On the Familial Infection of Bancroftian Filariasis due to the House Mosquitoes[1)]

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ABSTRACT : In Japan and Ryukyus where bancroftian filariasis is being transmitted respectively by *Culex pipiens pallens* and *C. p. fatigans* which are very domestic in breeding, resting, and feeding habits, the transmission of the disease is characterized by a from of familial infection indicated by the occurrence of more carriers in some houses and less or none in others. The trend is more marked in a community where the microfilarial incidence is rather higher and where houses or groups of houses are separated by topographical or some other barriers. It will be less marked in a village where the incidence is lower or houses are aggregated without such barriers. In a community where the incidence is much higher and where houses are situated very close to each other under poorly drained conditions and with no such barriers, the transmission of the disease may have the appearance of following a random distribution at a high level of probability for all persons due to equally heavy familial infections taking place in most houses.

Habits and susceptibility of the house mosquitoes, *C. p. pallens* and *C. p. fatigans*

In Japan, bancroftian filariasis is distributed mainly in southern parts, i.e., it is endemic partly in South-western parts of Shikoku Main Island and moderately or highly in South-western coastal region of Kyushu Main Island and its adjacent small islands where eleven mosquito species susceptible to *Wuchereria bancrofti* occur. Among these, however, the house mosquito, *C. p. pallens* is most common and highest in natural as well as experimental infection rates. In the Ryukyus, the disease is widely distributed and more highly endemic than in Japan in all the islands of the Archipelago where the only important vector is tropical house mosquito, *C. p. fatigans*.

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Table 1 Natural infection rates of *Culex pipiens pallens* collected under various conditions in Nagasaki and Kumamoto Prefecture, 1951—1963

Place and time of collection		Dissected	infected	% infection
Within carriers' houses	Within mosquito-nets early in the morning	774	146	18.9
	Within houses early in the morning	1672	156	9.3
	Within houses at night	1417	95	6.7
Near carriers' houses	Within houses early in the morning	18	0	0
	Human-baited-traps	347	1	0.3
	Within cow-sheds	297	0	0
	Outdoors	68	0	0

As has been reported by the author (Omori, 1962), the house mosquito is highly domestic and breeds in domestic foul water such as sinks, sewers, drains, and earthen jars containing polluted water or diluted night-soil near houses, and in some cases in fertilizer pits in the fields around the village. It is strongly androphilic in feeding habit. Its sheltering places are around barns, under bushes and in the undergrowth of thickets near houses. Occasionally, a great number of the mosquito is found by day in vacant damp rooms in poorly built farm houses,

To show the hiding and feeding habits of *C. p. pallens* as well as the rate of natural infection with *W. bancrofti*, the number of mosquitoes collected in various places and the number and rate of infected ones are given in Table 1.

The mosquito is very strong in penetrating mosquito-nets through holes (Omori, 1962) and naturally the infection rate should be highest when based on mosquitoes collected in mosquito-nets within which some persons including one or more carriers have spent a night. In fact, as shown in Table 1, a considerable number of *C. p. pallens* was collected in mosquito-nets and the highest rate of natural infection was found there. The rates are fairly high in mosquitoes found in carriers' houses early in the morning or at night. While, in mosquitoes captured in places near carriers' houses but free from them, the natural infections are insignificant. In Ryukyus, similar observations have been made with *C. p. fatigans* with nearly the same results.

Familial infection of bancroftian filariasis due to the house mosquitoes

During several years of filariasis survey in Japan and Ryukyus we have found that, in some cases, there exist remarkable differences in filariasis endemicity between neighboring villages and among houses or groups of houses of the same village. This seems to have close relation to the fact that the natural infection rates of mosquitoes are much more higher in the very close proximity of sleeping sites of the carriers as shown in Table 1. The fact implies namely that the transmission of the disease due to these domestic mosquitoes may take place much more actively in houses having carriers and rarely in houses close by and that in this way, familial infections of the disease may take place more actively in some houses, in some groups of houses, or in some villages than in others depending on the incidence of filariasis and breeding of the mosquitoes.

In the following, with the date we have at hand, close examinations will be made on the distribution pattern of microfilarial carriers in filariasis endemic villages of different environmental conditions and varying endemicity of the disease(Table 2). Of these thirteen villages, twelve are those in Nagasaki Prefecture where filariasis is transmitted by *C. p. pallens*, while, the last is a village in Miyako Island, the Ryukyus where the disease is due to *C. p. fatigans*.

In these villages, examinations for filariae were made with 60 cu mm blood for the entire populations above zero year old. The examinations were

Table 2 Endemicity of bancroftian filariasis in some villages in Nagasaki Prefecture

Name of village	No. of houses	Population	Persons with Mf	
			No.	%
Shioike	62	333	17	5. 11
Noshima	37	251	14	5. 58
Oshima	45	283	20	7. 07
Abumize	20	84	7	8. 33
Nagabae	37	254	26	10. 24
Katsurajima	39	264	31	11. 74
Setobatake	27	153	20	13. 07
Nagate	126	577	81	14. 04
Hyugashi	62	310	49	15. 81
Amakubo	109	635	109	17. 17
Yaburoki	26	158	34	21. 52
Ota	26	115	25	21. 74
Hisamatsu(*)	563	2998	1132	37. 76

*: Miyako Island, the Ryukyus

Table 3 Distribution of houses with filaria carriers in Nagabae Village

Size of family	No. carriers in a family							No. of houses
	0	1	2	3	4	5	6	
2	1							1
3	2		1					3
4	2							2
5	3							3
6	5	1	1					7
7	4	4	1					9
8	3							3
9	3		2					5
11		2						2
12				1			1	2
Total	23	7	5	1			1	37

No. of houses: 37 Population: 254
No. of carriers: 26 Mf incidence: 10. 24%

carried out at night during 9-12 p.m. by house visit and a map of the village showing the number of persons and carriers in each house was prepared.

Table 3 shows an example of the survey made at a farm village called Nagabae which has 37 houses, 254 population, and 26 or 10.24% positives, showing the frequency distribution of houses having varying number of carriers in each family size level and in total.

Assuming that all persons in the village would have been exposed equally to the same chance of infection by the house mosquito at a rate of 10.24%, then the frequency distribution of the number of houses having varying number of carriers is thought to follow a binomial distribution. Then, the hypothetical numbers of houses are calculated as in Table 4, on the assumption of binomial distribution with a probability of 10.24%.

Table 4 Hypothetical number of houses with filaria carriers, in a binomial distribution with p=10.24%

Size of family	No. of carriers in a family							No. of houses
	0	1	2	3	4	5	6	
2	0.806	0.184	0.011					1.001
3	2.170	0.743	0.085	0.003				3.001
4	1.298	0.592	0.101	0.008				1.999
5	1.748	0.997	0.228	0.026	0.002			3.001
6	3.660	2.506	0.715	0.109	0.009	0.001		7.000
7	4.225	3.374	1.155	0.220	0.025	0.002		9.001
8	1.264	1.154	0.461	0.105	0.015	0.002		3.001
9	1.891	1.942	0.887	0.236	0.041	0.005	0.001	5.003
11	0.609	0.764	0.436	0.149	0.034	0.005	0.001	1.998
12	0.547	0.749	0.470	0.179	0.046	0.008	0.001	2.000
Total	18.218	13.005	4.549	1.035	0.172	0.023	0.003	37.005

Table 5 Test of homogeneity of filaria infection in Nagabae Village

No. of carriers in a family	0	1	2≤	Total
Observed No. of houses	23	7	7	37
Hypothetical No. of houses	18.218	13.005	5.782	37.005
Deviation	4.782	-6.005	1.218	- 0.005
$(\text{Deviation})^2$	22.868	36.060	1.484	
$\frac{(\text{Deviation})^2}{\text{Hypoth. No. houses}}$	1.255	2.774	0.257	

$x^2=4.286$ Df=1 $p<0.05$

In Table 5, the observed number of houses having zero, one, two and more carriers are compared with those of the hypothetical number of houses shown in the preceeding table and the test of homogeneity of filarial infection in the village was made. The result shows that p is a little smaller than 5% level. This means that, in this village, the transmission by the mosquito would have not taken place at random to each inhabitant with the same probability of 10.24%, but might have taken place more intensely in some houses or groups of houses than in others. The results of similar analyses made with all the other cases are shown in Table 6 and 7.

In Table 6.1, with the first four villages, the observed and hypothetical distribution of the number of houses having varying number of carriers are compared. In these cases, however, the test of homogeneity can not be done because of the dgrees of freedom becoming zero, but the

Table 6. 1 Comparison of observed and hypothetical number of houses with carriers

Village	Mf incidence	No. of carriers in a family						
		0	1	2	3	4	5	6
Shioike	5.11	49 47.20	10 12.79	2 1.84	1 0.19			
Noshima	5.58	25 25.36	10 9.56	2 2.08				
Oshima	7.07	29 28.83	13 12.87	2 2.85	1 0.47			
Abumize	8.33	14 13.96	5 5.17	1 0.87				

Table 6.2 (Cont.)

Village	Mf incidence	No. carriers in a family						
		0	1	2	3	4	5	6≤
Nagabae	10.24	23 18.22	7 13.01	5 4.55	1 1.04	0 0.17	0 0.02	1 0.00
Katsurajima	11.74	18 17.60	14 13.97	4 5.63	3 1.84			
Setobatake	13.07	14 12.88	7 9.50	5 3.56	1 1.06			
Nagate	14.04	73 66.71	33 41.87	13 13.78	6 3.10	1 0.55		
Hyugashi	15.81	26 28.01	25 22.31	9 8.94	2 2.77			
Amakubo	17.17	54 39.94	26 40.11	10 20.25	14 6.77	4 1.64	1 0.32	
Yaburoki	21.52	9 6.76	7 9.41	5 6.19	4 2.61	0 0.80	1 0.23	
Ota	21.74	12 11.00	6 8.32	5 4.21	3 2.46			
Hisamatsu	37.76	94 81.86	142 150.22	133 143.59	105 100.52	52 53.99	24 22.65	13 10.05

Table 7 Results of the test of homogeneity of filaria infection

Village	cf	Mf incidence	Probability in goodness-of-fit of observed distribution to hypothetical binomial								
			>50 30 20 10 5 2 1>								
Nagabae	Fig. 2	10.24						p			
Katsurajima		11.74	p								
Setobatake		13.07			p						
Nagate	Fig. 2	14.04					p				
Hyugashi		15.81		p							
Amakubo	Fig. 3	17.17								p	
Yaburoki	Fig. 4	21.52				p					
Ota		21.74		p							
Hisamatsu	Fig. 5	37.76	p								

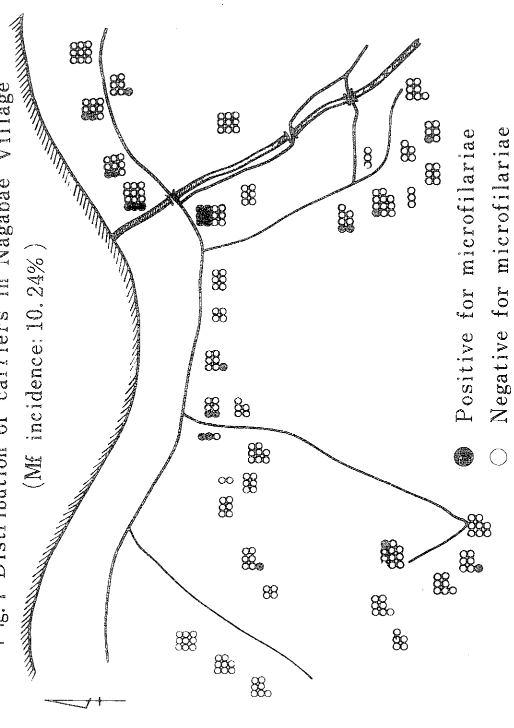

Fig. 1 Distribution of carriers in Nagabae Village
(Mf incidence: 10.24%)

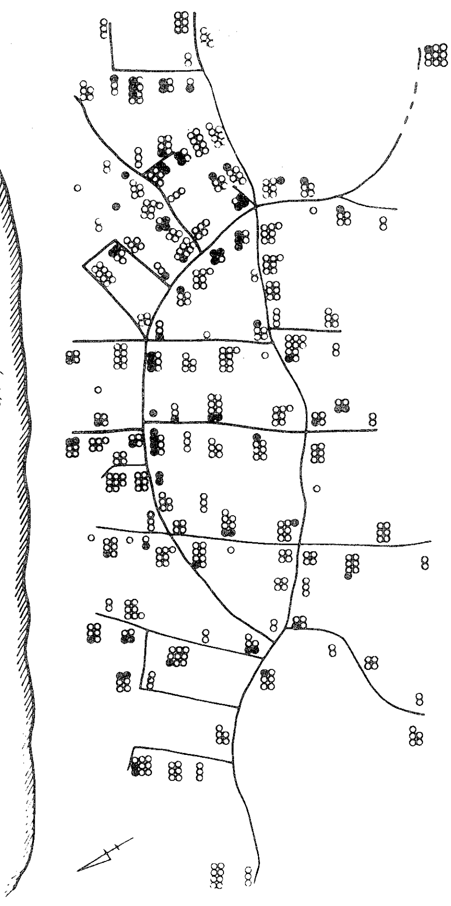

Fig. 2 Distribution of carriers in Nagate Village
(Mf incidence: 14.04%)

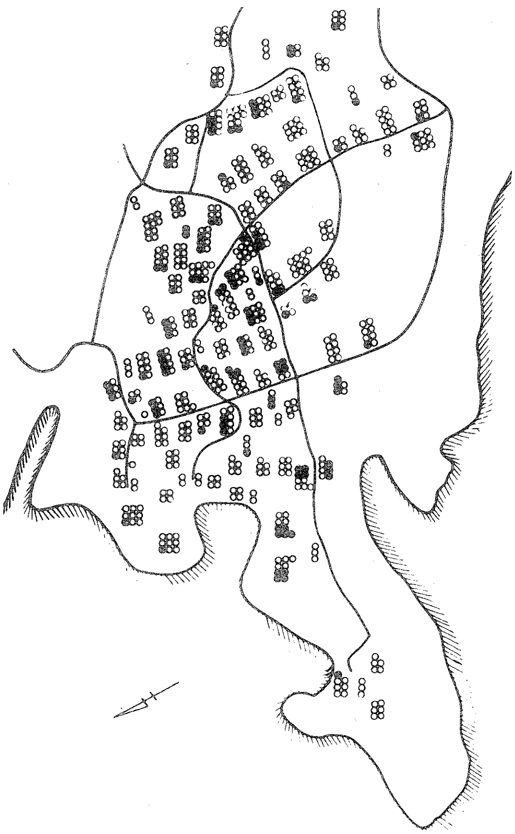

Fig. 3 Distribution of carriers in Amakubo Village
(Mf incidence: 17.17%)

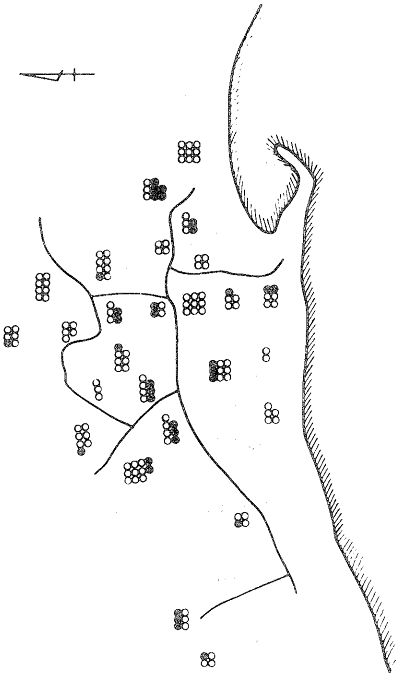

Fig. 4 Distribution of carriers in Yaburoki Village
(Mf incidence: 21.52%)

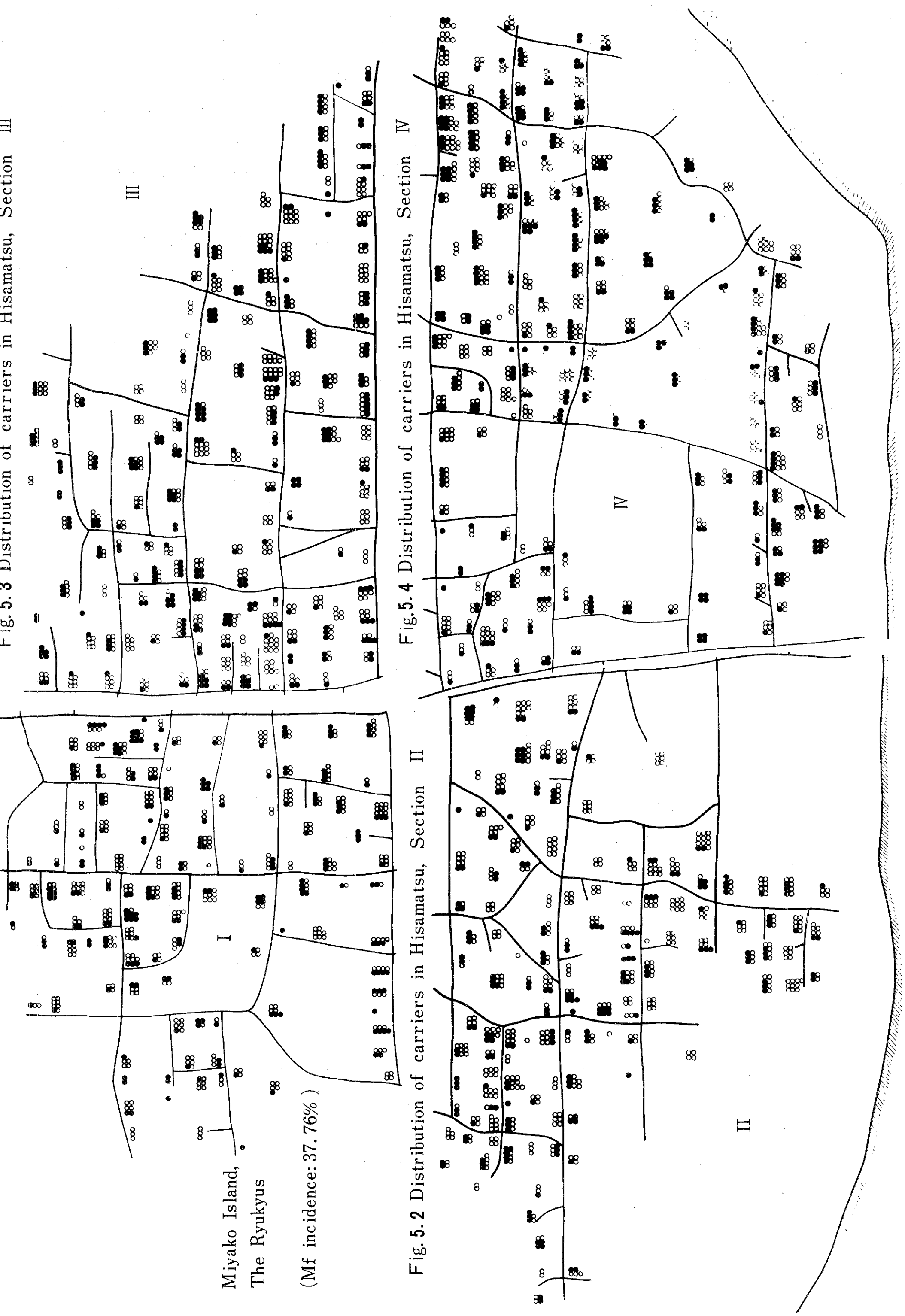

Fig. 5.1 Distribution of carriers in Hisamatsu, Section I

Fig. 5.3 Distribution of carriers in Hisamatsu, Section III

Miyako Island,
The Ryukyus
(Mf incidence: 37.76%)

Fig. 5.2 Distribution of carriers in Hisamatsu, Section II

Fig. 5.4 Distribution of carriers in Hisamatsu, Section IV distributions in each case are found to be very near, showing that in these villages of very low microfilarial incidence, the carriers may be distributed sparsely and homogeneously.

In the cases of the other nine villages shown in Table 6.2, the probability in goodness-of-fit of observed to hypothetical distribution was calculated and put on Table 7.

Table 7 shows that as p increases, the more the observed distribution of the number of houses becomes near to binomial from, that is, the more the distribution of the carriers become homogeneous. On the contrary, when p is smaller than the 5% level, it appears that familial infections or some localization of infection must have taken place within the village.

The actual states of distributions of carriers in some villages are shown in the following Figures.

Fig. 1 is a map of Nagabae Village. A mass of circles represents a family. A black circle shows a microfilarial carrier, and a white one a person free from microfilaria. In this village, p is smaller than 5% level as stated above. This seems to be due to the existence of a large and of small centers of infection. Near the centers, there were found favorable breeding places of the house mosquito.

In Nagate Village (Fig. 2), houses having several carriers are rather gathered in the central and eastern parts of the village, where a lot of collections of domestic foul water were found because of bad drainage, and p is only little larger than the 5% level.

In Amakubo Village (Fig. 3), p is extremely small. It is hilly in topography and group of houses are separated by valleys, groves, precipices, or bamboo thickets, and each group of houses are surrounded by bushes, bamboo thickets, or thick hedges, Whithin the hedges villagers usually have tanks and earthen jars collecting foul water or night-soil to grow vegetables. Because of the environmental conditions strong localization of infection was found as well as heavy familial infection of the disease.

In Yaburoki Village (Fig. 4), p is between 20% and 10%, showing the appearance of binomial distribution, although the occurrence of familial infections are clearly seen on the map.

Fig. 5 is a map of Hisamatsu village which is in Miyako Island, the Ryukyus. In the village bancroftian filariasis is highly endemic and is transmitted by *C. p. fatigans.* This farm village is located on the open plain near seashore and has no groves or thickets. The houses stand close to each other. There are no rivers or wells, and no water supply, and therefore the water for domestic use depends exclusively on the rain water. Consequently, the villagers economize greatly in water usage, and a small amount of foul water only collects in a small sink. This makes a favorable breeding place of *C. p. fatigans.* However, the numbers of mosquitoes breeding out from such small sinks are not so numerous even in the rainy season as nearly half the villagers pass the night without mosquito-nets. In the dry season they scarcely use them. Because of their mode of living, heavy familial infections are found, but because of the environmental conditions, it is of interest to note that the localization of infections can not be found. In other words, in this village, very heavy familial infections are taking place quite uniformly over all the village. This is the reason why p is very large in this village.

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イエカ類によるバンクフロト糸状虫症の家族感染．大森南三郎，長崎大学医学部医動物学教室．長崎大学風土病研究所衛生動物部．

総　　　括

日本でのフィラリアの主要伝搬蚊である *C. p. pallens* と琉球での主要伝搬者である *C. p. fatigans* は共に人血嗜好性が強く，人家附近の下水などに発生し，附近の藪などに潜伏していて吸血と産卵を繰返している極めて Domestic な蚊であるのでこれらの蚊によるフィラリアの浸淫は家族感染を基調とする．

部落の仔虫保有率の低い時はこの様な浸淫型式は必ずしも現われて来ないが，浸淫率の高い部落，特に部落内の家屋が1，2軒或るいは数軒ずつ，崖や谷間，或るいは竹藪や林などで隔離されている様な場合にはそれが強く現われ，部落内の家屋集団による著しい浸淫率の差も現われてくる．部落間の浸淫率の差も亦この様な機構によるものであろう．

然し宮古島の久松部落の例の様に平坦地に560戸もの家屋が密接して建ち，好適な発生場所を各戸に備えている部落では戸毎に家族感染が起り，浸淫の機序は家族感染を基調とはしていても実際の仔虫保有者の分布は二項分布に従う様な分布型となる．

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