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Mosquitoes of Guam and the Northern Marianas: Distribution, Checklists, and Notes on Mosquito-Borne Pathogens

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Abstract

This report includes the distribution records and updated checklists of the mosquitoes known to occur in Guam and nearby selected islands (ie, Saipan, Tinian, Rota), based on our field collections from various localities during 2010, published reports, and accessioned specimens deposited in the US National Museum of Natural History, Smithsonian Institution, Washington, DC. The status of common and potential mosquito vectors and their borne-pathogens are also noted.

Introduction

The US territorial islands in the western Pacific Ocean have strategic and logistic military significance, particularly Guam and the Commonwealth of the Northern Mariana Islands (Saipan, Tinian, Rota) (Figure 1), in addition to their increasing importance to the tourism industry. Protecting military personnel and civilians against arthropod vectors and the diseases they transmit should be a high priority to both military commands and civilian administrators. In order to protect the human populations in these islands, proper surveillance of vectors and the diseases they carry must be regularly conducted or improved in order to develop effective prevention strategies. Vector surveillance and control programs would minimize, if not totally prevent, occurrence of mosquito-borne infectious diseases in target areas.

Geography, Climate, and Demographics

Guam

Guam is located at 13.28 N, 144.47 E, with an area of 544 km^2, and is the largest and southernmost of the 15 islands in the Mariana Islands archipelago.[1] The northern part of the island is a forested coral line limestone plateau while the south contains volcanic peaks covered in forest and grassland. The northern and central regions have more dense populations than other parts. The climate is a typical tropical marine, and the weather is generally hot and very humid with little seasonal temperature variation. The mean high temperature is 30°C and mean low, 24°C, with an average annual rainfall of 2,180 mm. The dry season runs from December through June, and the remaining months constitute the rainy season. January and February are considered the coolest months of the year, with night time temperatures in the mid to low 20s (°C) and generally lower humidity levels. The highest risk of typhoons is during October and November, however, they can occur year-round.[1]

Figure 1. Guam, Rota, Tinian, and Saipan, and their location in the Mariana Islands archipelago (inset).

Guam has military strategic and logistic importance. The US military maintains jurisdiction over its bases in Guam, which cover approximately 3,160 km^2, or 29% of the island's total land area. In the coming years, Guam will be experiencing a tremendous population growth as a result of the military buildup which has been described as one of the largest military-related operations since World War II. The US Marine Corps 3rd Marine Expeditionary Force, currently in Okinawa (approximately 8,600 Marines with 9,000 dependents), will be transferred to Guam by 2016. At the peak of the buildup in 2015, Guam is anticipating an increase of 52,000 people,[2] or 28% of the current population of approximately 183,000. The largest portion of those people will be temporary workers coming from regions where mosquito-borne diseases are endemic. With the increase in the island's population and its over 1.2 million annual visitors, there may also be a corresponding increase in vector-borne disease risks, particularly among thousands of US military personnel and their dependents stationed in Guam, as well as other Department of Defense (DoD) civilians.

Saipan

Saipan (15.25 N, 145.75 E), the capital of the US Commonwealth of the Northern Mariana Islands, is about 193 km north of Guam with a total area of 120.4 km^2, or about 20 km long and 9 km wide.[3] Ships of the US Maritime Prepositioning Force regularly anchor at Saipan,[4] and there are US military training sites on the island. It is a popular tourist destination in the Pacific, particularly for US military personnel and other DoD civilians. Additional descriptions of this island are provided by Savage et al.[5]

Tinian

Tinian (15.0 N, 145.6 E) is about 8 km southwest of its sister island, Saipan, from which it is separated by the Saipan Channel. It has a land area of about 102 km^2. Tinian's largest village is San Jose. The Island has a variety of flora and fauna, as well as limestone cliffs and caves. There is also a variety of marine life and coral reefs surrounding the island.[6]

Rota

Rota (14.2 N, 145.2 E), is the southernmost island of the US Mariana Islands and the second southernmost of the Marianas Archipelago.[7] A popular tourist destination, Rota is approximately 17 km long and 5 km wide, with a coastline about 62 km in length. The highest point is Mount Manira at 495 m. The island is 76 km north of Guam, 101 km south of Tinian, and 117 km south of Saipan. There have been proposals to use areas on Rota for new and continuing military training, consisting of the airport and sites within West Harbor.[8]

Mosquito Vectors and Mosquito-Borne Diseases

The common potential infectious diseases in Guam, that could be transmitted by mosquitoes include malaria, dengue fever, Chikungunya fever, dengue hemorrhagic fever, Japanese encephalitis, Murray Valley encephalitis, yellow fever, filariasis (Bancroftian, Brugian filariasis) and other viral diseases.[9] Multiple human malaria cases were reported in Guam in 1966, 1969,[10] 1975, and 1980-1986.[9] Several *Anopheles* species have been reported in Guam, however, *An. subpictus* Grassi and/or *An.* Barbirostris Group species could be vectors of malaria in the island, although their vector potential needs to be confirmed. Two *Anopheles* species, *An. sinensis* Wiedemann and *An. lesteri* Baisas and Hu, have also been previously reported from Guam,[11] but presently they are not as common as other mosquito species. *Anopheles sinensis*, a known malaria vector, also occurs in Asian countries, such as Japan,[12] North Korea,[13] South Korea,[14] and China.[15,16] *Anopheles lesteri*, the major vector of malaria in China (and previously known as *An. anthropophagus* Xu and Feng),[15,17] also occurs in South Korea,[14] Japan,[12] Hong Kong,[18] and the Philippines.[19] Presently, limited information is available on the distribution and habitats of these 2 different malaria mosquitoes in Guam and nearby islands. *Anopheles lesteri* was recollected recently from Guam (W.K.R., unpublished data, March 2010). *Anopheles sinensis* was also recollected during recent mosquito surveys conducted from 10 to 14 December 2007.[20] About 18 adults of *An. sinensis* were collected using Centers for Disease Control and Prevention (CDC) light traps (Figure 2) from Andersen AFB (Nimitz Hill Housing Area and other civilian areas).[20] In addition to *Anopheles*, other potential and known mosquito vectors on Guam belong to the genera *Aedes*, *Culex*, and *Mansonia*.

The historical accounts of the epidemics of mosquito-borne diseases in Guam have been noted by various authors.[21,22] Comprehensive lists of annotated bibliographies of Guam mosquitoes, including their associated infectious diseases, were previously prepared.[23-25] In addition to available internet/search

engines, comprehensive publications about mosquitoes of Guam and the Commonwealth of the Northern Mariana Islands can be searched and downloaded (in PDF format) from the Armed Forces Pest Management Board Literature Retrieval System* and the Walter Reed Biosystematics Unit (WRBU).[26] Taxonomic mosquito literature (in printed form), including old publications of species descriptions, are also available from the WRBU library.

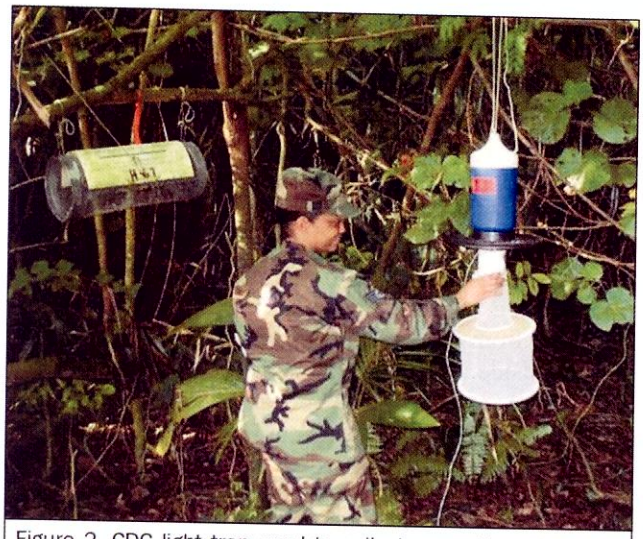

Figure 2. CDC light trap used to collect mosquitoes, including *Anopheles sinensis*, from a housing area in Andersen AFB, Guam, December 2007.

In recent years, the threat of mosquito-borne diseases has been a serious public health concern with epidemics on neighboring islands and the constant introduction of infected people. However, epidemics were not identified on Guam. With expanding and very transient military and civilian populations, including tourists from Asian countries, the threat of mosquito-borne disease transmission is increasing. In the past, multiple travelers returning to Guam from other locations have brought back cases of dengue, malaria, Japanese encephalitis, and even filariasis.

Historically, some of these mosquito-borne diseases have been autochthonously transmitted on Guam. For example, dengue has been one of the most troublesome mosquito-borne diseases with epidemics usually occurring in late summer. The primary urban vector of dengue fever, *Aedes aegypti* (Linnaeus), has rarely been found on Guam over the last several decades. A World Health Organization report indicated that it was apparently eradicated from Guam.[27] Results of various surveys in Guam in 1995,[28] 2007,[27,29] and this study (2009-2010) yielded no *Ae. aegypti*. It is surmised that it was either totally eradicated or missed during the collecting efforts due to errors in sampling, seasonal occurrence variation, time and techniques used, immatures shifting to habitats other than artificial containers, and change of mosquito behavior. This may be due to competitive pressure from other species, inadequate larval collections from various breeding habitats, etc. In view of the transient populations on Guam, it is important to remember that the human is the main reservoir of dengue. Since *Ae. aegypti* is widely spread in Pacific areas where dengue is endemic, its dispersal is still occurring, and so its movement into and through the region is still of concern and should be prevented.[30] Therefore, once dengue is reintroduced or reestablished in Guam, it will take considerable time and diligent control efforts to eradicate the disease.[20,29] More than 14,000 mosquitoes collected on Guam from 2009-2011 were tested for Japanese encephalitis virus or malaria by the US Army Public Health Command Region–Pacific and no positive samples were detected (W.K.R., written communication, March 2011). Also, a recent outbreak of Zika virus on Yap Island, Micronesia[31] raised concern over its spread to Guam and other islands of the Marianas.

Reports on the number of mosquito species occurring on Guam and nearby islands are confusing and exact numbers are difficult to ascertain. About 32 species of mosquitoes were recorded on Guam, including 8 implicated disease vectors in 3 genera (*Aedes*, 3 spp; *Anopheles*, 4 spp, and *Culex*, 1 sp).[32] Although one report indicates about 40 species of mosquitoes on Guam,[23] other sources[26] recorded different species numbers. This may be due to inaccurate identifications of the species, incomplete surveillance data, unavailability of voucher specimens to confirm species identifications and occurrence, shortage of taxonomic experts involved in surveillance, etc. Considering that there has been an increase in international travel to and from Guam[27] involving thousands of passengers, mainly tourists and military personnel, the introduction of new mosquitoes (including potential vectors) from other countries/territories may be very common.

In addition to Guam, other islands with DoD high importance include Tinian, Rota, and Saipan. Tinian

*http://lrs.afpmb.org/rlgn_app/ar_login/guest/guest

will be used for training by Marine units moving to Guam from Okinawa between 2012 and 2016, while Saipan and Rota (also with training sites) are popular rest and recreation locations for many US military and DoD civilians, in addition to other tourists.[33,34] Little is known about the mosquito vectors and their borne infectious diseases in Tinian, Rota, and Saipan, as well as other surrounding islands. In 1983, larval collections were conducted from 42 habitats at 21 different sites on Saipan, with 9 species collected, including those with potential as vectors of human diseases.[5]

Although some mosquito identification keys[11,35,36] are available, they do not exclusively cover Guam and surrounding islands, or they have to be updated to include all species known to occur in Guam and nearby islands, particularly Tinian, Rota, and Saipan. It is essential to know where mosquitoes currently occur and where potentially they will be found on the islands. Also, knowledge of introduced species (or invasive species) on those islands is important for mosquito control.

In this article, we report the distribution records of mosquitoes and provide updated checklists of known mosquito species found in Guam and nearby islands, particularly Saipan, Rota, and Tinian. We also note the status of common and potential mosquito vectors and the diseases they transmit.

Materials and Methods

Adults were collected from various localities in Guam (Figure 3), with a modified miniature CDC light trap (Figure 2), baited with white or ultraviolet light with or without CO_2 and hung from a tree branch or from a wall of a building. Most adult specimens were killed in trap jars with insecticidal strip (2,2 dichlorovinyl dimethyl phosphate, 10%), frozen in a freezer, or placed in a container with dry ice. Larvae were collected from household junk, tires, tree holes, river and roadside side pools, and other water-filled containers with mosquito dippers, turkey basters, and plastic cups. Larvae were reared to adults in individual containers. Specimens were initially sorted and brought to the laboratory for further processing and identification. They were mounted on points on pins, examined, and identified using diagnostic morphological characters with the aid of keys and descriptions from pertinent literature.[11,35,36] The latitude and longitude of each location were recorded using a hand-held global positioning system unit (Garmin International, Olathe, KS) set to the WGS84 datum. For molecular species identification, DNA was isolated from individual adults (1 or 2 legs per adult). In addition, mosquito specimens deposited at the US National Museum of Natural History (USNMNH) were examined and identified, and their collection data recorded. Coordinates for localities or collection sites of museum specimens were recorded using gazetteers.[37,38]

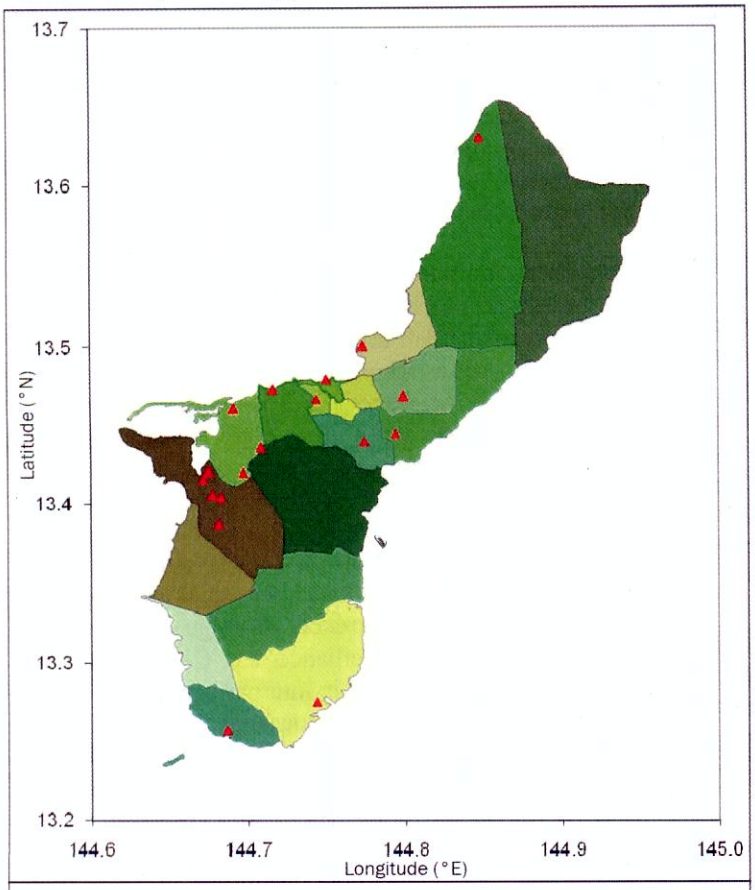

Figure 3. Mosquito collection sites in Guam.

Results and Discussion

A summary of collection localities of mosquitoes (based on observed specimens from field collected samples in 2010 and accessioned museum collections at the

USNMNH) is shown in Table 1. A total of 16 species in 6 genera and 8 subgenera were identified, with 15 species from Guam, 11 species from Saipan, 4 species from Rota, and 4 species from Tinian. The collection sites of the 2010 survey and those points of collection of previous surveys according to museum records are shown in Figure 3.

The updated checklists of mosquitoes reported from Guam, Saipan, Tinian, and Rota were based on combined records from selected literature and present observation, mainly from specimens deposited at USNMNH and our recent field collections (Table 2). For the 4 islands, we recorded 40 species (with 4 subspecies) representing 8 genera: *Aedeomyia* (1 subgenus), *Aedes* (3 subgenera), *Armigeres* (1 subgenus), *Anopheles* (2 subgenera), *Culex* (2 subgenera), *Lutzia* (1 subgenus), *Mansonia* (1 subgenus) and *Toxorhynchites* (1 subgenus). In our updated mosquito checklists, Guam has 40 species (including 3 subspecies in *Aedes* and 1 subspecies in *Culex*) while Saipan has 14 species; Rota, 9; and Tinian, 10. All species found on 3 islands (Saipan, Rota and Tinian) also occurred on Guam. Only a partial set of adult specimens from trap collections on Guam in 2009 and 2010 were processed, examined and identified. When completed, the collection data or occurrence records will be published in a separate article.

About 9 mosquito species were reported from Rota, representing 2 genera: *Aedes* (6 spp) and *Culex* (3 spp).[55] While *Ae. aegypti* was prominent during the early surveys on Guam and Saipan, the species declined rapidly following massive control programs during late 1940s. Only a single specimen of this species was discovered on a 1950 survey, for example, and the species was not recovered again until the 1970s. In 1980, a summary of the mosquito collection records of Southern Mariana Islands was reported.[39] *Culex (Cuc.) papuensis* were also reported on Guam,[11,56] however, it was not known to occur in the western Pacific islands,[26,56] and there is no voucher specimen of this species from Guam and other Mariana Islands in the USNMNH/Smithsonian national mosquito collections. About 39 species (with 2 subspecies) were recorded on Guam, but 16 of these species (including 1 subspecies) are no longer considered as occurring on Guam.[11]

Although several subspecies of *Ae. vexans*[57] (Meigen) were recorded, there is still a need to clarify the validity of these subspecies. While waiting for further studies to clarify the taxonomic identity of this species, we listed 3 subspecies of *Ae. vexans*, namely *vexans*, *nipponi* (Theobald) and *nocturnus* (Theobald), based on reviewed literature and observed specimens. *Aedes vexans nipponi*[40] was reported on Guam based on one collected larva, and it has not been reported since. This subspecies was not thought to occur on the Mariana Islands.[58] In 1984, Ward[40] excluded this subspecies from his list of Guam mosquitoes since it has not been reported or established subsequent to Reisen's article.[32] In 1973, Reinert[58] synonymized *nocturnus* with *vexans* from the Mariana Islands, but Lee et al[59] elevated *nocturnus* to species level in 1982. These authors considered all "*vexans*" from the Mariana Islands as "*vexans nocturnus*," probably because the specimens in the USNMNH national collections (prior to 1973 and after 1982) are mostly labeled as "*nocturnus*" or "*vexans nocturnus*." For *Culex* mosquitoes, the identity of *Cx.(Cux.) annulirostris marianae* Bohart and Ingram, should be studied to determine whether it should remain as a valid subspecies or be elevated to a distinct species. Several previous reports noted this subspecies as occurring only on the Mariana Islands.[35,41,42,55]

We recommend that intensive larval surveillance and collections from various breeding habitats be performed in Guam and nearby islands on a regular basis (weekly or monthly), in addition to adult light-trapping. Except for the larval and pupal collections conducted from September to October 1991 on Saipan,[5] very limited immature stage surveys were done in other islands. Past surveys in Guam using adult light traps might have missed those species of mosquitoes that are not attracted to light or other trap baits, or are not active during months when trappings were conducted. Adults of some species of *Aedes* and *Culex* are less attracted to lights or less collected from light traps. Therefore, in addition to adult surveillance, larval collections from different habitats (artificial containers, irrigation ditches, pools, marshes, etc) on a regular basis throughout the year are necessary to understand the larval ecology and population dynamics of mosquito species, particularly vectors, in target areas of various islands. With the ease with which exotic pathogens are transported between countries or even continents, there is an urgent need to have a strong surveillance program to detect the spread of vectors and the diseases they transmit. Proper adult and larval surveillance efforts are essential

Table 1. Summary of collection localities of mosquitoes (based on observed specimens) in Guam, Saipan, Tinian, and Rota.

Species	Island	Locality	Grid Coordinates	Collection Date	Number/ Stage	Collector	Remarks (Habitat)	Repository
Aedeomyia (Aedeomyia) catasticta Knab	Guam	Sta. Rita, Apra Landing, Navy housing and magazine areas	13.38688N/144.57828E (GU-004); 13.40386N/144.68299E (GU-006)	6, 10 Mar 2010	3F*	W.K. Reeves	LT	FC
	Guam		(ACC-522)	27 Aug 1975	3F, 3M		LC (pond-lake)	AC
Aedes (Aedimorphus) *oakleyi* Stone	Guam			3 Oct 1938	15F, 55M		LC (water drum)	AC
	Guam			1 Oct 1937; 6 Jun 1945; 26 May 1972	8M	W. Hull, R.G. Oakley	LC (coconut husk)	AC
	Saipan	Mt. Tabachan; Tanapag	15.23966N/145.75709E (TAN)	15 Jan 1949	1F, 9M			AC
	Saipan		(SAI-7)	19 Sep 1991	51M	H. Savage	LC (ground pool)	AC
Ae. (Adm.) vexans nocturnus (Theobald)	Guam	Pt. Oca; Pt. Ajayan	13.50018N/144.77308E (OC); 13.23333N/145.73333E (AJ)	23, 29 Jul 1951; 23 Aug 1951	14F,26M	W. H. Hull, J.L. Gressitt, R.M. Bohart	LC (ground pool)	AC
	Saipan	Charan Kanoa; Charan Ronoa; Charon;Tsutsuura; Hashigaro	15.20299N/145.71788E (CK);	2, 22, 23 Jul 1944; 22, 31 Aug 1944; 4 Sep 1944; 8-16 Oct 1944; 18 Jul 1945; 29 Jun 1951	16F, 64M	R.M. Bohart, J.L. Webb, C. Alley, 18th MLG	(swamp, tree hole in mangrove)	
	Saipan		(SAI-33)	23 Sep 1991	2F, 9M	H. Savage	(ground pool)	AC
	Tinian			23 Aug 1945	2M	Navy Medical School		AC
Ae. (Stegomyia) aegypti (Linnaeus)	Guam	Agana; Barrigada; Pt. Oca	13.47919N/144.75000E (AG); 13.46830N/144.79890E (BA); 13.50018N/144.77308E (OC)	27 May 1935; 27 Jun 1937; Sep 1945	24F, 40M	Navy Medical School	LC (water tank)	AC
	Guam				1F, 3M	C.P. Bagg		AC
	Rota			24 Oct 1945	1M		LC (artificial container)	AC
	Saipan	Charan Ronoa		25 Aug 1944	15F, 17M	D.G. Hall		AC
	Tinian			12 Jul 1944	2F, 5M	Navy Medical School		AC
Ae. (Stg.) albopictus (Skuse)	Guam	Merizo	13.25757N/144.68652E (GU-011)	6 Mar 2010	1F	W.K. Reeves	LT (mangrove swamp)	FC
	Guam		(ACC-512)	21Jul 1975	4F, 32M			AC
	Guam			4 Nov 1948; 11 Sep 1951	19F, 36M	W. Hull W.C. Reeves		AC
	Saipan	Charan Ronoa; Charan Taja; Garapan	15.20778N/145.72926E (GA)	22, 27 Aug 1944; 1 Sep 1944	11F, 10M			AC
	Saipan			Jun, Jul, Oct 1944; 4 Apr 1945	29F, 69M	D.G. Hall, J. Greenberh; D. Pashley; J.L. Webb; 18th MGL		AC
	Saipan		(SAI-10, 11, 13, 21, 22, 24, 61)	20 Sep 1991	33F, 31M	H. Savage	LC (refuse, toilet bowl, water barrel)	AC
	Tinian			19 Aug 1944	5F, 3M	Navy Medical School		AC
	Rota		14.19594N/145.24933	27 Feb 2010	3F	W.K. Reeves	AD (landing and biting)	FC
Ae. (Stg.) guamensis Farner and Bohart	Guam	Merizo	13.25757N/144.68652E (GU-011)	6 Mar 2010	1F	W.K. Reeves	LT (mangrove swamp)	FC
Ae. (Stg.) neopandani Bohart	Guam	Inarajan, Wolford Heights Road	13.27556N/144.68652E (GU-010)	6 Mar 2010	1F, 1M	W.K. Reeves	LT	FC
Ae. (Stg.) pandani Stone	Guam	Inarajan, Wolford Heights Road; Merizo; Sta. Rita, Apra landing, Navy housing and main gate areas; Yigo, Anderson AFB NW Field	13.42038N/144.67496E (GU-005); 13.40386N/144.68299E (GU-006); 13.27556N/144.68652E (GU-010); 13.25757N/144.68652E (GU-011); 13.63025N/144.84793E (GU-012)	6, 9, 10 Mar 2010	8F	W.K. Reeves	LT (mangrove swamp)	FC

ACC – museum accession code; AC – museum collection of the National Museum of Natural History (NMNH), Washington, DC; AD – adult collection, landing and biting; F – female; FC – field collected, deposited in the NMNH; LC – larval collection; LT – CDC light trap collections; M – male.

Table 1 continued on next page.

Table 1 (continued). Summary of collection localities of mosquitoes (based on observed specimens) in Guam, Saipan, Tinian, and Rota.

Species	Island	Locality	Grid Coordinates	Collection Date	Number/ Stage	Collector	Remarks (Habitat)	Repository
Ae. (Stg.) pandani Stone (continued)	Guam	Barrigada	13.46830N/144.79890E (BA)	27 Jul 1937	37M		LC (leaf axils of Pandanas dubius); type series	AC
	Guam	Inarajan; Mt. Tenjo; Mt. Chachao; Piti	13.44430N/144.79373E (IN); 13.41944N/144.69722E (TE); 13.43583N/144.70833E (CH); 13.46083N/144.69083E (PI)	2, 3 May 1936 7, 16 May 1936	1F, 16M			AC
	Guam			25 Jul 1938	23F, 29M		LC (leaf axils of Pandanas dubius); type series	AC
	Guam			25 Oct 1945	6M	L. Rozeboom	(coconut)	AC
	Guam			Jul, Aug 1951	10F	W.B. Hall		AC
	Guam	Fena Lake-Tolaeyuus R.		9 Sep 1975	23M		(bamboo grove; biting)	AC
	Rota	Hill 82			2F, 6M	D. Pashley		AC
An. (Cellia) indefinitus (Ludlow)	Saipan		(SAI-28)	21 Sep 1991	9F, 9M	H. Savage		AC
An. (Cel.) vagus Donitz	Guam	Agana Heights, Sta. Rita, Apra Landing, Navy housing and magazine areas	13.46646N/144.74339E (GU-001); 13.39364N/155.57828E (GU-003); 13.38688N/144.57828E (GU-004); 13.40386N/144.68299E (GU-006)	6, 7 Mar 2010 9, 11 Mar 2010	4F, 2M	T. Gutierrez, W.K. Reeves	LT	FC
	Guam			24 Sep 1951	1F, 2M	W.B. Hull		AC
	Guam	Naval magazine area		10 Feb 1971	7F, 8M			AC
Cx. (Cux.) annulirostris marianae Bohart and Ingram	Guam	Sta. Rita, Navy magazine main gate area	13.38688N/144.57828E (GU-004)	6 Mar 2010	1F	W.K. Reeves	LT	FC
	Guam	Agana; Pago R. Piti	13.47919N/144.75000E (AG); 13.4392N/144.77400E (PA); 13.46083N/144.69083E (PI)	13 Sep 1936; 5 Jul 1945; 4 Jun 1946	3M			AC
	Saipan	Charan Jiga, Charan Konoa, Charan Ronoa; Tsutsuura	15.20299N/145.71788E (CK)	24 Aug 1944; 31 Nov 1944	23F, 63M	D.G. Hall		AC
	Rota	Poniya; South and West Rota Is.	14.10000N/145.16667	25 Oct 1945	1F, 7M			AC
	Tinian			1944	3M			AC
Cx. (Cux.) litoralis Bohart	Guam	Pt. Oca		Sep 1945	1F			AC
	Rota	North Shore		26 Oct 1945	10F, 10M		(type series)	AC
Cx. (Cux.) quinquefasciatus Say	Guam	Sta. Rita, Navy Base, CB area; Yigo, Anderson AFB NW Field	13.41522N/144.67183E (GU-002); 13.63025N/144.84793E (GU-012)	4, 17 Mar 2010;	2F	P. Nuhn, W.K. Reeves	LT	FC
	Guam			Oct 1945	1F	L. Rozeboom		AC
	Guam			28, 29 July 1975	4F, 6M		(container on abandoned airfield)	AC
	Saipan		(SAI-9, 37, 40, 42, 47, 48, 59, 80)	Aug 1991	32F, 85M	H. Savage	LC (flooded terrestial grasses, ground pool, water barrel, Phragmites marsh); biting pigs	AC
	Saipan			Sep 1944; Nov. 1982	6M	J.L. Webb, D. Pashley		AC
	Saipan	Charan Ronoa; Jija		Aug 1944	4M			AC
	Saipan			18 Jul 1944	1F, 1M		treehole, mangrove	AC
	Tinian			Aug 1944		Navy Medical School		

AC – museum collection of the National Museum of Natural History (NMNH), Washington, DC; F – female; FC – field collected, deposited in the NMNH; LC – larval collection; LT – CDC light trap collections; M – male.

Table 1 continued on next page.

Table 1 (continued). Summary of collection localities of mosquitoes (based on observed specimens) in Guam, Saipan, Tinian, and Rota.

Species	Island	Locality	Grid Coordinates	Collection Date	Number/ Stage	Collector	Remarks (Habitat)	Repository
*Cx. (Cux.) tritaeniorhynchus*Giles	Guam	Sta. Rita, Apra Navy landing, housing and magazine areas	13.42038N/144.67496E (GU-005); 13.40386N/144.67735E (GU-007)	9, 10 Mar 2010	5F	W.K. Reeves	LT (deer pen)	FC
	Guam	NAVSTA, Pt. Apaca		Aug, Sep 1975	16F, 12M			AC
	Guam			3 Oct 1975; 24 Dec 1975; 5 Jan 1976	3F, 4M		(ground pool, ditch)	AC
	Saipan		(SAI-7, 9)	15-25 Aug 1991	7F, 36M	H. Savage	(Phragmites marsh, ground pool; biting pigs	AC
*Lutzia (Metalutzia) fuscana*Wiedemann	Saipan			Jan 1972	2M	N. Siren		AC
Mansonia (Mansonoides) uniformis (Theobald)	Guam	Sta. Rita, Apra Navy landing, housing and magazine areas	13.42038N/144.67496E (GU-005); 13.40386N/144.67735E (GU-007)	9, 10 Mar 2010	2F	W.K. Reeves	LT	FC

AC – museum collection of the National Museum of Natural History (NMNH), Washington, DC; F – female; FC – field collected, deposited in the NMNH; LT – CDC light trap collections; M – male.

components in developing effective strategies for the prevention and control of mosquito vectors and their borne-infectious diseases.

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Table 2. Updated checklists of mosquito species from Guam and neighboring islands.

Species	Guam	Rota	Saipan	Tinian
Aedeomyia (Aedeomyia) catastictaKnab	B2, R1, W1, X			
Aedes (Aedimorphus) oakleyiStone	B2, R1, X		B3, S1, X	
Aedes (Adm.) vexans nipponi(Theobald)	R1			
Ae. (Adm.) vexans nocturnus(Theobald)	B2, X		B3, B4, S1, X	X
Ae. (Adm.) vexans vexans(Meigen)	B2, K1, P2, R1		N2	V
Ae. (Stegomyia) aegypti(Linnaeus)	K1, R1, R2, X	N1, X	B3, E, K2, X	N2, X
Ae. (Stg.) albopictus(Skuse)	B2, K1, P2, R3, X	N1, N3, X	B3, B4,K2, P1,S1, X	V, X
Ae. (Stg.) burnsiBasio and Reisen	B1, R1			
Ae. (Stg.) dybasiBohart	B1, R1			
Ae. (Stg.) guamensisFarner and Bohart	B2, R1, R3, X	N1, N3	B3, S3	N2
Ae. (Stg.) hensilliFarner	B2, R1			
Ae. (Stg.) marshallensisStone and Bohart	B2, R1			
Ae. (Stg.) neopandani Bohart	B3, P2, X	N1, N3	B3, S1, W3	B3, N2
Ae. (Stg.) pandaniStone	B2, P2, R1, R2, X	N1, N3, X		
Ae. (Stg.) rotanus Bohart and Ingram	B2, B3, P2, R1, R2	B3, R2, N1, N3, X		
Ae. (Stg.) saipanensisStone	B2, B3, P2, R1		B3, B4, P1, S2, W3, X	B3, V
Ae. (Stg.) scutellaris(Walker)	B2, R1, R2			
Armigeres (Armigeres) subalbatus (Coquillett)	R1, W1			
Anopheles (Anopheles) baezaiGater	B1, R1, R2, W3			
An. (Ano.) barbirostrisVan der Wulp	K1, R1, W1, W2			
An. (Ano.) lesteri aisas and Hu	B1, R1			
An. (Ano.) sinensisWiedemann	B2, R1, X			
An. (Cellia) indefinitus(Ludlow)	B2, D1, R1, W1		P3, S1, X	V
An. (Cel.) litoralisKing	R1, W1			
An. (Cel.) subpictusGrassi	B3, D1, D2, P2, K1, R1			V
An. (Cel.) tessellatusTheobald	B1, R1			
An. (Cel.) vagus Donitz	D1, D2, K1, R1, W1, X			
Cx. (Cux.) annulirostris marianae Bohart and Ingram	R1, X	N1, N3, X	B3, B4, W3, X	
Cx. (Cux.) fuscocephala Theobald	R1, W1			
Cx. (Cux.) hutchinsoni Barraud	R1			
Cx. (Cux.) litoralisBohart	B3, R1, X	N1, W3, X	B3	N2
Cx. (Cux.) quinquefasciatusSay	K1, P2, R1, X	N1, N3	B3, E, K2, S1, X	V, X
Cx. (Cux.) pseudovishnuiColless	R1			
Cx. (Cux.) sinensisTheobald	R1			
Cx. (Cux.) sitiensWiedemann	B3, R1		S1	
Cx. (Cux.) tritaeniorhynchusGiles	B3, K1, P2, R1, X		S1, X	
Cx. (Cux.) vagansWiedemann	R1			
Cx. (Culiciomyia) papuensis(Taylor)	N2			
Lutzia (Metalutzia) fuscanaWiedemann	B3, P2,R1		S1, X	
Mansonia (Mansonoides) uniformis (Theobald)	W1, X			
Toxorhynchites (Toxorhynchites) amboinensis(Doleschall)	R1			
Tx. (Tox.) brevipalpisTheobald	R1			
Total Number of Species	40 (4 subspecies)	9 (1 subspecies)	14 (3 subspecies)	10 (1 subspecies)

Species Reported	Reference
B1	43
B2	21
B3	35
B4	41
D1	44
D2	45
E	46
K1	9
K2	47
N1	27
N2	39
N3	42
P1	48
P2	22
P3	49
R1	11
R2	32
R3	50
S1	5
S2	51
S3	52
V	53
W1	40
W2	54
W3	26
X	This Survey

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