, Government of. 1975. Environment impact assessment for aerial ULV application of malathion at three ounces per acre in Guam. Pp. 42 + Tabs A-E. (mimeographed). Examines the impact, on man and his environment, of the administration of 95% Malathion at the rate of 3 ounces per acre by aerial application to prevent an outbreak of dengue fever among the civilian community following the influx of Vietnamese refugees during "Operation New Life."
- Haddock, R.L. 1973. A history of health on Guam, 2nd Ed. Cruz Publ., Guam. 50 pp. Cites the dengue fever (1944) and Japanese B encephalitis (1948) epidemics on Guam, and the outbreaks of malaria which occurred in 1966 and again in 1969, pp. 29, 32. Two dengue fever (1921, 1944) and 1 Japanese B encephalitis (1947) outbreaks are listed in the chronology of Epidemics Reported on Guam, pp. 38-39.

Velimirovic, B. 1969. Japanese Encephalitis history and geographical distribution, in Report on the Second Regional Seminar on Virus Diseases: Mosquito-Borne Virus Diseases (Arboviruses), p. 2. WHO Regional Office for the Western Pacific, Manila, Philippines, 6-11 October 1969, WPR/416/69, 58 pp. A single epidemic of JE occurred in Guam in 1947. The virus was apparently introduced, was not reported previously, and has not reappeared since, p. 2. *Culex annulirostris marianae* was considered to be the vector, p. 6. Dengue fever virus on Guam, p. 49/50; JE virus on Guam, p. 51/52; Arbovirus disease map, showing Guam, p. 57/58. (see W.H.O., 1969)

World Health Organization. 1976. Information on malaria risk for international travellers, Second Edition (updated). WHO Weekly Epid. Rec. 51(24):181-200. There is no risk of contracting malaria in Guam, and no preventive measures against malaria are required, Table 1, p. 195.