Epidemiology and Control of Bancroftian Filariasis in Some Villages of Nagasaki Prefecture

1. Incidence of filariasis and natural infection rate of mosquitoes in Nanatugama and Taira villages*

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Introduction

Blood and mosquito surveys for filariae were made in Nanatugama and Taira villages of Nagasaki prefecture in August, 1954. The villages lie along the coast facing the open sea, in the middle part of the Nisisonoki peninsula. The peninsula is mountainous and only has very narrow level land along the coast. The houses are situated in foot-hill and villagers are mostly engaged in agriculture and only a few of them are in fishery. Owing to such topography there are very scanty of paddy field and consequently they are generally rather poor in living. It could, therefore, be imagined that filariasis might be endemic in these villages. The surveys for filariae in persons and in mosquitoes were, therefore, projected and the results as under were obtained.

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Method of examination

Three thick films amounting about 20 mm^3 of blood from the ear-lobe of persons at night from 9 to 12 p. m. were made on a slide. The films were stained with Giemsa's solution and examined for microfilariae.

Mosquitoes found early in the morning within mosquito-nets or in houses were dissected for filariae. The developmental stages of filariae in the body of the mosquitoes are distinguished as lst, 2nd, and 3rd or infective stage larvae. The present author, however, divided the stages into some number of sub-stages, after Omori (1957), as under:

Ia: Microfilariae with egg membrane. The sub-stage larvae are usually not found in mosquitoes which are dissected on the next day of their being captured because the exsheath of microfilariae takes place within several hours after their being taken up. Length 0.24-0.31mm.

Ib: Exsheathed microfilariae. The sub-stage larvae are found mainly in the thoracic muscles. Length 0.31-0.18mm.

Ic: The shortest sub-stage larvae. Length 0.17-0.14-0.17mm.

Id: The growing sub-stage larvae. The sub-stage lasts from Ic to lst ecdysis. Length

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0. 18-0. 34mm.

IIa: The first sub-stage larvae. Length 0. 34-0. 68mm.

IIb: The second sub-stage larvae. Length 0. 68-1. 02mm.

IIc: The third sub-stage larvae. Length 1. 02-1. 19mm.

IIIa: The first sub-stage larvae. Length 1. 19-1. 36mm.

Just after the 2nd ecdysis, the larvae are till thick but clearly recognized by the three caudal papillae. The larvae become slender and a little longer within about a day, that is, IIIb or infective larvae.

IIIb: Infective larvae. Length 1. 19-1. 87mm.

The development from IIIa to IIIb is rapid and to draw a line of demarcation between them is very difficult and hence many authors have regarded both IIIa and IIIb as infective larvae.

In this paper, the present author also treats the 3rd stage larvae (IIIa and IIIb) as infective ones.

The inspection of mosquitoes for filariae

Table 1 Summary of blood examinations by Sections and by sexes in 1954

Vill-age	Section	Persons examined			Persons Mf(+)			% (+)		
		♂	♀	Total	♂	♀	Total	♂	♀	Total
Nanatugama	Kusazumi	26	46	72	4	5	9	15.4	10.9	12.5
	Kitadomari	31	48	79	5	4	9	16.1	8.3	11.4
	Matuyama	40	39	79	3	1	4	7.5	2.6	5.1
	Kakiuti	57	78	135	6	6	12	10.5	7.7	8.9
	Yaranokubi	29	36	65	3	5	8	10.3	13.9	12.3
	Kubinota	38	24	62	4	2	6	10.5	8.3	9.7
	Simosikama	30	8	38	3	1	4	10.0	12.5	10.5
	Kamisikama	24	41	65	8	4	12	33.3	9.8	18.5
	Minami	19	30	49	0	0	0	0	0	0
	Koba	48	67	115	4	4	8	8.3	6.0	7.0
	Kubo	27	38	65	3	2	5	11.1	5.3	7.7
	Torisaki	26	35	61	2	1	3	7.7	2.9	4.9
	Noguti	37	48	85	5	4	9	13.5	8.3	10.6
	Isanoura	35	21	56	3	2	5	8.6	9.5	8.9
	Isimune	0	1	1	0	0	0	0	0	0
	Total	467	560	1027	53	41	94	11.3	7.3	9.2
Taira	Utigo	127	109	236	10	8	18	7.9	7.3	7.6
	Yanagi	88	65	153	6	2	8	6.8	3.1	5.2
	Hirakura	82	95	177	4	4	8	4.9	4.2	4.5
	Total	297	269	566	20	14	34	6.7	5.2	6.0

were made as under: the mosquitoes collected in houses were anaesthetized and after the wings were cut off, the legs, abdomen, thorax, head, and proboscis were cut apart and put separately on the drops of saline solution on the slides. Each part is crushed and examined for filariae under the binocular microscope. Then, the drops were dried and stained with Giemsa. The stained slides were dried without washing by tap-water and examined again under the microscope or binocular microscope more precisely for the developmental stages of microfilariae.

Result of blood survey

In Nanatugama, at 15 out of 17 sections, and in Taira village, at 3 larger sections out of 18 ones, blood survey was made in August, 1954, the results of which are tabulated in Table 1.

The incidence of blood positives varies with

Table 2 Summary of blood examinations by age groups and by sexes. (cf. Fig. 1)

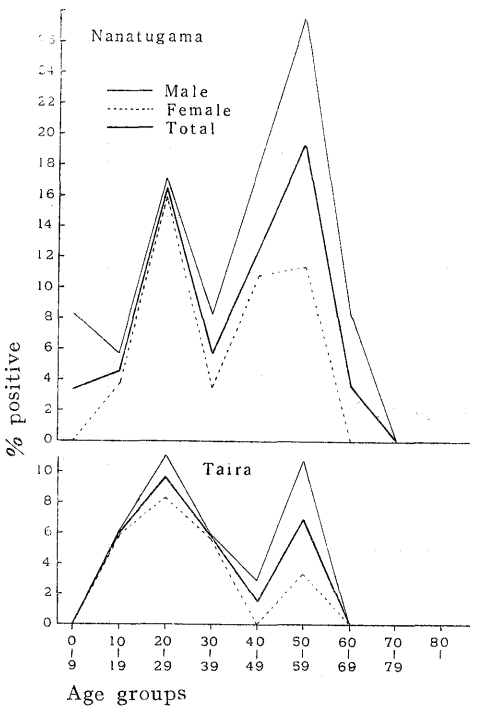
A: Nanatugama village

Age groups	Persons examined			Persons Mf(+)			% (+)		
	♂	♀	Total	♂	♀	Total	♂	♀	Total
0 — 9	12	17	29	1	0	1	8.3	0	3.4
10 — 19	212	240	452	12	9	21	5.7	3.8	4.6
20 — 29	93	113	206	16	18	34	17.2	15.9	16.5
30 — 39	49	57	106	4	2	6	8.2	3.5	5.7
40 — 49	40	65	105	7	7	14	17.5	10.8	13.3
50 — 59	43	44	87	12	5	17	27.9	11.4	19.5
60 — 69	12	16	28	1	0	1	8.3	0	3.6
70 — 79	5	8	13	0	0	0	0	0	0
80 +	1	0	1	0	0	0	0	0	0
Total	467	560	1027	53	41	94	11.3	7.3	9.2

B: Taira village

0 — 9	0	0	0	0	0	0	0	0	0
10 — 19	147	121	268	9	7	16	6.1	5.8	6.0
20 — 29	45	48	93	5	4	9	11.1	8.3	9.7
30 — 39	34	36	70	2	2	4	5.9	5.6	5.7
40 — 49	34	32	66	1	0	1	2.9	0	1.5
50 — 59	28	30	58	3	1	4	10.7	3.3	6.9
60 — 69	8	2	10	0	0	0	0	0	0
70 — 79	1	0	1	0	0	0	0	0	0
Total	297	269	566	20	14	34	6.7	5.2	6.0

Fig. 1 Microfilarial infection rates by age groups, by sexes, and by villages in 1954



sections. The variation is remarkable in Nanatugama and not so remarkable in Taira village and on the whole the former village is higher in endemicity of the disease than the latter.

In the both villages, males are higher in percentage infection than the females. This may be partly due to such customs in these sections that unmarried young men, by five or six or more, spend only the night in certain houses, that is, young men's club-houses scarcely using mosquito-nets.

The incidence of blood positives by age groups, in these villages is shown in Table 2 and Fig. 1 showing that the percentages are higher in 20-29 and 50-59 age groups in both villages. Here, it is unaccountable that in 30-39 group in Nanatugama and in 40-49 group in Taira village are very low in percentage. Children under ten years old and old men above 60 years old were found mostly negative for filariae. Some of these old men, however, stated to have experienced filarial fever or other clinical symptoms.

The number of microfilariae per male, female, and positive person were 17.6, 13.7, and 15.8 in Nanatugama and 18.5, 14.4, and 16.8 in Taira respectively.

The youngest positive in the former village was a boy of five years old who had only one microfilaria in about 20 mm^3 of his peripheral blood and in the latter a ten aged girl whose microfilarial count was 23.

The oldest positive in the former village was a man of 64 years old whose microfilarial count was 37 and in the latter a 57 aged man whose count was 4.

The highest microfilarial count in Nanatugama was 110 which was found in the blood of 57 aged man and in Taira it was 165 in a young man of 16 years old.

Mosquito survey

Mosquito survey was made in houses in parallel with the blood survey in these two villages.

In Nanatugama,the blood films from sections Kakiuti, Kubinota, Koba, and Kamisikama were stained and examined by microscope on the next day of the survey at the place under examination and the situations of the houses having at least one microfilarial carrier were ascertained. Then, collection of mosquitoes were made early in the morning within the mosquito-nets used by persons among which was included at least one positive, within houses having one or more carriers and in one occasion on the grassy stone wall of a carrier's house. The states of natural infection of the mosquitoes captured by the way as above are tabulated in Tables 3, 5, 6, and 7.

In Taira, microscopical examination of blood films could not made untill the end of our survey trip. Consequently the collection of

Table 3 Result of dissection for filariae of mosquitoes captured early in the morning, within mosquito-nets in which at least a microfilarial carrier has slept, within houses having at least a carrier, or on the grassy stone wall near a carrier' shouse, in **Nanatugama** village

Section	House number	In mosq. net (carrier +)	In house (carrier +)	Out-doors	Remarks
Kaki-uti	No. 1	*C.p.p.* 18(6)	*C.p.p.* 1(0)		*C.p.p.* : *Culex pipiens pallens*
	No. 2	*C.p.p.* 1(1)			Figures: No. mosquito disected (No. mosq. infected)
	No. 3		*C.p.p.* 7(0) *Ae. togoi* 1(1)		
	No. 4		*C.p.p.* 1(0) *Ae. togoi* 1(0)		
Kubi-nota	No. 1	*C.p.p.* 5(1)	*C.p.p.* 8(0) *C.whitmorei* 1(0)	*C.p.p.* 6(0)	
	No. 2		*C.p.p.* 4(0) *Ar. subalbatus* 1(0) *T. bambusa* 1(0)		
Koba	No. 1		*Ae. togoi* 4(0) *C. bitaeniorhynchus* 1(0)		
Kami-sikama	No. 1	*C.p.p.* 4(2)			
	〃	*C.p.p.* 8(2)			
	No. 2		*C.p.p.* 7(3)		The family has not used mosquito net
	No. 3	*C.p.p.* 1(0)			
	No. 4		*C.p.p.* 10(5)		1)

1) : This is a young men's club-house of the section where 3 or 4 men Mf negative and 2 positive usually have spent the night scarcely using the mosquito net

mosquitoes in the sections, Utigo and Yanagi, was made at random within a mosquito-net or houses where, however, no carriers were proved afterwards to have occurred. The results of dissection of mosquitoes captured in these sections are tabulated in Tables 4 and 5.

As will be stated on a later paragraph, there found about twenty six mosquito species in these villages in question and neighboring villages. Among these, the following seven species are very common and abundant in breeding number. They are *An. h. sinensis*, *C. p. pallens*, *C. tritaeniorhynchus*, *Ae. albopictus*, *Ae. japonicus*, *Ae. togoi* and *Ar. subalbatus*. Epidemiologically, however, the mosquitoes breeding in a great number, having nocturnal feeding habit, having house frequenting habit and being androphilic, should be regarded as important species. Besides the above, the mosquito which is high in natural infection rate with filariae should be said as the most dangerous one.

In this meaning, Tables 3 and 4 show that

Table 4 Result of dissection for filariae of mosquitoes staying early in the morning in houses where by chance none of carriers were found, in **Taira** village

Section	House number	In mosq. net	In house	
Utigo	No. 1		*C. vishnui*	2(0)
			An. h. sinensis	1(0)
	No. 2		*C.p.p.*	8(0)
	No. 3	*C.p.p.* 5(0)		
	No. 4		*C. bitaeniorhynchus*	1(0)
			An. h. sinensis	1(0)
Yanagi	No. 1		*C.p.p.*	1(0)
	No. 2		*C.p.p.*	1(0)
			C. vishnui	1(0)
	No. 3		*C.p.p.*	3(0)
	No. 4		*C. tritaeniorhynchus*	1(0)
			C. vishnui	1(0)
	No. 5		*Ar. subalbatus*	1(0)
	No. 6		*Ae. togoi*	1(0)

C. p. pallens is the most important, while *Ae. togoi* is not so important and the others are entirely out of question.

As to the natural infection of *C. p. pallens* with filariae, in Nanatugama, the percentage positives were 32.4% (12 out of 37) in mosquitoes captured within mosquito-nets, 21.1% (8 out of 38) in those collected in houses, 0% in those captured outdoors, and 24.7% (20 out of 81) in total. It is noteworthy fact that these positive mosquitoes were those which were captured at the very close proximity of microfilarial carriers. On the contrary, Table 4 shows that, in Taira, all mosquitoes, even *pallens* were negative for filariae in both sections. This perhaps may be due to the fact that in the very houses in which mosquiotes were collected, no human carriers were being found, despite of the fact that within the scope of about three or four hundred meters from the houses there occurred carriers in 7.6 and 5.2% of the villagers in Utigo and Yanagi respectively.

Table 5 Summary of Tables 3 and 4, showing the difference in natural infection of mosquitoes collected in Nanatugama village in the close proximity of carriers and in Taira village in houses where by chance none of carriers were found

Species \ Village	Nanatugama			Taira		
Species \ No. & % mosq.	No. mosq. dissected	No. mosq. infected	% infected	No. mosq. dissected	No. mosq. infected	% infected
An. h. sinensis	0			2	0	0
C. p. pallens	81	20	24.7	18	0	0
C. tritaeniorhynchus	0			1	0	0
C. vishnui	0			4	0	0
C. whitmorei	1	0	0	0		
C. bitaeniorhynchus	1	0	0	1	0	0
Ae. togoi	6	1	16.7	1	0	0
Ar. subalbatus	1	0	0	1	0	0
T. bambusa	1	0	0	0		

Table 6 Stage and number of microfilariae found in the body of infected mosquitoes

Infected mosquito	1st stage			2nd stage			3rd stage					Total filariae
	Ib	Ic	Id	IIa	IIb	IIc	Legs	Abd.	Thor.	Head	Prob.	
C. p. pallens												
No. 1				1								1
No. 2			4									4
No. 3	1											1
No. 4				4	4							8
No. 5	1											1
No. 6			2									2
No. 7	38											38
No. 8			4		2							6
No. 9	3											3
No. 10	16											16
No. 11				2					11	2		15
No. 12				1								1
No. 13	1											1
No. 14	1											1
No. 15				2	7							9
No. 16	4											4
No. 17	2											2
No. 18	1											1
No. 19	5											5
No. 20	1											1
Ae. togoi												
No. 1			1									1

These findings, which are being summarized in Table 5, show that the house mosquito, *C. p. pallens* is the most dangerous in the transmission of filariasis in these villages but its flight range may be very short.

Ae. togoi was found positive in 16.7% (1 out of 6) but it seems to be very poor vector of the disease by the reason as will be mentioned later.

In Table 6, the numbers of filariae found in mosquitoes on the day or the following day of capture are demonstrated. The mosquitoes having Ib, Id, or IIb sub-stage larvae are presumed to have fed on carriers at the last night, at the last or the before-last feeding time. The mosquito which was found har-

Table 7 Summay of Table 6, showing the number and percentage infection (in parentheses) of mosquitoes having all, lst, 2nd, and 3rd or infective stage larvae in Nanatugama village

Mosquito species	No. mosq. dissected	No. mosq. infected	No. mosq. having the indicated stage larvae		
			I	II	III
C. p. pallens	81	20 (24.7)	15 (18.5)	6 (7.4)	1 (1.2)
Ae. togoi	6	1 (16.7)	1 (16.7)		

Remark: An average number of filariae per ♀ *pallens* was 6, ranging from 1 to 38.

boring infective larvae is thought to have fed an infective blood meal on an occasion more than 12 days ago. The presumption is based on the developmental days of filariae in mosquitoes kept at a constant temperature of 27°C (Omori, 1957). It Is especially of interest that *pallens* No. 8 and No.11 seem to have fed on human carriers twice, successively and in different occasions respectively. The above findings show that how androphilic the house mosquito is.

That the house mosquito is not only large in number of infected with filariae but also in number of having advanced stage larvae, as seen from Table 7, is another proof of being dangerous.

Considerations on the role of the indigenous mosquitoes playing on the transmission of filariasis

There have been found by us to occur twenty six mosquitoes in these and neighboring villages. They are: 3 Anophelines, 13 Culicines, 6 Aedines, and 4 species belonging to *Armigeres*, *Uranotaenia*, *Tripteroides*, and *Orthopodomyia*.

On the other hand, mosquitoes which have been proved experimentally by Japanese authors to be susceptible to *W. bancrofti* are, in order of suitable to poor: *C. p. pallens*, *C. p. molestus*, *C. vagans*, *C. whitmorei*, *Ae. togoi*, *C. bitaenior hynchus*, *C. sinensis*, *An. h. sinensis*, *C. tritaeniorhynchus*, and *C. vishnui*. Among these, *C. p. molestus* is not distributed in these villages, *C. vagans* is extremely rare, *C. whitmorei* and *C. sinensis* are rather rare, *C. bitaeniorhynchus* and *C. vishnui* are less common and zoophilic, *An. h. sinensis* and *C. tritaeniorhynchus* are very common but strongly zoophilic, and consequeutly only *C. p. pallens* and *Ae. togoi* come to the front.

Ae. togoi is, in general, distributed mainly in coastal areas having many tide pools and is not necessarily fond of human blood. In these villages, it was rather few in the breeding number because of the scantiness of favorable breeding place and being very small in collected number and also in the actual number infected. Consequently it must be said, as to the role of this mosquito in the transmission of filariasis, that it is of little importance in these villages.

C. p.pallens was found the most abundant in houses, very fond of human blood, and strong in habit of invading mosquito-net and of staying houses, and moreover very high not only in natural infection rate but also in percentage of harboring advanced stage larvae. Consequently, the house mosquito must be said to be the most or even the only important vector of the disease in these villages.

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Summary

1) Blood and mosquito surveys for filariae were made in some sections of Nanatugama and Taira villages, which lie along the sea coast in the middle part of the Nisisonoki peninsula, Nagasaki prefecture, in August, 1954.

2) In Nanatugama village, the percentage blood positives were 11.3%, 7.3%, and 9.2% in males, females, and in total, and in Taira village, they were 6.7 %, 5.2 %, and 6.0 % respectively, showing relatively higher percentage in the former than in the latter and fairly higher in males than the other sex in both villages.

3) The incidence of blood positives by age groups were higher in 20–29 and 50–59 groups in both villages. The incidences were very low in 30–39 group in Nanatugama and so in 40–49 group in Taira, the reason of which, however, is unknown now.

Children under ten years old and old men above 60 years old were found mostly negative for filariae, though some of these old men remembered their clinical symptoms.

4) The youngest blood positive in Nanatugama was a boy of five years old and in Taira it was a ten aged girl, whose microfilarial counts in about 20 mm^3 of peripheral blood were one and 23 respectively.

The average microfilarial counts per positive person were 15.8 and 16.8 in the former and latter villages respectively. The highest count in the former was 110 microfilariae in 57 aged man and that in the latter was 165 in a 16 aged boy.

5) Most of the mosquitoes collected during the survey seem to be of no meaning in the transmission of filariasis because of their rareness in distribution or being little androphilic, and only two species, *Ae. togoi* and *C. p. pallens* come to the front.

Ae. togoi, though it was proved positive for filariae in nature, was rather few and may be said as a very poor vector in the villages in question.

C. p. pallens was found the most abundant in houses, very fond of human blood, strong in the habit of invading mosquito-nets and of staying houses and moreover high not only

in natural infection rate but also in the percentage of harboring 2nd or 3rd stage larvae. Consequently, the house mosquito must be said to be the most dangerous vector in these villages.

6) That the infected females of *C. p. pallens* could be collected only at the very close proximity of the sleeping places of microfilarial carriers, seems to show that the flight range of this mosquito would, as a matter of fact, be very short. The fact also seems to suggest that this mosquito might cause the family infection of the disease in the area in which the species is playing the chief role in the transmission of the disease.

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