

I. HABIT, HABITAT AND HYPERFILARIATION IN THE EPIDEMIOLOGY OF FILARIASIS IN WESTERN SAMOA

BY

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In a previous paper it was suggested that the great difference in filarial incidence between males and females in Western Samoa might be due to differences in working and clothing habits, and that the changes in microfilarial blood density, which appear to have occurred during the years between BUXTON's survey in 1925 and that of 1953-54, reflect changes within the village environment. This suggestion arose from the observation that while mosquito infestation in the open coastal villages was slight, it was heavy in inland villages and heavier still along bush paths and in plantation areas. These observations are in conformity with those of JACKOWSKI and his colleagues (1952) in American Samoa. The present paper gives a general description of the activities of the various age-groups of Samoans and discusses their possible relationship to the epidemiology of filariasis. The average microfilarial counts in 20 c.mm. of peripheral blood of the inhabitants of coastal and inland villages are given and compared with one another and with similar figures obtained by BUXTON nearly 30 years previously. The possible significance of the differences is discussed, and the apparent correlation between the average counts in certain age-groups and the onset of major clinical signs of the disease is mentioned.

HABIT

The pattern of Samoan life is much the same throughout the territory. Up to the age of five or six years there is little difference between the activities of the sexes. The small boys and girls of this age-group are never far from the house and rarely wander beyond the village precincts. They are therefore subject only to those infection risks which exist within the village itself. During the next 5 years, both boys and girls are occupied by baby tending, though during this period the boys are beginning to explore the village surroundings to a greater extent than the girls, a factor which brings them into closer contact with the mosquito hazards of the surrounding bush. From the age of 10 to 15 years the girls are still occupied with baby tending and in addition are beginning to acquire knowledge of the simpler techniques and disciplines of weaving and cooking and running errands. The girls are thus during this stage still much more within the village environment than are the boys. The boys, having been relieved of many of their domestic duties by about the age of 9 or 10 years, are then admitted to the interesting and important activities of assisting the men with

reef fishing and in the food plantations. At the same time they are beginning to form themselves into groups or gangs which roam and play together during their leisure hours. The girls, although they also have their play groups, are forbidden by tabus from joining in with the gangs of boys. The two groups are at this stage distinct and without common activities except for the attendance at school which occupies most of the years between 6 and 16. After puberty and as the girl gains strength and added skills, her household duties again absorb her energies. During this period she learns to fish, to make the oven and to work on the plantations, though her associations and contacts with bush hazards are lighter and more intermittent than are those of males of corresponding age. When she marries, and as her household duties and responsibilities increase, her life is lived chiefly in the village, though she may spend short periods of time on the plantations with the male members of her family. In many cases also she is concerned with the carriage of food products from the inland plantations to the family home in the village. As she approaches the age of 40 years, her contact with the plantations becomes increasingly infrequent until it practically ceases, and the village becomes once again her interest and environment.

As the adolescent males develop their various skills they become a part of the adult age-groups which provide the village as a whole with its food supply. During this period which spans approximately the period from 20 to 40 years of age, the male spends most of his daylight hours outside the village environment where he is more or less continuously exposed to the mosquito hazards of the bush environment. After the age of 40 years the normal "untitled" person looks forward and may indeed expect to become "titled." When this happens his energies are used to assist with the direction of his community and family affairs, and he returns to the village environment.

The degree of contact between host and vector is affected not only by environment but also by the amount of body surface which is exposed to mosquito attack. Females both young and old are for the most part covered from neck to knee while the boys and men are generally, within the village and while working, bare from the waist upwards. Within the village the men, and particularly those of middle age and older, are seen mostly sitting in conference or discussion on matters of family and community interest. The women and the children in particular are much more active within the village and hence do not present to the mosquito the same facilities as does the sitting male. Thus, from the point of view of working and clothing habits, the Samoan male is more vulnerable to mosquito attack than is the female, and hence it is likely that this factor alone can produce a higher filarial incidence and infestation in males than in females.

HABITAT

In this paper, habitat is used to cover the various environments resulting from the siting of villages and the occupational conditions in which the Samoan works and has his being. These can be grouped under five headings: (1) the village itself, (2) the village environs, (3) the plantations, (4) the sea and its beaches and reefs, and (5) the territory as a whole. The villages are of two main types, the coastal and the inland. The coastal village straggles along the coastal shelf. It contains houses and shade trees, but little or no ground vegetation other than grass. These villages are open and airy being exposed to the sea breezes and during the period of the survey were remarkably free from mosquitoes. The inland village, on the other hand, is generally set round an open grassy space or village green with dense bush round the periphery where the houses are mainly situated. Some villages are traversed by

a stream, while others again are set in its curve. In all, however, the majority of the houses are built closely against dense bush with heavy ground cover. In such villages the mosquito nuisance was very noticeable. The immediate environs are in all cases thick bush which must generally be traversed to reach water supplies and bathing and laundry sites on adjacent streams. This is a factor common to almost all inland villages, which is absent in most coastal ones. The mosquito hazards of this particular environment would appear to have special significance in regard to infections in women and children. The microfilarial incidence in the peripheral blood of males and females from coastal and inland villages is given in Table I and Figures 1, 2.

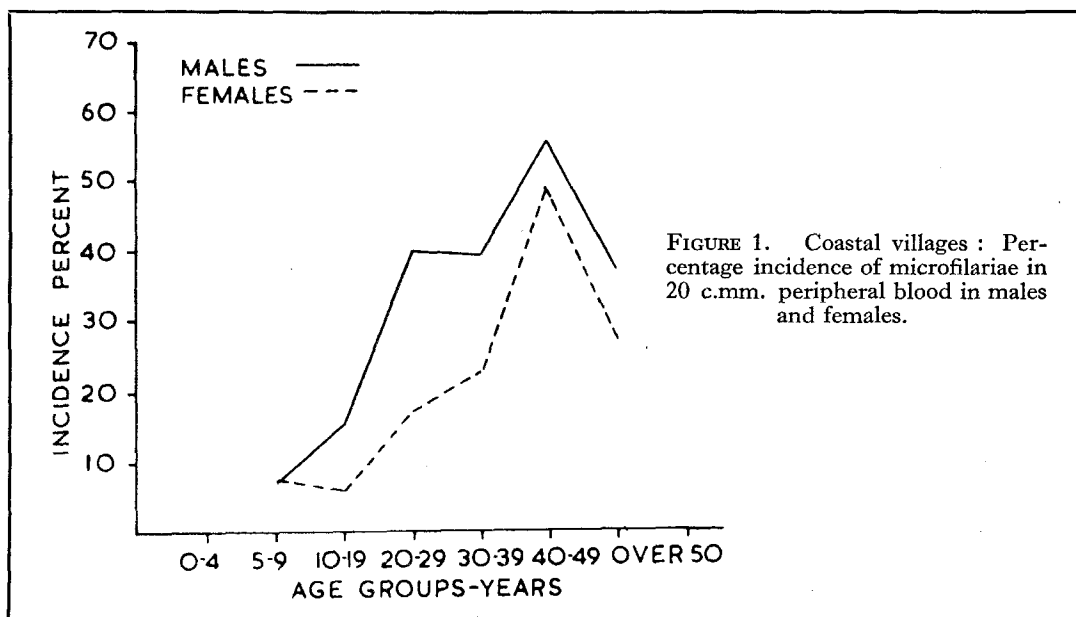


FIGURE 1. Coastal villages : Percentage incidence of microfilariae in 20 c.mm. peripheral blood in males and females.

The plantation areas are situated in the foot-hills of the island's mountainous core. These are surrounded by heavy bush, and within themselves provide shelter and breeding places for *Aedes polynesiensis* which here occurs in high density.

This factor primarily affects the working men who are continuously engaged thereon. The women who transport much of the food from plantation to village and those who sojourn periodically for long or short periods on the plantations with their menfolk are subjected to an intermittent effect from this environment. Those who work on the sea and the reefs are free from any mosquito hazard during this period, though there are few whose full time occupation is on or by the sea. The young boys and girls, many of the women and those few full-time male fishermen, thus have a varying proportion of their days free from the risks of filarial infection. The territory as a whole is mentioned because of the propensity of the Samoan for visiting friends and kinsmen in all parts of the territory. This movement is widespread and visits may be prolonged into weeks and months, and, though the practice is indulged more by males than females, the latter are not infrequently visiting. This custom tends to reduce the differences in endemicity of different localities and to conceal the fact that endemicity differs widely in different areas.

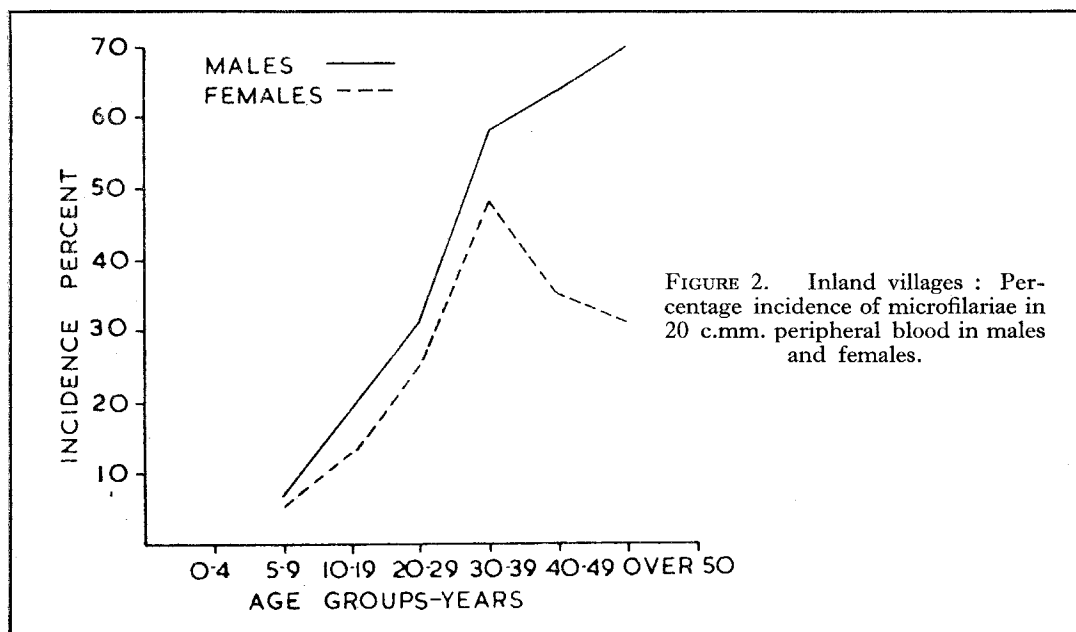


TABLE I. Incidence of microfilariae in peripheral blood of males and females in coastal and inland villages in Western Samoa. 1953 - 54.

	Age-group — Years	MALES							Total
		0 - 4	5 - 9	10 - 19	20 - 29	30 - 39	40 - 49	Over 50	
Coastal villages	No. examined	27	62	140	106	89	63	38	525
	No. positive	—	4	22	42	35	35	14	152
	% positive	—	6.5	15.7	39.6	39.3	55.5	36.8	28.9
Inland villages	No. examined	11	64	102	131	50	22	20	400
	No. positive	—	4	21	41	29	14	14	123
	% positive	—	6.2	18.8	31.3	58.0	63.6	70	30.7
	Age-group — Years	FEMALES							Total
		0 - 4	5 - 9	10 - 19	20 - 29	30 - 39	40 - 49	Over 50	
Coastal villages	No. examined	31	60	166	81	61	39	33	471
	No. positive	—	4	10	14	14	19	9	70
	% positive	—	6.6	6.0	17.3	23.0	48.7	27.3	15.0
Inland villages	No. examined	17	57	34	56	29	14	16	223
	No. positive	—	3	4	14	14	5	5	45
	% positive	—	5.3	11.8	25.0	48.3	35.7	31.3	23.2

HYPERFILARIATION

The number of microfilariae in 20 c.mm. of peripheral blood varies so considerably in different individuals and in successive samples from the same individual that the possible

significance of microfilarial counts as an index of filarial infection has largely been discounted. Nevertheless the results of the present survey, given in Table II, when compared with those of BUXTON, suggest that average counts over the series of age-groups may have a practical application in expressing changes and degrees of endemicity. In the present series counts ranged from one to 327. In BUXTON's series higher densities were encountered. In the males of all three groups, *viz.* BUXTON's 1925 series, and the present inland and coastal groups, the highest average count for any age-group was 80-83 microfilariae in 20 c.mm. blood. In BUXTON's series this density peak occurred in the 16-20 year age-group, whereas in the 1953-54 series it occurred in the 30-45 year age-group. Thus, whereas the maximum was built up in less than 20 years of life in 1925, the same maximum was reached in 1953-54 after about 40 years of infection and re-infection. Among the females, the build-up of microfilarial density proceeds more slowly than in the males but mounts steadily through advancing age-groups to a maximum average of over 60 per 20 c.mm. in those over 45 years of age. Throughout all age-groups the average counts in females of inland villages is higher than the corresponding figure for coastal women. When the curves of incidence of hydrocele and elephantiasis are plotted with the curves of microfilarial density (Figures 3, 4), it is seen that the significant average density appears to be about 60 microfilariae in 20 c.mm. It will be noted that hydrocele begins to appear as a clinical entity about 5 years after this average has been reached, and that elephantiasis begins to appear about 5 years later than this again. Among the women the same relationship is seen. In both groups of women the average density

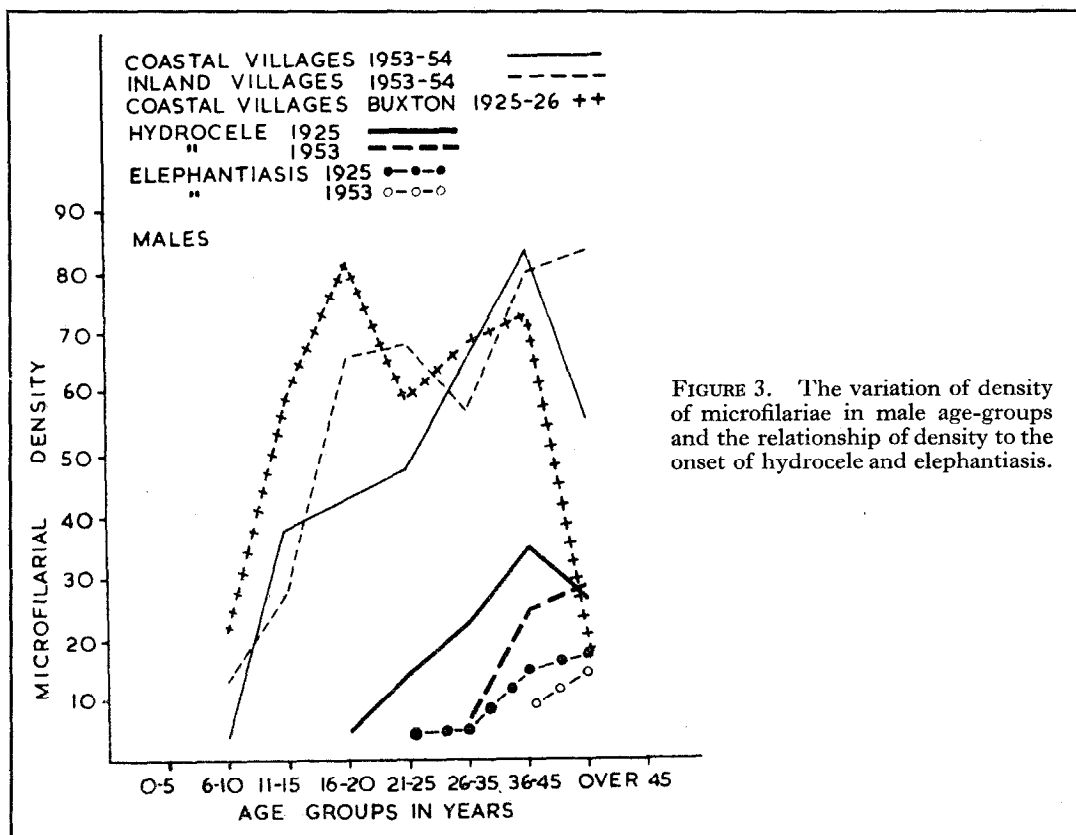
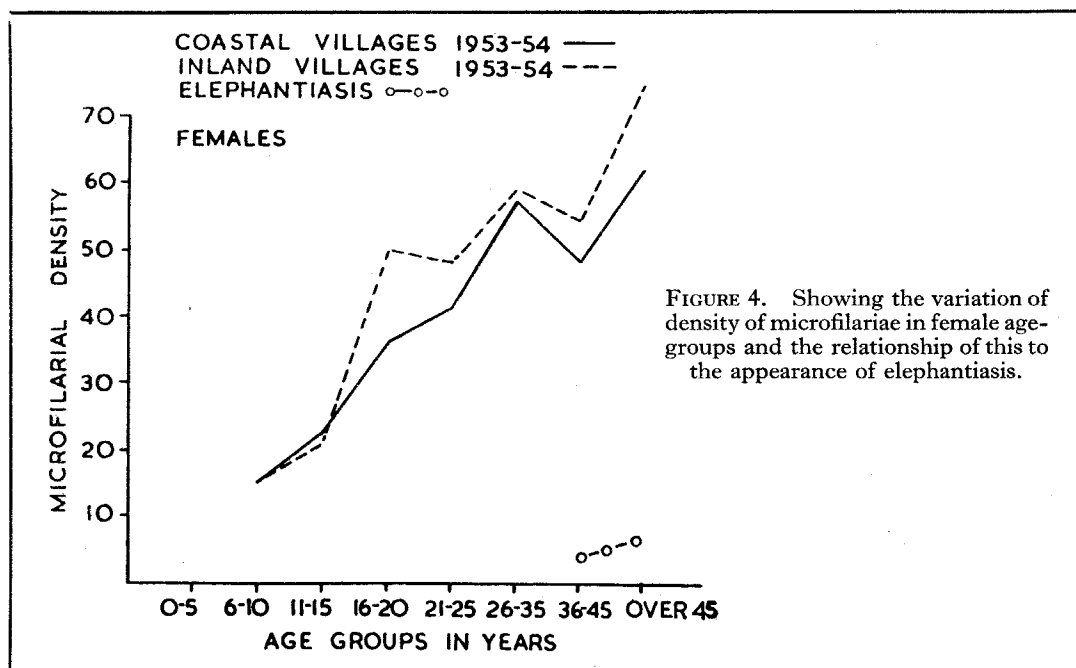


FIGURE 3. The variation of density of microfilariae in male age-groups and the relationship of density to the onset of hydrocele and elephantiasis.



curves closely approach the figure of 60 in the 25-35 year age-group. Elephantiasis in females first appears in the 36-45 year age-group. The youngest female case seen was in fact in her 40th year. The incidence of epitrochlear gland enlargement does not bear any close correlation with the microfilarial density curve, though the close relationship of the incidence of epitrochlear gland enlargement to that of microfilariae in the peripheral blood which was demonstrated by BUXTON is again clearly shown.

TABLE II. Average density of microfilariae in 20 c.mm. peripheral blood in positive cases, Western Samoa, by age-groups.

Age-group—Years		0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 35	36 - 45	Over 45
Buxton's Series 1925 - 26		—	21 (1)	59 (22)	81 (72)	59 (42)	68 (88)	73 (70)	13 (45)
Male 1953 - 54	Coastal	—	4 (3)	38 (12)	43 (17)	48 (21)	66 (38)	83 (34)	56 (27)
	Inland	—	13 (7)	28 (18)	66 (23)	68 (21)	57 (19)	80 (19)	83 (16)
Female 1953 - 54	Coastal	—	15 (4)	22 (5)	36 (9)	41 (13)	57 (15)	48 (11)	62 (13)
	Inland	—	15 (3)	21 (4)	50 (4)	48 (8)	59 (13)	54 (8)	75 (5)

The figures in brackets give the number of positive cases.

The average counts of the older age-groups are perhaps worthy of some consideration. In BUXTON's series of males taken in 1925-26 at a time of high filarial endemicity, the average count, after remaining high from the age of 16 years to that of 45 years, is seen to fall dramatically from an average count of 70 to one of 13. In 1953-54, among the males of the coastal

group, the average density in the same age-groups is 83 and 56, respectively ; while in the inland male group of the same period, the density shows a continued increase in those over 45 years of age though this increase is very slight and not statistically significant. Thus in Western Samoa there would appear to be a maximum average count which can be built up rapidly or slowly according to the degree of endemicity occurring, and which a given degree of transmission will maintain for a number of years. In BUXTON's series the whole of this plateau of density occurs within the life span of the persons examined, but in the male inland series of 1953-54, because of the slower rate of increase of density with advancing age, only the commencement of this plateau is seen. In the coastal male series of the same period the return of the males to the village environment, where transmission is low, results in a fall of density in the older people. The possible reasons for these differences are discussed below.

DISCUSSION

The primary object of this study was to examine the habits and environment of Western Samoan villagers in an endeavour to ascertain which factors were responsible for the difference in incidence of filariasis in males and females which was found in a survey of a group of coastal villages. In addition it was considered that the information collected might throw some light on the apparent change in endemicity which had occurred over the past 30 years between BUXTON's survey of 1925-26 and the present one of 1953-54.

The differences in blood incidence of microfilaria and in the average microfilarial density for different age-groups in inland and coastal villages suggests that the open coastal villages are not heavy foci of infection but that bush tracks and plantations are the loci of heaviest transmission. The bathing and washing points, particularly those used by inland villages and in which the women and younger children are gathered together for an hour or two at a time, are also danger points of special importance to the women and children. The lower rate of incidence among the children, both males and females, of school age in coastal villages compared with those of the same age in inland villages seems to indicate a difference in intensity of infection in the villages themselves.

In spite of the great variability of microfilarial blood counts, both generally and individually, and of the apparent absence of correlation between individual counts and physical signs, it would appear that these counts averaged in age-groups can indicate changes in intensity of transmission and endemicity. In this form it is suggested that microfilarial blood counts have a value as an index of endemicity and when repeated at intervals over the same area will point to changes in endemicity more clearly than will figures for blood incidence or the incidence of obvious physical signs.

It is of interest to speculate on the significance of some of the features of these density curves. It will be noted that the highest average figure for any age-group — 81/82—is common to all three series of figures for males. This suggests that this figure, in Western Samoa, represents either a saturation point of parasite load within the host or perhaps that degree of parasitism which permits maximum reproductive effort in the female worms. The fact that densities diminish after this point has been attained, suggests that this may be so, and that BERTRAM's findings (1953) concerning *L. carinii* in the cotton-rat and relating to the suppression of microfilarial density as a result of overcrowding of the female adult worm habitat may indeed have a parallel counterpart within the human host.

This peak average density apparently bears no relationship to the onset of the major clinical signs of filariasis, such as hydrocele or elephantiasis, for elephantiasis occurs among the women in whom the highest average microfilarial density is only 65. This figure is reached in only the oldest age-groups. However, in all three male groups it is noted that hydrocele first appears in the population 5 years after the average density in any age-group approximates the figure of 60, and that in both males and females the first appearance of elephantiasis occurs about 10 years after this same average count of 60 microfilariae per 20 c.mm. of blood has been reached.

SUMMARY

(1) The working and clothing habits and the environment of villagers in Western Samoa have been studied in relation to the intensity of filarial infection.

(2) It is suggested that these factors are responsible for the difference in incidence between males and females, and that infection and reinfection of the human host occurs principally in the plantation areas and along the bush paths leading to water points, bathing and ablution sites or bush streams.

(3) The microfilarial density expressed as the average count per positive case for each age-group can provide useful information regarding the intensity of transmission, and can be used to demonstrate changes of filarial endemicity which may be occurring in any given locality.

(4) The average age-group densities, considered in relation to the incidence of major physical signs of filarial disease, suggest that the development of these major signs requires a certain minimum parasite load to be maintained for some few years. In Western Samoa it is suggested that the minimum parasite load is that equivalent to an average age-group count of 60 microfilariae per 20 c.mm. blood, and that if this be maintained hydrocele will appear in the male population approximately 5 years later, and that elephantiasis will first appear approximately 10 years later.

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