Potentialities for Accidental Establishment of Exotic Mosquitoes in Hawaii[1]

C. R. JOYCE
PUBLIC HEALTH SERVICE QUARANTINE STATION
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
HONOLULU, HAWAII

Public health workers frequently become concerned over the possibility of the introduction of exotic anophelines or other mosquito disease vectors into Hawaii. It is well known that many species of insects have been dispersed by various means of transportation and have become established along world trade routes. Hawaii is very fortunate in having so few species of disease-carrying or pest mosquitoes. Actually only three species are found here, exclusive of the two purposely introduced *Toxorhynchites*. Mosquitoes still get aboard aircraft and surface vessels, however, and some have been transported to new areas where they have become established (Hughes and Porter, 1956).

Mosquitoes were unknown in Hawaii until early in the 19th century (Hardy, 1960). The night biting mosquito, *Culex quinquefasciatus* Say, is believed to have arrived by sailing vessels between 1826 and 1830, breeding in water casks aboard the vessels. Van Dine (1904) indicated that mosquitoes were introduced into the port of Lahaina, Maui, in 1826 by the "Wellington." The early sailing vessels are known to have been commonly plagued with mosquitoes breeding in their water supply, in wooden tanks, barrels, lifeboats, and other fresh water containers aboard the vessels.

The two day biting mosquitoes, *Aedes aegypti* (Linnaeus) and *Aedes albopictus* (Skuse) arrived somewhat later, presumably on sailing vessels. *Aedes aegypti* probably came from the east and *Aedes albopictus* came from the western Pacific. Reports indicate that *A. aegypti* was abundant in 1892 and that by 1896–97 both species were common pests (Perkins, 1913). All three of these mosquitoes have become adapted to living in close proximity to man, breeding in and around his place of abode, and are thus well suited to being transported along routes of commerce.

Van Zwaluwenburg (1929) records a reported occurrence of an *Anopheles* on Oahu in which an anopheline thorax was identified among specimens submitted in a monthly sample forwarded to the U.S. Department of Agriculture for identification from Oahu military posts. No evidence is available to indicate

[1] Presented as presidential address at December, 1960, meeting of the Hawaiian Entomological Society.

that the *Anopheles* species ever became established. No locally captured anopheline has been reported since that date.

Although no additional species of mosquito has become accidently established in Hawaii since 1900, the threat of further introductions continues. In recent years living mosquito larvae have been found breeding in tires and other salvage equipment brought back from combat areas of the Pacific. Bonnet (1947) reported finding *C. quinquefasciatus* larvae in a shipment of bulldozer tires landed in Honolulu from Saipan. Mosquitoes are still sometimes found breeding in barrels and buckets on shipboard. In some southern U.S. ports they have been found in aircraft tires flown back from South America (Hughes and Porter, 1956). These authors also report that one recovery was made at the Miami airport of living mosquito larvae at the base of the corolla of a bird of paradise flower brought in from Panama.

It is well known that mosquitoes do frequently board aircraft and hitch-hike considerable distances. Mosquitoes were found on 3,873 or 4.8 per cent of the aircraft inspected at seven U.S. ports during a ten year period, 1937–1947 (Hughes, 1949). Seven species of mosquitoes were reported by Laird (1951) on aircraft arriving in New Zealand from other areas. To date a total of 62 species of mosquitoes have been recovered from aircraft arriving at the Honolulu International Airport from various areas of the world. Many of these have disease carrying potentials.

There are a number of records of mosquitoes gaining access to new areas in the Pacific in recent years, particularly since World War II. *Anopheles subpictus indefinitus* (Ludlow) was found on Guam in 1948 and is thought to have come via surface craft from the Philippines during military operations (Yamaguti and LaCasse, 1950). It thrived on Guam and has become a common mosquito there. *Aedes albopictus* first appeared in Guam in 1944 and has flourished since that time (Hull, 1952). *Aedeomyia catastica* Knab was first taken in a light trap near Apra Harbor, Guam, in January of 1958, and has been taken frequently since (Nakata, 1960). This species may have been introduced from the Philippines or the Western Carolines.

Prior to December of 1941 Wake Island was free of mosquitoes. *Aedes aegypti* and *Culex quinquefasciatus* both gained entry and were abundant in later surveys. They were found breeding in abandoned Japanese concrete cisterns and storage drums soon after World War II (Reeves, 1953). A survey in 1949 showed *Culex quinquefasciatus* mosquitoes to be present on Palmyra, an island also reportedly free of mosquitoes prior to World War II (Hu, 1949). The first records of mosquitoes on Midway Island are from specimens of *C. quinquefasciatus* collected by Hadden in 1937. In 1955, Clagg reported on the abundance of *Aedes albopictus* there. According to published records mosquitoes have apparently been introduced, eradicated, and reintroduced to Kwajalein Island several times since 1951 (Keck, 1951, Reeves, 1953, and Clagg, 1957.)

More recently *Aedes vigilax* (Skuse) has become established in Fiji (Burnett,

TABLE 1. Summary of aircraft inspections. (spot-checks,) 1955 to 1959.

Number of aircraft inspected				2,341
Number carrying insects				1,323
Per cent carrying insects				56.5
Number of insects recovered				10,835
Average number per aircraft				8.19
Alive	237,	Knock-down	347, dead	10,261
Per cent alive or knock-down				5.4
Number carrying mosquitoes				172
Number mosquitoes recovered				267
Alive	8,	knock-down	1, dead	258

TABLE 2. Summary, insects from aircraft—1959

Rank	Order	Total No.	Per cent
1	Diptera	1,159	70.1
2	Coleoptera	136	8.2
3	Hymenoptera	78	4.7
4	Hemiptera	74	4.5
5	Homoptera	69	4.2
6	Orthoptera	49	3.0
7	Lepidoptera	48	2.9
8	Acarina (mites)	15	.9
9	Isoptera	8	.5
10	Araneida (spiders)	5	.3
	Other Misc. orders (7)	13	.8

TABLE 3. Diptera from aircraft (breakdown)—1959

Rank	Family	Total No.	No. Species	Per cent
1	Chironomidae	479	?	41.3
2	Muscidae	194	6	16.7
3	Culicidae (mosquitoes)	108	25	9.3
4	Drosophilidae	107	?	9.2
5	Sciaridae	33	?	2.8
6	Chloropidae	27	5	2.3
7	Ceratopogonidae	26	5	2.2
8	Anthomyiinae	23	4	2.0
9	Calliphoridae	19	6	1.6
10	Ephydridae	18	?	1.6
11	Cecidomyiidae	15	?	1.3
12	Otitidae	12	3	1.0
	Other Misc. families (19)	98	?	8.5

1960). The species is a salt marsh breeder and has become the worst pest mosquito in some coastal areas of Fiji. It is thought to have been introduced by aircraft from New Caledonia, where it is abundant, and where it serves as a vector of the New Caledonia strain of non-periodic bancroftial filariasis (Iyengar and Menon, 1956). *A. vigilax* was first noted near Suva, Fiji, in December of 1957, and later was found along much of the coastal area of Viti Levu. It has been a nuisance in the vicinity of the Nandi Airport. The writer found *A. vigilax* in the vicinity of the Nandi Airport, and near the Tontouta airfield in New Caledonia in the fall of 1958.

It thus appears that mosquitoes still have not lost their capacity to travel and to become established in new areas. It is surprising that more accidental introductions have not taken place. For instance, why have *Anopheles* mosquitoes and malaria not become established in New Caledonia, since both are prevalent to the north and west in the New Hebrides, Solomon Islands and New Guinea? Much early World War II traffic took place between these areas. Perhaps some ecological or physical barrier operates naturally to keep *Anopheles* out. Many introduced species seem to have become established only after man has moved in and made changes in the environment. Countless introductions have no doubt failed to become established.

Today surface vessels do not pose a very serious threat to Hawaii. No live adult mosquitoes or living larvae have been found on vessels arriving at the port of Honolulu for several years. Modern ocean-going vessels have enclosed water supplies, covered life-boats, and offer very little in the way of mosquito breeding possibilities. Crews and passengers are mosquito conscious and would not condone a mosquito nuisance aboard ship. The widespread use of modern insecticides has also greatly lessened the hazard. The great distances involved also work to Hawaii's advantage. Hitch-hiking adult mosquitoes tend to disappear after a vessel is out to sea a few days, and by the time a vessel reaches Hawaii the mosquitoes are usually dead or have disappeared, unless they are breeding aboard the vessel. However, we should not become too complacent. Surface vessels need to be watched as a potential source of exotic mosquitoes and should be maintained as mosquito proof and as mosquito free as possible. Particular attention should be paid to certain types of cargo such as old tires, scrap, and heavy equipment that can hold pockets of water in which mosquitoes may breed. Cargo of this type can also carry dry mosquito eggs which may hatch out later if given suitable conditions.

Aircraft seem to pose the more immediate danger. During the last few years the U.S. Public Health Service and the Hawaii Bureau of Mosquito Control have spot-checked a number of aircraft arrivals at the Honolulu Airport from both foreign and domestic ports for the presence of mosquitoes. To date a total of 62 species, all but two of which do not occur in Hawaii, have been taken from aircraft. Only 3.3 per cent of the mosquitoes were alive when recovered. Included

TABLE 4. Mosquito species most commonly intercepted on aircraft arriving at Honolulu. (Spot-checks) 1952 to 1960.

Species	No. taken	Region of origin	Med.* import
Culex pipiens quinquefasciatus Say	113	Gen.	E, F
Culex whitmorei (Giles)	65	O, A, P	F?
Anopheles subpictus indefinitus (Ld.)	39	O	M?, F?
Culex annulirostris Skuse	21	A, O	F?, E?
Aedes vexans nocturnus (Theob.)	16	A, O	E
Aedes vexans vexans (Meigen)	14	N, P	E?
Culex sitiens Wiedemann	8	A, O	...
Aedes lineatopennis (Ludlow)	7	O, A, E	F
Aedes dorsalis (Meigen)	6	N, P	E
Culex tritaeniorhynchus summorosus Dyar	6	O, P	E
Mansonia uniformis (Theobald)	5	O, A, P	F

*E—encephalitis, F—filariasis, M—malaria.

TABLE 5. List of *Anopheles* species intercepted on aircraft at Honolulu, Hawaii.

Species	Region	Med. Imp.
Anopheles annularis Van der Wulp	Ori.	M, F
" *annulipes* Walker	Austr.	M
" *barbirostris* Van der Wulp	Ori.	M, F
" sp. near *barbirostris* ?	Ori.	...
" *freeborni* Aitken	Nea.	M
" *litoralis* King	Ori.	...
" sp. near *minimus* Theobald	Ori.	...
" *nigerrimus* Giles	Ori.	M, F ?
" *occidentalis* Dyar and Knab	Nea.	...
" *peditaeniatus* (Leicester)	Ori.	...
" *pseudopunctipennis* Theobald	Nea., Neo.	M
" *punctulatus* Dönitz	Austr.	M
" *sinensis* Wiedemann	Ori., Pal.	M, F
" *subpictus indefinitus* (Ludlow)	Ori.	M ?
" *subpictus subpictus* Grassi	Ori. Austr.	M, F
" *umbrosus* (Theobald)	Ori.	M
" species ?	...	...

in the list are 17 species of *Anopheles*, 16 of *Aedes*, 14 of *Culex* and 15 species scattered among five other genera. The most common mosquito encountered in aircraft is the cosmopolitan *C. quinquefasciatus*, followed by *Culex whitmorei* (Giles), an abundant pest species in the Philippines. *Anopheles subpictus indefinitus*, which recently gained entry to Guam, is the most frequently encountered anopheline. Ten of the *Anopheles* species recovered are proven vectors of malaria in other parts of the world, and pose a threat to these *Anopheles*-free islands.

Several mosquito recoveries of vector importance have been made. *Anopheles*

freeborni Aitken, a malaria vector of the western United States, has been taken alive on occasion. *Culex tarsalis* Coquillett, the principal vector of western equine encephalitis in the U.S., has been recovered a number of times, once alive. The vector of Japanese "B" encephalitis, *Culex tritaeniorhynchus summorosus* Dyar, has arrived on aircraft from Japan and other parts of the Orient during the peak mosquito breeding season. *Aedes vigilax*, the vector of filariasis in New Caledonia and a recent immigrant to Fiji, is encountered frequently. *Aedes vexans* (Meigen) and its subspecies, which are abundant pests in many parts of the world, are frequent aircraft hitch-hikers. *Aedes polynesiensis* Marks, the Fijian vector of filariasis, has recently been encountered on aircraft from the south Pacific.

An analysis of the recoveries indicates that mosquitoes may be recovered from aircraft in Honolulu during any month of the year. The ports of origin and call and the season of the year govern their possible presence. From the spot-checks April and May appear to be the low months while October and November are the peak months. The latter is perhaps due to the increased mosquito activity in the South Pacific and the season of heavy rains and typhoons in the area of the Philippines and Guam.

When separated according to probable geographic origin, 22 of the species recovered from aircraft came from the Oriental region, 18 from the Nearctic, 11 the Australian, 2 the Palaearctic, and the other nine are of general distribution or of unknown origin. Some of the specimens recovered dead were in bad condition and cannot be identified to species. Records indicate that mosquitoes may be found aboard aircraft arriving at Honolulu from any direction depending upon their seasonal activity and abundance. More specimens seem to come from the Philippines and southeast Asia, probably because mosquitoes are more abundant both in number of individuals and in numbers of species in this area. In relation to the volume of traffic the number of mosquitoes coming from the mainland United States is relatively small in comparison to that from foreign areas. Normally mosquitoes are relatively scarce in the vicinity of the major United States west coast ports.

A tabulation of the ports of origin and call of foreign commercial aircraft arrivals during a six months period in 1957 indicates 965 stopping at Wake Island, 739 at Tokyo, Japan, 234 at Guam, 234 at Nandi, Fiji, 229 at Sydney, Australia, 173 at Manila, P. I., 107 at Canton Island, and 201 from 21 other ports throughout the Pacific area. With the advent of jets since that time, Wake and Canton Islands are being bypassed by many aircraft so these ports are assuming less importance. From the volume of traffic and the mosquito problems concerned, Japan, Fiji, Guam, and the Philippines seem our major areas of concern.

Mosquitoes follow the rule that the faunas of Pacific islands are progressively more impoverished with less development of endemic faunas from the west toward the east. In the South Pacific area 313 species of mosquitoes are definitely known to occur, with strong affinities to those of the Indo-Malayan area (Iyengar,

TABLE 6. List of *Aedes* species intercepted on aircraft at Honolulu, Hawaii.

Species	Region	Med. Imp.
Aedes albopictus (Skuse)	O, A, P	D, Y ?*
" *dorsalis* (Meigen)	N, P	E
" *lineatopennis* (Ludlow)	O, A, E	F
" *pampangensis* (Ludlow)	O	...
" species near *pandani* Stone	O, A ?	...
" *polynesiensis* Marks	Austr.	F
" *sollicitans* (Walker)	N	...
" *squamiger* (Coquillett)	N	...
" *sticticus* (Meigen)	N, P	...
" species near *sticticus* (Meigen)	N	...
" *taeniorhynchus* (Wiedemann)	N	...
" *vexans vexans* (Meigen)	N, P	E
" *vexans nocturnus* (Theobald)	A, O	E ?
" *vexans nipponii* (Theobald)	P	E ?
" *vigilax* (Skuse)	O, A	F
" species ?	...	...

*D—dengue, Y—yellow fever.

TABLE 7. List of *Culex* species intercepted on aircraft at Honolulu, Hawaii.

Species	Region	Med. Imp.
Culex annulirostris Skuse	A, O	F ?, E ?
" sp. near *annulirostris*	...	...
" sp near *brevipalpis* (Giles)	O, A	...
" *fuscocephalus* Theobald	O	F
" *peus* Speiser	N	E
" *pipiens pipiens* Linnaeus	Gen.	F, E
" *pipiens quinquefasciatus* Say	Gen.	F, E
" *sitiens* Wiedemann	A, O, E	F
" *tarsalis* Coquillett	N	E
" *tritaeniorhynchus summorosus* Dyar	P, O	E
" *whitmorei* (Giles)	O, A, P	F ?
" sp. near *whitmorei*	...	...
" sp. near *sitiens* Wiedemann	O	...
" species ?	...	...

1960). In the Philippines 239 species are known (Stone, Knight, and Starcke, 1959). Japan has 51 species (LaCasse and Yamaguti, 1950), Fiji 20, Guam 12, Samoa 12, and Wake 2. Most of the species probably progressed across the Pacific via island stepping stones. In the other direction, 141 species are reported in North America north of Mexico (Carpenter and LaCasse, 1955).

Some of the important mosquito-borne diseases and vector mosquitoes which we wish to keep out of Hawaii are:

1. Malaria—*Anopheles sinensis* Wiedemann, the principal vector in Japan and Korea; *Anopheles minimus flavirostris* (Ludlow), the important vector in the Philip-

pines; *Anopheles farauti* Laveran and *A. punctulatus* Dönitz of the South Pacific; *Anopheles freeborni* Aitken, *A. quadrimaculatus* Say, *A. pseudopunctipennis* Theobald, and *A. albimanus* Wiedemann, vectors in North America.

2. Encephalitis—*Culex tarsalis* Coquillett, the vector of western equine encephalitis and *Culiseta melanura* (Coquillett), principal vector of eastern equine encephalitis in the United States; *Culex tritaeniorhynchus summorosus* Dyar, the chief vector of Japanese "B" encephalitis; and *Culex annulirostris* Skuse, the vector of Murray Valley encephalitis of Australia.

3. Filariasis—*Aedes vigilax* (Skuse), vector in New Caledonia; *Aedes polynesiensis* Marks of Fiji and Samoa; other *Aedes* of the *scutellaris* complex; *Mansonia uniformis* Theobald and some *Anopheles* and *Culex* species which serve as vectors in the South Pacific and Southeast Asia areas.

From the number of specimens recovered from aircraft, the abundance of traffic, and the suitability of Hawaiian climate and ecology, I might venture a guess as to the mosquito species most likely to be accidently introduced to Hawaii. *Aedes vexans* (Meigen), a rain pool and flood water breeding pest species, seems the first choice, with the subspecies *nocturnus* (Theobald) of Guam and Fiji being the most readily adapted to conditions in Hawaii. Next might come *Culex annulirostris*, which is one of the most common mosquitoes of Guam, Fiji, and the South Pacific, and one which will breed in a very wide variety of larval habitats from muddy marshes, fresh ground water pools, to rock holes. *Aedes vigilax*, *Aedes sollicitans* (Walker), or another of the salt marsh breeders might gain a foothold with the extension of salt marsh areas. *Anopheles subpictus indefinitus* appears to be the most imminent *Anopheles*.

Several factors operate to prevent the establishment of exotic species in Hawaii. At the port of departure efforts are made to keep mosquitoes from getting aboard the aircraft in the first place. Basic sanitation and sanitary engineering practices have improved considerably in recent years. The World Health Organization through the International Sanitary Regulations promotes the establishment of International Airports as sanitary airports where control efforts seek to keep vector species at a minimum (1957).

If mosquitoes do get aboard aircraft an additional toll is taken enroute. Airline crews and passengers are mosquito conscious and will not condone a mosquito nuisance aboard aircraft. Spraying at time of departure or enroute will knock-down any living mosquito, if properly applied. The Public Health Service requires that all foreign arrivals at Honolulu be disinsected if they originate at ports between 45 N and 45 S latitude (Surgeon General, 1955, Foreign Quarantine Circular #76, 1960). A minimum of 5 grams of a recommended aerosol formulation per 1000 cu. ft. with a 3 minute exposure time is required as sufficient to kill mosquitoes. The Hawaii State Department of Health likewise requires the disinsecting of all aircraft arriving in Hawaii from any possession, territory, state, or district of the United States (1954).

TABLE 8. Other genera and species of mosquitoes intercepted on aircraft at Honolulu, Hawaii.

Species	Region	Med. Imp.
Aedeomyia catasticta Knab	A, O	...
Culiseta incidens (Thomson)	N	E ?
" *inornata* (Williston)	N	E
" species ?	...	...
Chaoborinae species	N	...
Chaoborus sp. ?	N	...
Psorophora signipennis (Coquillett)	N	...
Mansonia crassipes (Van der Wulp)	A, O	...
" *dives* (Schiner)	A, O	F
" *uniformis* (Theobald)	O, A, P	F
" sp. near *uniformis*	...	...
" (*Coquillettidia*) sp. ?	...	...
" (*Mansonioides*) sp. ?	...	...
" species ?	...	...
Genus & species ?	...	...

At the port of arrival an inspection and an additional treatment is performed. The U.S. Department of Agriculture applies a spray to the aircraft after discharge of passengers on all foreign arrivals (except arrivals from Japan during the winter months). This spray is designed to kill other insects of agricultural importance more resistant than mosquitoes. No mosquitoes have been found to survive this heavier dosage of 30 grams per 1000 cubic feet.

Even if a mosquito survives all of these hazards, it may still encounter difficulties in becoming established. The fertile female must find a suitable habitat in which to lay eggs where they will hatch and the larvae can develop. Such a habitat may not be present at the particular time the mosquito arrives. Competition with already established species is often keen, and parasites and predators may cause heavy mortality. Although it is possible for a single fertilized female to establish an infestation, successful introductions are usually accomplished after a species has arrived several times in numbers.

Other factors make it difficult for mosquitoes to establish themselves near the Honolulu Airport. The airport is located on a rather barren area on the drier leeward side of the island, and the normal prevailing trade wind blows out to sea. The coral fill soil is quite porous allowing water to percolate away rapidly thus leaving few pools of standing water for any lengthy period. In most areas of Hawaii there is a steep slope from the mountain tops to the sea which results in rapid run-off of water. Tidal fluctuation is small and alluvial flats are not extensive; thus Hawaii has few salt marsh areas of any size. However, mangrove trees are becoming established in a few areas in the islands and seem to be extending their range, thus increasing tidal salt marsh areas.

And finally, surveillance and control operations are continually practiced in the airport vicinity. Possible mosquito breeding sites are checked each month

and treated when necessary. A mosquito light trap is kept in continuous operation at the airport as a surveillance measure, to check on the mosquito activity and to detect any exotic species which might have become established. A new arrival could no doubt be eradicated before it had a chance to become firmly established.

In summary, mosquitoes do get aboard ships and planes and have become established in new areas. Some occasionally reach Hawaii in viable condition. Sixty two different species have been identified from arriving aircraft in recent years. It is possible for new exotic mosquitoes to become established here, although none have succeeded in recent years in spite of the tremendous wartime traffic and increasingly numerous postwar arrivals. With the continuance of present precautions and the improvement of sanitation and control about airfields, the danger does not appear to be extremely great. With aircraft coming faster and from greater distances the threat will probably increase. Insects can now come on direct flights from almost any part of the world, whereas formerly they approached in short hops via island stepping stones.

References

BOHART, R. M. 1955. INSECTS OF MICRONESIA, DIPTERA, CULICIDAE. B. P. Bishop Mus. Vol. 12(1).

BONNET, D. D. 1948. Notes and exhibitions, *Culex quinquefasciatus* Say. PROC. HAW. ENT. SOC. 13(2):205.

BURNETT, G. F. 1960. The arrival of *Aedes* (*Ochlerotatus*) *vigilax* (Skuse) in Fiji. PAC. SCI. 14(4), 389–394.

CARPENTER, S. J. and W. J. LACASSE. 1955. MOSQUITOES OF NORTH AMERICA. Univ. of Calif. Press, Berkeley, Calif.

CLAGG, C. F. 1955. Notes and exhibitions, *Aedes*. PROC. HAW. ENT. SOC. 15(3):375.

CLAGG, C. F. 1957. Notes and exhibitions, *Culex quinquefasciatus*. PROC. HAW. ENT. SOC. 16(2):193.

HARDY, D. E. 1960. INSECTS OF HAWAII, Vol. 10: DIPTERA: NEMATOCERA-BRACHYCERA. Culicidae. 18–22, 81–90. Univ. of Hawaii Press.

HAWAII, DEPT. OF HEALTH. 1954. PUBLIC HEALTH REG. 2nd amendment, Chapt. I. Sanitation, Sec. 90-A. Disinsectization of aircraft.

HU, S. M. K. 1949. Notes and exhibitions, *Culex quinquefasciatus*. PROC. HAW. ENT. SOC. 14(1):5.

HUGHES, J. H. 1949. Aircraft and Public Health Service foreign quarantine entomology PUB. HEALTH REPT. SUPPL. No. 210. Wash. D. C. U.S. Govt. Printing Office. 38 pp.

HUGHES, J. H. and PORTER, J. E. 1956. Dispersal of mosquitoes through transportation, with particular reference to immature stages. MOSQUITO NEWS. 16(2):106–111.

IYENGAR, M. O. T. 1960. A review of the mosquito fauna of the South Pacific. (Diptera: Culicidae). SO. PAC. COM. TECH. PAPER No. 130.

KECK, C. B. 1951. Notes and exhibitions. *Culex quinquefasciatus*. PROC. HAW. ENT. SOC. 14(3):369.

LACASSE, W. J. and S. YAMAGUTI. 1950. MOSQUITO FAUNA OF JAPAN AND KOREA. 213 pp. 207th malaria Survey Det. Offic. Surgeon. 8th U.S. Army, Kyoto, Japan.

LAIRD, M. 1951. Insects collected from aircraft arriving in New Zealand from abroad. ZOOL. PUBL. No. 11. VICTORIA UNIV. COLLEGE. Wellington, N. Z. 30 pp.

NAKATA, S. 1960. Notes and exhibitions, for Cantelo. *Aedeomyia catastica* Knab. PROC. HAW. ENT. SOC. 17(2):161.

PERKINS, R. C. L. 1913. FAUNA HAWAIIENSIS, INTRODUCTION David Sharp Ed. 1(6) xv-ccxxviii. Cambridge Univ. Press.

REEVES, W. C. 1953. Possible recent introductions of mosquito vectors of human disease in the Central Pacific. PROC. SEVENTH PAC. SCI. CONGR. 7:371–373.

SACKETT, A. P. 1960. P. H. S. FOR. QUAR. CIRCULAR #76. Aircraft to be disinsected.

STONE, A., K. L. KNIGHT, and H. STARCKE. 1959. A synoptic catalog of the mosquitoes of the world. THOMAS SAY FOUND. Vol. 6.

SURGEON GENERAL. 1955. DISINSECTIZATION REQUIREMENTS 71.90 and 71.102 of P.H.S. Reg. (Part 71.102 title 42, code of Fed. Reg., as amended July 10, 1955).

VAN DINE, D. L. 1904. Mosquitoes in Hawaii. HAWAII AGR. EXPT. STA. BULL. 6:1–30.

VAN ZWALUWENBURG, R. H. 1929. Notes and exhibitions, *Anopheles*. PROC. HAW. ENT. SOC. 7(2):226.

WORLD HEALTH OEGANIZATION. 1957. INTERNATIONAL SANITARY REGULATIONS. Geneva.

YAMAGUTI, S. and LACASSE, W. J. 1950. MOSQUITO FAUNA OF GUAM. Office of Surgeon, Hdq. U.S. 8th Army. 101 pp.