STUDIES ON POPULATIONS OF HEAD-LICE (*PEDICULUS HUMANUS CAPITIS*: ANOPLURA)

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STUDIES ON POPULATIONS OF HEAD-LICE (*PEDICULUS HUMANUS CAPITIS*: ANOPLURA)

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A method has been described by which one may dissolve a quantity of hair or feathers, and recover from it any lice, etc., which it may contain. Large numbers of complete crops of human hair, each from a separate individual, have been collected in several parts of the world and investigated by this method: the infestation with head-lice has been studied in relation to season, the host's age, sex, etc. (Buxton, 1936, 1938).

The material which is dealt with in the present paper consists of 1437 specimens, each of them the complete crop of hair, removed with a razor from an adult male prisoner on admission to jail at Cannanore, on the Malabar coast, South India (12° N., at sea-level). The prisoners were shaved within a few days of admission to the jail, though some had already been in prison elsewhere, awaiting sentence. For this large and interesting collection of material I am indebted to my friend Major P. V. Karamchandani, I.M.S., who organized the supply, and supervised the work of the barber and clerk. The collecting was carefully done, with attention to detail, and this materially increased the value of the work. The considerable amount of work which has been carried out in this country has fallen on several people, particularly Mr S. Smith who performed all the routine of weighing, dissolving hair and counting lice, and Miss V. E. Buxton and Miss F. R. Mold who have carried out the tabulating.

Gross figures. As Table 1 shows, a total of 1437 crops of hair were examined, in which the gross infestation rate was 37·79 %. Among those infested two-thirds had from one to ten lice, and counts over 100 were rare, amounting to less than 3 % of infested heads: the highest count was 385 lice, not at all a high figure, comparatively speaking. One may compare these facts with those collected elsewhere (Buxton, 1938, Fig. 1 and Table XIII; alternatively Buxton, 1939, p. 47). It will then be seen that in the present collection the rate of infestation is high, but the number of lice per infested head is unexpectedly low. This is not really contrary to the general rule that *within one group of people* (for instance those from one area), those subgroups in which the rate of infestation is high are also those in which the number of lice per infested person tends to be highest.

Table 1. *Showing the numbers of persons infested, and the infestation rates, in the gross figures*

	Total heads	Heads with: Nil	1–10	11–100	101 lice and up	Infested total
Gross no.	1437	894	356	173	14	543
%	100	62·21	24·77	12·04	0·97	37·79
%	—	—	65·56	31·86	2·58	100

Weight of hair. If one considers comparable human beings (for instance, the members of one race, sex and age group), one often finds that the individual's weight of hair is positively correlated with infestation. For instance, this has already been shown, in previous papers, for male Hausas, of several age groups, at Sokoto, Northern Nigeria; also for adult male prisoners at Colombo, Ceylon (both Sinhalese and "all prisoners"); and it has been suggested that the much higher rate of infestation in women than men, among those studied at Lagos, Nigeria, is due in part to the woman's heavier crop of hair. On the other hand, no relation between hair weight and infestation was demonstrated in several of the collections.

In the present material those with heavier crops of hair tend to be more often infested than those with lighter; for instance, the rate of infestation is 14·6 % in those with under 10 g. of hair, and 56–59 % in those with over 20 g. (Table 2). It is interesting that though some of the crops of hair exceeded 60 g., the rate of infestation is almost uniform in all the groups above 20 g. It is clear that the weight of hair is a large and important factor, which must be allowed for in considering the relation between a man's age, sect, etc., and infestation.

Table 2. *Showing incidence of lice in all heads, divided according to the weight of the individual crop of hair*

	Hair weight (g.): Up to 9·9	10–19·9	20–29·9	30–49·9	50 and up	Total
Heads						
Negative	386	280	111	91	19	887
Positive	66	186	139	125	27	543
Total	452	466	250	216	46	1430
% positive	14·6	39·9	55·6	57·8	58·7	37·97

Age. In considering the relation between age and infestation one must remember that there are no children in the group. There were a few prisoners of 18 or 19 years old, but the great majority were fully adult (lower part of Table 3). If one tabulates all heads, except a few for whom age was not recorded, it seems at first as if the effect of age is considerable, the proportion falling as age increases or at least after 30 years. Taking all hair weights together (bottom 5 lines of Table 3), the differences between the 2nd and 3rd, and also 3rd and 4th age groups are highly significant by the test for goodness of fit ($P < 0{\cdot}01$).

Table 3. *Showing relation of prisoner's age and weight of hair to infestation*

Age years	Total heads	No. of heads with: Nil	1–10	11 lice and up	Infested total	%
		Hair weight up to 9·9 g.				
21–30	150	130	17	3	20	13·3
31–40	114	100	12	2	14	12·3
41–up	180	150	26	4	30	16·7
		Hair weight 10·0–19·9 g.				
21–30	219	127	62	30	92	42·0
31–40	140	85	43	12	55	39·3
41–up	95	60	30	5	35	36·7
		Hair weight 20·0 g. and upwards				
21–30	319	128	102	89	191	59·8
31–40	112	51	36	25	61	54·5
41–up	57	30	20	7	27	47·3
		All hair weights together				
To 20	42	24	7	11	18	42·86
21–30	687	386	181	120	301	43·81
31–40	365	234	92	39	131	35·89
41 and up	334	242	76	16	92	27·54
All ages	1428	886	356	186	542	37·96

In view of the importance of weight of hair the data have been classified further, to take account both of age and hair weight (top part of Table 3). It now becomes evident that age in itself has little or no effect on rate of infestation, indeed one might say that the older men are less frequently infested because they carry smaller crops of hair. The matter may be summarized thus, to show the percentage infested, in relation to age and weight of hair:

Hair weight	21–30 years	31–40 years	41 years, and up
Up to 9·9 g.	13·3	12·3	16·7
10–19·9 g.	42·0	39·3	36·7
20 g. and up	59·8	54·5	47·3

Social factors. In India a man's religion and caste is probably the best index we can get of his work, habits and social state: so that it is particularly interesting to study the infestation in the different religious groups. Many of the original records give the caste or subcaste, where the man is a Hindu, and corresponding distinctions for Moslems and Christians. But there are so many of these divisions (with correspondingly few individuals in most of them), and the subject is so complex and my ignorance of it so deep, that it seems best to distinguish only the three main groups, Hindu, Moslem and Christian. It would be of great interest, and of value to the public health services of the country, if a more extended enquiry could be carried out in India, by someone able to consider the religious, social and anthropological issues that would arise.

If the people are grouped under the three main religious heads, and by hair weight, one obtains the results given in Table 4. One may express them briefly, as percentages infested, as follows:

	Hair up to 9·9 g.	10–19·9 g.	20 g. and over	All hair weights
Hindu	20·51	42·98	56·76	42·96
Moslem	4·00	22·54	61·76	16·86
Christian	12·00	42·31	45·00	32·39

These figures show clearly that, on the whole, weight of hair is more important than those social factors of which religion is an index. But the social factors have their own importance, for within one hair weight the degree of infestation is quite different in the different religious groups. The social factors are probably very complex, and one cannot say that the members of one religious group are consistently more infested than the others, irrespective of hair weight. One suspects that each religious group is heterogeneous, and that this is particularly true of the Hindus.

Table 4. *Showing relation of prisoner's religious denomination, and weight of hair, to infestation*

Religion	Total heads	No. of heads with: Nil	1–10	11 lice and up	Infested total	%
		Hair weight up to 9·9 g.				
Hindu	273	217	47	9	56	20·51
Moslem	150	144	6	0	6	4·00
Christian	25	22	3	0	3	12·00
		Hair weight 10–19·9 g.				
Hindu	356	203	112	41	153	42·98
Moslem	71	55	14	2	16	22·54
Christian	26	15	7	4	11	42·31
		Hair weight 20 g. and up				
Hindu	444	192	145	107	252	56·76
Moslem	34	13	9	12	21	61·76
Christian	20	11	3	6	9	45·00
		All hair weights				
Hindu	1073	612	304	157	461	42·96
Moslem	255	212	29	14	43	16·86
Christian	71	48	13	10	23	32·39

The figures given in Table 4 provide an excellent example of the fact that within one broad group, those subgroups with a high percentage of people infested are also those in which the higher counts of lice tend to occur. If we take the Hindus (because they are numerically the largest), and divide them into subgroups by weight of hair we obtain the "observed" figures given in Table 5. If the hair weight had had no effect on the number of men having nil lice, 1–10 lice, etc. (the totals in each column and line remaining constant), we should have obtained the "expected" distribution given in the same table. The differences between the two are very great. The men in the least infested

Table 5. *Showing actual or "observed" distribution of lice in Hindu prisoners, who are divided into subgroups according to weight of hair; also the "expected" distribution, i.e. what would be found if weight of hair had no influence on infestation*

Hair g.	No. of heads with: Nil	1–10	11 lice and up	Total heads	% infested
		OBSERVED			
Up to 9·9	217	47	9	273	20·51
10–19·9	203	112	41	356	42·98
20 and up	192	145	107	444	56·76
All weights	612	304	157	1073	42·96
		EXPECTED			
Up to 9·9	155·7	77·3	39·9		
10–19·9	203·0	100·9	52·1	As above	
20 and up	253·2	125·8	65·0		
All weights	As above				

subgroups (up to 9·9 g. of hair), include too many with nil lice and too few with over eleven lice: conversely for those with heavy crops (20 g. and over), and a high infestation rate. The difference between the observed and expected figures is clearly very great; judged by the test for goodness of fit, it is highly significant, for the odds against it being due to "chance" are much more than a thousand to one ($N=4$; $\chi^2=108$).

Season. Crops of hair were collected for 24 consecutive months, starting in May 1937: the average number was 60 per month, the extremes 12 and 100. It seems to follow that even if there is a seasonal factor in rate of infestation, it might be a difficult matter to demonstrate it.

I have taken the original gross figures, added the two Januaries, two Februaries, etc., and obtained the following values:

Month ...	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Heads	97	163	126	112	90	110	122	144	119	155	82	117	1437
% positive	45	40	35	32	31	32	40	34	45	42	44	32	37·79

At first sight these figures appear to indicate a steady fall in infestation for the first 6 months of the year, followed by a rather irregular rise. But if one takes the monthly figures, and compares them with "expected" figures, in which the rate of infestation is uniform throughout the year, one does not obtain evidence of a high degree of heterogeneity ($\chi^2=15·3$, $N=11$, P nearly 0·2). Rather similarly the value of χ^2 for the 24 separate months is 33·85, giving a value of P between 0·05 and 0·02, significant by conventional standards, but not perhaps very large in view of the obviously heterogeneous nature of the material. This does not indeed exclude the possibility of a periodic change in the rate of infestation, but it shows that if such a change exists it is within rather narrow limits.

As hair weight has been shown to be an important factor, one might expect

to show a seasonal periodicity within one hair weight group, if the periodicity is real. The following figures are given by the men with 10–19·9 g. of hair:

Month ...	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Heads	38	68	46	37	21	32	36	34	41	46	31	36	466
% positive	53	46	35	40	43	25	39	29	39	50	55	19	39·9

Comparing these figures with the gross figures given above one finds little similarity: in this second collection of figures there is little tendency for the rate of infestation to fall steadily during January to June, and a high degree of inconsistency from month to month (compare November, December and January).

One might view the matter in another way. If a seasonal factor exists it seems probable that it would depend on rainfall, for the Malabar coast receives very heavy rain which is confined to 6 consecutive months (May to October), the others being rainless. Can we demonstrate any relationship between infestation and the rainy season? Confining attention to the men with 10–19·9 g. of hair one gets these figures:

Year	Rainy months: Total heads	% infested	Dry months: Total heads	% infested
First	85	36·5	95	36·8
Second	125	39·2	161	44·1
Together	210	38·0	256	41·4

The figures show no significant differences in rate of infestation during the two seasons: substantially the same result is given by the group with hair under 10 g. Moreover, one can demonstrate no difference if one allows one month's lag for the possible effect of rain or drought.

There must doubtless be other seasonal events which might have an influence on infestation. Temperature is not likely to be important, for it is very equable; but there may well be important events in the agricultural year, such as harvest, and also social and religious factors, such as holidays and pilgrimages.

My colleague, Dr Bradford Hill, who has given much time to examining these figures, agrees that there is little evidence for any regular seasonal fluctuation in the proportion of men infested. He suggests that there may be a secular change in rate of infestation, and that when collecting started (May 1937) the rate was falling. In support of this he points out that if one compares the period May–December 1937 with the same months in 1938, the percentage infested is consistently higher in the first year: the rates for these two 6-monthly periods are 42·5 and 35·2%, which are significantly different. It seems difficult to establish the existence of such a secular change in data collected for only 24 months: one would require figures for a longer period, and would then wish to eliminate the important factor of hair weight. The suggestion that there may be such secular changes is extremely interesting.

SUMMARY

The author has examined 1437 crops of hair, removed from adult or adolescent males on admission to jail, at Cannanore, South India. There is a high positive correlation between weight of hair and rate of infestation with head-lice, men with less than 10 g. of hair being 14·6 % infested, those with 10–19·9 g. 39·9 %, and those with over 20 g. 56–59 %.

There appears to be a negative correlation with age, but this seems to be due to the older men having less hair: if one standardizes hair weight there is no tendency for older men to be less infested than younger. In a similar way, the large differences in rate of infestation between different religious groups appear to be due to a great extent (but not entirely) to differences in hair weight.

No evidence was found that rate of infestation is different at different times of year. The rates in the rainy and dry seasons scarcely differ, in spite of the intensity of the rain, and of the fact that the rainless period lasts for six months. It is possible that there is a long-period, secular change in rate of infestation.

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