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A Review of the Role of Mosquitos in the Transmission of Malayan and Bancroftian Filariasis in Japan *

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Malayan filariasis is found in Japan only on the small island of Hachijo-koshima and is transmitted there by Aëdes togoi *and probably by* Culex pipiens pallens.

Bancroftian filariasis is widely distributed in the three main islands, and is of particularly high endemicity in the south. Of the ten mosquito species proved experimentally susceptible to Wuchereria bancrofti, *only* Aëdes togoi *and* Culex p. pallens *seem to be responsible for transmission of the disease. The former species is of importance only in fishing villages situated on a rocky seashore with many tidal pools or in villages engaged in the processing of dried sardines.* Culex p. pallens *is domestic in habit, highly anthropophilic and highly susceptible to* W. bancrofti *infection, and must be considered the most important vector of this disease in Japan.*

Bancroftian filariasis is widely distributed in Japan, including the Ryukyu islands. The only exception is a small islet called Hachijo-koshima, which is located about 360 km south of Tokyo, and has only malayan filariasis (Sasa et al., 1952).

In Honshu, endemic foci of bancroftian filariasis are found as far north as Aomori prefecture, the northern extremity of the island, but they are sparsely located and the incidence is extremely low. In Shikoku, especially in its south-western parts, the disease occurs with moderate prevalence. In Kyushu, the southernmost main island—and especially in Nagasaki, Kumamoto, and Kagoshima prefectures and their adjacent small islands—it is widely distributed with mild or high (40% or more) prevalence.

The total number of cases of bancroftian filariasis in Japan, including Ryukyu, is roughly estimated at one million. In view of the gravity of the disease in Japan, work on experimental and natural infection rates, ecology of vector mosquitos, epidemiology and chemical treatment of the disease has been carried out by many Japanese investigators. A review of field experiments in the control of bancroftian and malayan filariasis in Japan was recently published by Sasa et al. (1959). Here, the present author will content himself with a review of work on the habits of vector mosquitos of bancroftian and of malayan filariasis in Japan and their role in the transmission of the disease.

VECTORS OF MALAYAN FILARIASIS IN JAPAN

As stated above, malayan filariasis in Japan occurs on only the small islet of Hachijo-koshima, 3.2 square miles (about 8 km²) in area. The islet has only two small villages, Utsuki and Toriuchi, which have 76 and 107 residents respectively. The disease has been investigated exclusively by Sasa and his associates since 1948, and they found 29 persons, or 31% of the 93 examined, in Toriuchi village to be positive for malayan microfilariae in May 1960. In September of the same year, they collected 68 females of *Aëdes togoi* and two of *Culex pipiens pallens* in dwelling houses and cow-sheds or in the act of biting in the village. In one of the females of *Aëdes togoi*, they found two filariae, one second-stage and one infective-stage larva, of *Brugia* (former *Wuchereria*) *malayi*. Later, they proved experimentally that the larvae of this filarial worm can reach maturity in *Aëdes togoi* and also in *Culex pipiens pallens*. Of

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seven mosquito species found on the islet, these two species are the most active in breeding and the most abundant in houses, but Sasa and co-workers are of the opinion that *Aëdes togoi* is the most important in the transmission of malayan filariasis there.

The occurrence of malayan filariasis in Japan, though only on a very small and remote islet, is very interesting and noteworthy from the standpoint of the geography of the disease, although it is obviously of minor importance as a public health problem in Japan.

VECTORS OF BANCROFTIAN FILARIASIS IN JAPAN

Experimental infection

Laboratory experiments relating to the subject have been conducted by Mochizuki (1911, 1913) and Yamada (1927), and recently have been carried out by the author and his associates. Mochizuki carried out his experiments during the summer, in 1910 and 1911, in Fukuoka city, Kyushu, under natural room-temperature conditions, and found some of the filaria larvae to reach maturity in mosquitos as soon as 12 days after taking infective meals. Yamada (1927) carried out his experiments in Tokyo with a temperature of 24°-27°C, and found the larvae to reach maturity 12 or 13 days after taking infective meals. Unfortunately, however, Yamada has not given the number of microfilariae in the patient he studied. The present author and his associate, Fujisaki, conducted their experiments from 1953 to 1958, keeping mosquitos at a constant temperature of 25°C at Isahaya city, Nagasaki prefecture. They, however, had to use hospitalized carriers, or persons from filariasis endemic areas, because no filariasis was found in the city where the experiments were carried out.

Altogether, 26 species of Japanese mosquitos have been tested for susceptibility to *Wuchereria bancrofti*. Of these, ten species have been found more or less susceptible and to allow the complete development of filariae from microfilariae to infective-stage larvae. Details of experimental infections with these ten species are summarized in Table 1.

Culex pipiens pallens. The results of experiments summarized in Table 1 show that the house mosquito, *Culex pipiens pallens*, can be said to be the most susceptible to *Wuchereria bancrofti* in Japan because the infection rate, the rate of maturity, and also the index of infective larvae are generally higher in this mosquito than in the others, although the values obtained by ourselves are not entirely parallel with those of the other two authors.

Data recently collected show that the infection rates and indices of infective larvae become lower, while the rates of maturity become higher, when the mosquitos are allowed to feed on carriers having lower microfilarial counts. It is of interest that in an extreme case, as shown in the table, this mosquito can still be infected with infective larvae even when fed on a carrier having only one or two microfilariae per 20 mm^3 of blood.

On the other hand, when mosquitos were fed on carriers having as many as 80 or more microfilariae per 20 mm^3 of blood, the rates of maturity, and consequently the indices of infective larvae, generally became rather low, though the infection rates were high. This is mainly because the heavily infested mosquitos were very often killed when a number of filariae began to reach maturity.

Here, however, it is noticeable that the indices of infective larvae in experiments conducted by the author still seem to be too low and not necessarily parallel to the number of microfilariae in the blood of the carrier. This may be partly due to the fact that the number of microfilariae taken up by an individual mosquito—and consequently the mean number of those taken up by a batch of mosquitos—may be subject to a great variation, owing to the patchy or aggregate type of distribution of microfilariae in the peripheral blood stream of the carrier (Omori, 1958), and partly to the possible escape of infective larvae from the tip of the proboscis of mosquitos when they feed on the cotton pad soaked with dilute sugar solution. Such an escape might have taken place more often in this author's experiments, as he dissected the mosquitos over much longer periods than the other authors.

At any rate, it can be concluded that the house mosquito is the most susceptible to *Wuchereria bancrofti* of the ten mosquito species considered here.

Culex pipiens molestus. This species is a little smaller in body length than *C. p. pallens* and it does not engorge with blood as much as the latter does; accordingly, the index of infective larvae is low. Nevertheless, both the infection rate and the rate of maturity are very high and this species is therefore considered to be very highly susceptible.

Aëdes togoi. This species is not so easily induced to feed on man and engorge with blood in captivity as is the house mosquito. The index of infective larvae is therefore not often high, but the rate of maturity of filariae is very high, indicating high susceptibility. It is also noteworthy that two out of

TABLE 1

EXPERIMENTAL INFECTION OF MOSQUITOS WITH *WUCHERERIA BANCROFTI* IN JAPAN

Species	Author	No. micro-filariae in blood of carrier [a]	Dis-section period of mosquito [b] (days)	No. mosquitos dissected	Infection rate of mosquito [c]	Rate of maturity [d]	Index of infective larvae [e]
Culex pipiens pallens	Mochizuki (1911)	3.735	11–17	58	98.3	89.8	19.14
Culex pipiens pallens	Yamada (1927)		13–19	25	100.0	86.1	22.28
Culex pipiens pallens	Yamada (1927)		16–19	17	100.0	81.5	19.18
Culex pipiens pallens	Omori, 1953-55, unpublished	0.092	14–19	118	19.5	93.3	0.24
Culex pipiens pallens	Omori, 1953-55, unpublished	0.375	19	33	15.2	100.0	0.21
Culex pipiens pallens	Omori, 1953-55, unpublished	1.090	14–48	99	91.9	94.4	5.28
Culex pipiens pallens	Omori, 1953-55, unpublished	1.165	14–92	104	96.2	90.1	8.74
Culex pipiens pallens	Omori, 1953-55, unpublished	4.600	12–49	49	89.8	64.3	11.41
Culex pipiens pallens	Omori, 1953-55, unpublished	6.125	12–44	24	87.5	70.9	5.58
Culex pipiens molestus	Fujisaki (1958)	2.190	14–19	26	80.8	77.7	3.62
Aëdes togoi	Mochizuki (1913)		15–16	15		97.4	2.53
Aëdes togoi	Yamada (1927)		12–18	20	70.0	96.1	8.55
Aëdes togoi	Omori, unpublished	0.017	14–16	15	13.3	100.0	0.20
Culex vagans	Yamada (1927)		18	2	100.0	81.8	27.00
Culex whitmorei	Yamada (1927)		16–21	5	80.0	68.3	5.60
Culex sinensis	Mochizuki (1913)		13	4		75.8	6.25
Culex sinensis	Yamada (1927)		18–35	4	50.0	15.4	1.50
Culex bitaeniorhynchus	Mochizuki (1911)	3.735	11–13	11	54.5	28.5	4.64
Culex bitaeniorhynchus	Yamada (1927)		13–17	12	0	0	0
Culex vishnui	Yamada (1927)		14–28	12	0	0	0
Culex vishnui (?) [f]	Mochizuki (1911)	3.735	11–16	47	6.4	10.3	0.49
Culex tritaeniorhynchus	Yamada (1927)		13–60	16	31.3	13.2	1.69
Culex tritaeniorhynchus	Fujisaki (1959)	2.150	12–23	120	8.3	5.0	0.10
Anopheles hyrcanus sinensis	Yamada (1927)		13–16	10	30.0	9.3	1.20
Anopheles hyrcanus sinensis	Mochizuki (1911)	3.735	11–13	23	0	0	0
Anopheles hyrcanus sinensis	Fujisaki (1959)	1.636	14–32	215	0	0	0

[a] Mean number of microfilariae per 1 mm^3 of carrier's blood before and after the infective meal.
[b] Mosquitos were dissected during the indicated days after the infective meal.
[c] No. of mosquitos having infective larvae ÷ No. of mosquitos dissected × 100.
[d] No. of infective larvae ÷ No. of larvae found in mosquitos dissected × 100.
[e] Number of infective larvae per mosquito dissected.
[f] The mosquito used by Mochizuki seems to be mostly *C. tritaeniorhynchus*.

15 females were found harbouring infective-stage larvae, two larvae in one female and one in another, despite the fact that the females were fed on a carrier with only one microfilaria in 60 mm^3 of blood and that they took blood meals of an average of only about 3 mm^3.

Culex vagans. Only two females were examined by Yamada, but in view of the very high infection rate and rate of maturity, he considered this species to be highly susceptible.

Culex whitmorei. This species is rather small in size, the index of infective larvae is not high, and the number of females examined by Yamada was only five; but, owing to the high values of both infection rate and rate of maturity, he regarded it also as a highly susceptible species.

Culex sinensis. This species may be said to be moderately susceptible, judging from the data of Mochizuki and of Yamada, although the numbers of females used were very small and the values obtained by these authors showed considerable differences.

Culex bitaeniorhynchus. The data obtained by Mochizuki and by Yamada are quite different. The reason is not clear at present, but this mosquito seems to have extremely low susceptibility.

Culex vishnui. Yamada found that all the filariae taken up by this mosquito remained entirely undeveloped.

Mochizuki reported that he had studied this species, but there is clear evidence that some of the mosquitos he used were *C. tritaeniorhynchus* and therefore the data obtained with his *vishnui* should be considered as results obtained with a mixed population of *vishnui* and *tritaeniorhynchus.*

Culex tritaeniorhynchus. The data obtained by the three investigators are nearly in accord, showing that this mosquito has very low susceptibility.

It is of interest that, according to Fujisaki, the filariae which invade the thoracic muscles were mostly killed at about the end of the first stage and, moreover, they were not chitinized.

Anopheles hyrcanus sinensis. Yamada showed this mosquito to have a very low susceptibility, while Mochizuki and Fujisaki failed entirely to prove it. The latter two authors, however, found well-developed second-stage larvae in a very few mosquitos—that is, in one out of 23 females dissected by Mochizuki and in one of 215 dissected by Fujisaki. It is of interest that most of the larvae are killed in the thoracic muscles in the very early days of the first stage and are well chitinized.

Conclusion. From the results of investigations by Japanese authors on experimental infection, it may be briefly concluded that the most susceptible species is *Culex pipiens pallens*; four are highly susceptible species, *Culex pipiens molestus, Aëdes togoi, Culex vagans,* and *Culex whitmorei*; one is moderately susceptible, *Culex sinensis*; three are poorly susceptible, *Culex bitaeniorhynchus, Culex tritaeniorhynchus,* and *Anopheles hyrcanus sinensis*; and one is doubtful or non-susceptible, *Culex vishnui.*

Natural infection

As for natural infection of Japanese mosquitos with *Wuchereria bancrofti*, the only data are those from Yamashita and Nagahana obtained in Kagoshima prefecture, and those of the Omori and co-workers, Oshima and Nagatomo, in Nagasaki and Kumamoto prefectures.

The results of these investigations, conducted during the years after the Second World War, are summarized in Table 2. The mosquito surveys were carried out mostly in houses with carriers, in some cases in human-baited traps, and in rare cases in houses close to the carriers' houses. Among the mosquitos thus collected, *Culex pipiens pallens* is the largest in number, followed by *Culex vishnui, Armigeres subalbatus, Aëdes togoi* and *Culex tritaeniorhynchus*, while the others are very few. On the other hand, the mosquitos found to harbour filariae in any stages of development include only four species, *Culex p. pallens, Aëdes togoi, Culex vishnui,* and *Anopheles hyrcanus sinensis*, as shown in Table 3.

However, only two species, *Culex p. pallens* and *Aëdes togoi*, were found presenting a high infection rate and also infested with a large number of second- and infective-stage larvae. The former species shows a very large absolute number of infested females and consequently it can be concluded that it is the most dangerous species, followed by *Aëdes togoi*, while *Culex vishnui* and *Anopheles hyrcanus sinensis* seem to be of no importance.

The relative importance of these two more dangerous species can be analysed further. *Aëdes togoi*, as will be more fully discussed later, is very active in breeding in tide-pools, bilge water, and artificial

TABLE 2

INVESTIGATIONS FOR NATURAL INFECTION WITH *WUCHERERIA BANCROFTI* IN MOSQUITOS COLLECTED IN CARRIERS' HOUSES IN JAPAN [a]

Species	Author										Total	
	Yamashita (1955)		Oshima (1956)		Nagahana (1957)		Nagatomo (1960a)		Omori (1959)			
	Number of mosquitos											
	Dis-sected	In-fected	Dis-sected	In-fected	Dis-sected	In-fected	Dis-sected	In-fected	Dis-sected	In-fected	Dis-sected	In-fected
Culex pipiens pallens	384	84	1 051	41	846	85	99	20	339	61	2 719	291 (10.7%
Aëdes togoi	3	0	69	1	65	6	7	1	1	0	145	8 (5.5%)
Culex whitmorei	1	0			24	0	1	0			26	0
Culex sinensis			5	0	2	0					7	0
Culex bitaeniorhynchus			11	0	10	0	2	0			23	0
Culex vishnui			234	0	24	1	4	0			262	1 (0.4%)
Culex tritaeniorhynchus	3	0	78	0	15	0	1	0	17	0	114	0
Anopheles hyrcanus sinensis	3	0	37	0	7	2	2	0	5	0	54	2 (3.7%)
Anopheles sineroides			4	0							4	0
Culex pallidothorax			1	0							1	0
Aëdes albopictus			3	0	6	0					9	0
Aëdes japonicus			8	0	3	0					11	0
Aëdes vexans			1	0							1	0
Armigeres subalbatus	10	0	81	0	102	0	2	0	1	0	196	0
Tripteroides bambusa			1	0			1	0			2	0

[a] In many cases, catches were made in houses having one or more carriers; in some cases, in human-baited traps set up near these houses; and in rare cases, in neighbours' houses.

containers of a great variety in fishing villages, but it breeds scantily in inland farm villages; moreover, it does not appear to have a particular preference for human blood.

We had the opportunity to examine the blood-sucking habits and natural infection of this mosquito in two fishing villages which had few cattle, though there were many breeding places of this species.

TABLE 3

DETAILED DATA ON NATURAL INFECTION WITH *W. BANCROFTI* LARVAE IN THE FOUR MOSQUITO SPECIES SHOWN IN TABLE 2 TO HARBOUR FILARIAE

Species	No. mosquitos dissected	Mosquitos infected						
		Total	With 1st-stage larvae		With 2nd-stage larvae		With 3rd-stage larvae	
			No.	%	No.	%	No.	%
Culex pipiens pallens	2 719	291	253	9.3	48	1.8	12	0.4
Aëdes ogoi	145	8	5	3.4	2	1.4	1	0.7
Culex vishnui	262	1	1	0.4	0	0	0	0
Anopheles hyrcanus sinensis	54	2	2	3.7	0	0	0	0

TABLE 4

NATURAL INFECTION RATES OF MOSQUITOS CAUGHT IN 14 HOUSES HAVING FILARIA CARRIERS IN TWO JAPANESE COASTAL FISHING VILLAGES, 1959 [a]

Species	No. mosquitos dissected	Mosquitos infected					
		Total		With 1st-stage larvae		With 2nd-stage larvae	
		No.	%	No.	%	No.	%
Culex pipiens pallens	52	14	26.9	12	23.1	2	3.8
Aëdes togoi	45	1	2.2	1	2.2	0	0
Armigeres subalbatus	8	0	0	0	0	0	0

[a] The two villages investigated had a microfilarial incidence of 5.3% and 10.6% respectively. There were few cattle in these villages. A great number of breeding places of *Aëdes togoi* were found.

As many *Aëdes togoi* could be collected in houses as *Culex pipiens pallens*, as shown in Table 4. However, the natural infection rates were very much lower in *Aëdes togoi* than in the house mosquito.

It can be concluded from these findings and from the results of the examinations of natural filarial infection in mosquitos carried out by other Japanese authors, that the house mosquito, *Culex pipiens pallens*, is the most important bancroftian filariasis vector in Japan and that *Aëdes togoi* appears to be of minor importance, and only in fishing villages.

Taxonomical notes on some vector mosquitos

The conclusion on the taxonomic status of the Japanese house mosquito arrived at by the members of our Department (Bekku, 1956; Kamura & Bekku, 1957) is that *pallens* is a hybrid population of *Culex pipiens pipiens* and *Culex pipiens fatigans*, and is widely distributed throughout Japan from the north of Hokkaido to the south of Kagoshima prefecture, including its adjacent islands, the Amami archipelago.

The morphological characteristics of the male genitalia alter gradually with the locality, showing more resemblance to subspecies *pipiens* in the north and to *fatigans* in the south. The southern end of the distribution in Japan appears to be the Amami islands. The house mosquito in Ryukyu must be described as the subspecies *fatigans*.

Culex pipiens molestus is another member of *pipiens* group present in Japan and is distinguishable from *C. p. pallens* without much difficulty by the morphology of the male genitalia, at least in the southern parts of Japan.

Culex vagans is a species closely related to *C. p. pallens*, and the author supposes that it can be considered as a member of the *C. pipiens* group.

It is interesting and noteworthy that the three closely allied species or subspecies have very high susceptibility to *Wuchereria bancrofti* in Japan and also that *C. p. fatigans* in Ryukyu possibly has the same susceptibility to the filaria, although the relationship of the one to the other there has not been studied extensively so far.

Ecological and epidemiological notes on vector mosquitos

Table 5 illustrates the host preference of vector mosquitos and compares the number and percentage of mosquitos in houses or human-baited traps with those in cattle-sheds. These figures are derived from collections by several investigators at many villages in Kyushu, where bancroftian filariasis is endemic. The first eight species shown in the table are mosquitos which have been proved more or less susceptible to *Wuchereria bancrofti*, as already mentioned. Among these, *Culex pipiens pallens* is predominant in houses or in human-baited traps, showing strong anthropophilism in feeding habits, while the others are very small in number and mostly zoophilic, except for *Aëdes togoi*, the feeding habits of which will be discussed later.

The numbers of mosquitos collected early in the morning in mosquito-nets in houses in villages where filariasis is endemic are given in Table 6, in order to show the habit of invading mosquito-nets through holes. *Culex pipiens pallens* shows a strong invading habit; next comes *Aëdes togoi*, while *Culex vishnui*

TABLE 5

NUMBER AND RELATIVE ABUNDANCE OF MOSQUITOS COLLECTED IN HOUSES AND HUMAN-BAITED TRAPS AND IN CATTLE-SHEDS IN FILARIASIS ENDEMIC VILLAGES IN JAPAN [a]

Species	Author						Total			
	Oshima (1956)		Nagahana (1957)		Nagatomo (1960b)					
	Place of collection						In house or HBT [b]		In cattle-sheds	
	Houses or HBT [b]	Cattle-sheds	Houses	Cattle-sheds	Houses or HBTb	Cattle-sheds	No.	%	No.	%
Culex pipiens pallens	1 051	163	1 177	104	834	70	3 062	65.7	337	13.9
Aëdes togoi	69	37	137	6	28	1	234	5.0	44	1.8
Culex whitmorei			154	313			154	3.3	313	12.9
Culex sinensis	5	0	4	8			9	0.2	8	0.3
Culex bitaeniorhynchus	11	0	61	131	7	4	79	1.7	135	5.6
Culex vishnui	234	77	107	161			341	7.3	238	9.8
Culex tritaeniorhynchus	78	199	21	95	47	25	146	3.1	319	13.1
Anopheles hyrcanus sinensis	37	213	68	232	86	326	191	4.1	771	31.8
Anopheles sineroides	4	28					4	0.1	28	1.2
Armigeres subalbatus	81	114	300	71	19	28	400	8.6	213	8.8
8 other species	14	16	13	6	13	0	40	0.9	22	0.9
Total	1 584	847	2 042	1 127	1 034	454	4 660	100	2 428	100

[a] The villagers mostly owned cows but some kept swine or sheep. Some figures shown in Table 2 are also included in this table.
[b] HBT = Human-baited traps.

TABLE 6

NUMBER AND RELATIVE ABUNDANCE OF MOSQUITOS COLLECTED IN 16 MOSQUITO-NETS AT 15 HOUSES IN FIVE JAPANESE VILLAGES WHICH HAD MICROFILARIAL INCIDENCES OF 4%-18% IN SUMMER 1952

Species	Mosquitos collected	
	No.	%
Culex pipiens pallens	190	85.2
Aëdes togoi	16	7.2
Armigeres subalbatus	14	6.3
Culex tritaeniorhynchus	1	0.4
Culex vishnui	1	0.4
Aëdes japonicus	1	0.4
Total	223	100

and *Culex tritaeniorhynchus* show a very slight invading habit in spite of their smaller size.

In addition to these findings, the seasonal prevalence of adult mosquitos, nocturnal feeding activity, house-staying habits and breeding places of larvae have been investigated by Omori et al. (1959). From the results of those investigations and from the data on laboratory and natural infection rates given above, the relationship of the mosquitos listed in Table 5 to bancroftian filariasis may be summarized as follows.

Culex pipiens molestus breeds only in underground pools or wells in Nagasaki city and is not found in rural areas where filariasis is endemic. *Culex vagans* is commonly distributed in the northern parts of Honshu and in Hokkaido, but is extremely rare in Kyushu. *Culex whitmorei* is rather rare in Kyushu and is very zoophilic (Table 5). These three species of mosquitos can be said to have no connexion with the disease in Kyushu although they are highly susceptible to filariae experimentally.

Culex sinensis is rare anywhere in Japan. *Culex bitaeniorhynchus* is less rare and breeds in some paddy fields or grassy ponds but is strongly zoophilic. These two species of mosquitos have rather low susceptibility to filariae even in experiments, and therefore they too can be said to have no connexion with the disease.

Culex vishnui breeds in paddy fields in foothills or mountainous regions and is rare in the plains; it is, moreover, strongly zoophilic. The catches in houses or human-baited traps shown in Table 5 are rather large and appear to show that it is anthropophilic, but this is probably due to the fact that in several cases the human-baited traps were set up at places in the foothills, surrounded by paddy fields, where there were no cattle. *Culex tritaeniorhynchus* and *Anopheles hyrcanus sinensis* breed actively in paddy fields, irrigation ditches and grassy and shallow ponds and are strongly zoophilic and hardly susceptible to filariae. These three mosquito species also can be said to have no connexion with the disease.

Aëdes togoi breeds in tide-pools, bilge water, and artificial containers of many kinds found around houses and shrines in fishing villages. It breeds in rainwater, brackish water, and even in water saltier than sea water. It also breeds in large tubs and kettles filled with sea water and used for processing dried sardines. The tubs are used for washing sardines before they are boiled in the kettles. The larvae of this mosquito are rare in the tubs when these are in use but are found in large numbers when they are not in use. Larvae breed numerously in the kettles when they are left unused for a week or more and after the fishing season. Thus, this mosquito is found in abundance in fishing villages with a rocky shore and engaged in the processing of dried sardines, but is found only in small numbers in farm villages or even in fishing villages that have a sandy seashore and are not engaged in the processing of dried sardines. It is scarcely found at all in inland villages, although the reason is hard to explain.

Only a small number of adult female mosquitos of this species have been caught indoors—either in houses or in cattle-sheds—in villages which have many breeding places. In one extreme case, in spite of the presence of a surprisingly large number of tide-pools on a rocky shore 40-80 m wide and over 6 km long extending on both sides of a fishing village, only a very few adults were caught indoors.

The author has presumed for a long time that autogenous reproduction of this mosquito must explain this finding. In London, Lien (1959) discovered autogamy in this mosquito using material of Formosan origin, and Miss Ito of our Department made the same finding in Nagasaki in 1960. If autogenous reproduction of this mosquito actively occurs in nature, the importance of this mosquito in the transmission of filariasis may become progressively less.

Therefore it can be said that this mosquito may have limited importance in some fishing villages only, although more precise ecological and epidemiological studies are necessary to draw firm conclusions on its role in the transmission of bancroftian filariasis.

Culex pipiens pallens breeds in cesspools, sewers, barrels and earthen jars with stagnant water around houses, and fertilizer pits in the fields or near villages. It is the predominant species among those found in houses or human-baited traps and is strongly anthropophilic (Tables 2 and 5). It begins to appear from early May, reaching a high peak in late June to early August, and disappears in early October. Its active feeding hours at night cover from 9 p.m. to 4 a.m., which corresponds to the nocturnal periodicity of microfilariae in the peripheral blood stream of carriers. It has a strong tendency to rest in houses, and frequently hides in bushes, copses, or bamboo thickets around a house or a group of houses.

Owing to these habits and to its high infection rates—both experimentally and naturally—it can be said that this mosquito is the most dangerous and is chiefly responsible for the transmission of bancroftian filariasis in Japan. In addition, its domestic habits and high susceptibility to the parasite render the occurrence of family infection probable.

Distribution pattern of microfilarial positives due to Culex pipiens pallens *in a village*

Blood surveys for microfilariae were conducted three times in nine months in a village of 109 houses and 630 residents in Nagasaki prefecture, and 109 positive persons were found (Nagatomo, 1961).

This village is located on a hillside and the villagers are all engaged in agriculture, especially in growing vegetables. There are therefore plenty of jars and fertilizer pits for the storage of nightsoil, and these become favourable breeding places for *Culex pipiens pallens* when diluted with domestic water or rainwater.

The sea-coast near the village is gravelly and has no breeding places for *Aëdes togoi.* There are small areas of paddy fields around the village, which allow the breeding of a fair number of *Anopheles hyrcanus sinensis* and *Culex tritaeniorhynchus* and a small number of several other mosquitos which are, however, mostly zoophilic.

A mosquito survey in the houses revealed that *Culex pipiens pallens* was predominant and that a fair percentage of them were infected with filariae. Blood examinations of all families in the village revealed a rather high microfilarial incidence for Japan and apparently a strong tendency to family infection. To ascertain this, a statistical study was made of the distribution pattern of the carriers.

Table 7 gives the frequency distribution of houses with various numbers of carriers, showing size of family. When the total frequency distribution given in the line " Total " of the table is compared with the hypothetical one shown in the last line of the same table and obtained under the assumption of a binomial distribution with P = 17.17% (that is, under the assumption that microfilarial infection has taken place at random in each inhabitant with a probality of 17.17%) significant disagreement is found between the two. This shows that the observed frequency distribution cannot be called a random sample drawn from a binomial distribution with P = 17.17%. This, in turn, indicates the existence of a tendency for the disease incidence to be concentrated in certain families in this village.

TABLE 7

DISTRIBUTION OF HOUSES WITH FILARIA CARRIERS, SHOWING SIZE OF FAMILY, IN A FILARIASIS ENDEMIC VILLAGE

Size of family	No. of carriers in a family						No. of houses
	0	1	2	3	4	5	
1	1						1
2	8	0	2				10
3	6	3					9
4	7	4	1				12
5	10	1	2	2			15
6	10	9	0	3	1		23
7	4	3	1	1			9
8	2	2	1	5	1	1	12
9	3	3	2	3	2		13
10	3	1	1				5
Total	54	26	10	14	4	1	109
Hypothetical No. of families	39.94	40.11	20.25	8.71			109.01

No. of houses: 109. Population of the village: 635.
No. of carriers: 109. Microfilarial incidence: 17.17%.

Family infection cannot necessarily be proved either in villages with low filarial incidence or in some others where carriers leave their families in order to marry or to build new homes.

RÉSUMÉ

La filariose à *Brugia malayi* est localisée au Japon à un seul îlot, Hachijo-koshima; elle est surtout transmise par *Aëdes togoi* et probablement par *Culex pipiens pallens*. En revanche, la filariose à *W. bancrofti* est largement répandue sur les trois îles principales, Honshu, Shikoku et Kyushu où elle est particulièrement répandue dans la région de Nagasaki. L'infestation expérimentale par des larves infestantes de *W. bancrofti* a montré la réceptivité de dix espèces de moustiques. Cette réceptivité est très forte chez *C. p. pallens*, *C. p. molestus*, *Aëdes togoi*, *C. vagans* et *C. whitmorei*; celle de *C. sinensis* et *C. bitaeniorhynchus* est variable, et celle de *C. vishnui* douteuse; enfin, *C. tritaeniorhynchus* et *Anopheles h. sinensis* sont très peu réceptifs aux filaires. Parmi ces dix espèces réceptives à *W. bancrofti* au Japon, seules *Aëdes togoi* et *C.p. pallens* semblent être responsables de la transmission de la maladie, les autres ne l'étant pas du fait de leur rareté, de leur zoophilie ou de leur très faible réceptivité. *C. p. pallens* se trouve en général dans les habitations, et il s'abrite dans les maisons ou dans les buissons qui les entourent. Ce fait expliquerait pourquoi la maladie a un caractère endémique fortement familial dans les communautés japonaises. Il est fortement androphile et très réceptif aux larves, aussi bien expérimentalement que naturellement. Pour toutes ces raisons, il est le vecteur principal de la filariose de Bancroft au Japon. Par contre, *Aëdes togoi* n'a d'importance comme vecteur que dans les villages de pêcheurs situés sur un littoral rocheux où les lagunes sont nombreuses et dans ceux où l'on procède au séchage des sardines.

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