Draft

Measurements of head lice and body lice from individuals with double infestations

James R. Busvine
London School of Hygiene & Tropical Medicine

INTRODUCTION

The differentiation of parasitic insects to separate species on different parts of the same host presents interesting problems. Of human lice, the crab louse, Pthirus pubis, must have become a distinct entity in very distant times, whereas the two forms of Pediculus humanus presumably diverged much later, at a time when man lost his body hair and began to wear clothing. Because the process of differentiation is not far advanced, there has been considerable lack of agreement as to the status of the two forms. Some tend to consider that they are merely transient forms of a polymorphic species; others believe them to be true species. This is not the place to review all the arguments which were well collected by Ferris (1935) and further discussed in relation to experimental studies by myself (Busvine, 1948) and Siegfried Scholl (1955). The purpose of this paper is to introduce a little evidence of a type not previously examined; the morphology of head and body lice from individuals with double infestations. The object was to seek for signs of interbreeding, which is known to be quite feasible in laboratory experiments with colonised strains. The absence of intermediate forms may perhaps suggest that ethological barriers to interbreeding have been responsible for maintaining the two forms separately on the same hosts.

Double infestations, of head and body lice on the same individual, are now rather unusual in Europe and North America (though, according to Hase, 1916, this was not the case in East Europe 60 years ago). At present in Britain, head

lice are characteristically found on children, often quite cleanly in most respects; whereas body lice are largely restricted to adult vagrants, who sleep in their clothes. This additional element of separation might be expected to accentuate the progress of the two forms towards specific status, providing mankind is willing to remain subject to their attacks for long enough.

An opportunity for examining head and body lice from double infestations was provided when Comdr. Lance Sholdt of US Naval Medical Unit No. 5, undertook to collect the material in Ethiopia.

OBSERVATIONS

Material. The specimens collected by Comdr. Sholdt from scalps or clothing were preserved in 70% alcohol and I examined them in London. The adult lice available for measurements were as follows:

Host	Head lice	Body lice
1. Astawesym Shewarega (169070)	2 ♂ 3 ♀	1 ♂ 10 ♀
2. Emblest Zeleka (1422)	10 ♂ 8 ♀	16 ♂ 20 ♀
3. Wolde Tsegaye (169073)	4 ♂ 5 ♀	3 ♂ 18 ♀
4. Mengesha Tadessa (170962)	1 ♂ 3 ♀	8 ♂ 22 ♀
5. Wowdemu Habete (170541)	4 ♂ 24 ♀	2 ♂ 20 ♀
6. Kdebago Zeleke (169462)	2 ♂ 3 ♀	18 ♀
7. Sabseba Abebe (169889)	18 ♀	nil
8. Zegene Zeleke (169890)	4 ♂ 45 ♀	nil

Methods. The most obvious character used to distinguish head and body lice, which is susceptible to measurement, is the size difference. Measurements of total body length were made and also of the head and thorax. Whole lice were mounted on Faure's gum chloral medium on microscope slides and measured by a micrometer scale in the eyepiece of a dissecting microscope. At the magnification used, one division corresponded to 0.0077 mm. Total body length, however, tends to be unreliable, because of the elastic nature of much of the louse's integument. Well fed lice are liable to be extended telescopically and the same effect can be caused by pressure of a coverslip, when the lice are mounted on slides. This unreliability is reflected in the divergence of mean values for head and body louse types recorded by different investigators (as shown in Table 1).

The various alternative body measurements used by myself in an earlier (1948) investigation did not seem entirely satisfactory, in that all of them resulted in considerable overlap between small body lice and large body lice. I therefore took advantage of the further measurements of Scholl (1956) and used the dimensions of the second pair of legs which he found to give greatest degree of discrimination. The parts selected are shown in Figure 1. To measure them, a leg was cut off each louse and mounted in Faure's gum chloral. Because the legs were all slightly flexed, they tended to lie on the slide in a uniform orientation. Efforts were made to avoid errors due to parallax. The sizes were measured by a micrometer scale in the eyepiece of a compound microscope. At the magnification used, one division corresponded to 0.0115 mm.

Results.

1. Head louse/body louse comparisons

The data were recorded separately for the various human hosts and examined for possible indications that some individuals had larger or smaller specimens than others. No such trends were noted (with one exception to be mentioned shortly) and the data were accordingly combined according to sex and origin (head or body).

The mean body length dimensions are set out in Table 2. The main findings, which are conveniently illustrated in Figure 2, are as follows. In general, there was a surprisingly sharp separation of size in the specimens taken from heads and clothing. The only exceptions were two male lice and three females, taken from heads, but well in the body louse range. The three females were all from the same head (of Host No. 4). The two males were taken respectively from Hosts Nos. 2 and 6. It may be mentioned that all these lice conformed in general appearance to the body louse type (i.e. in colour and the shape of abdominal segments).

The measurements of the parts of the middle legs of the lice are recorded in Table 3 and illustrated by Figure 3. Again, there is rather clear separation of the sizes, which is particularly marked in measurements of tibiae, less so in tarsi and somewhat less again for the claws. This order of degree of separation was also found by Scholl (1955), though to a less marked degree. His percentage differences (for males) were respectively 32.6, 29.3, and 25.8 as compared with 33, 22 and 14 in my results.

Once again, the three aberrant females and two males (found on the head but within the body range) are evident.

Discussion

Scholl (1955), after very extensive series of measurements on wild and cultured louse strains, comes to this conclusion: "Eine engültige Enscheidung über die systematische Bewertung der Leiden Formen ist selbst mit den aufgefundenen Unterschienden in den Längenrelationen der Borsten und Körperanhänge noch nicht möglich". I am inclined to agree with him. The present investigation has shown that in persons infested with lice on the head and in clothing, the two populations remain at least as recognisably distinct as in separate infestations. One can only speculate about the incidence of interbreeding. If the genetic size determinants were multifactorial, a higher proportion of intermediate sized lice would be expected. Unfortunately, there is no entirely satisfactory evidence. My own (1948) crossing experiments produced F_1 and F_3 generations which were rather close to the size of the larger body louse parent. These experiments were reared in continuous contact with the body, to minimise possible selective mortality (which might favour survival of the body louse type, because it is better adapted to rearing in captivity). However, I gave no information on the critical mortality of the first instar nymphs at this first feed; nor are there details about size distribution, which should reveal segregation if only one or two major genes were involved.

Even if full data on the inheritance of size were available, it would also be essential to know how the choice of head or garment environment is inherited. It is difficult to see exactly how this could be determined. No-one has even studied the behaviour of head lice removed to the body or vice versa. (Hilda Sikora (1944) states that head lice on the clothing find their way back to the head, but then admits that she has never tried the experiment.)

The final matter to be discussed is the status of the five aberrent "body louse" types which were collected from heads. One possibility might be that they represent hybrids, in which the body size charactersand the head choice character are both dominant. Perhaps a simpler explanation might be merely accidental contamination. It could well be that body lice could be detached and fall onto the head during undressing, especially if garments are pulled over the head.

2. Sex comparisons

It is generally agreed that female body lice are larger than males (c.f. Table 1). I was therefore rather surprised to find that the measurements of tibiae, tarsi and claws showed no significant differences ($P > 3$) whereas the head/body comparisons were highly significant ($P < .01$). It seemed likely that most of the size differences noted were due to the large female abdomen and the data in Table 2 support this. It also seems that the head and thorax of the females are larger (though it was not possible to estimate standard deviations because the micrometer divisions were too coarse in relation to the means).

One can only speculate about this situation. The similarity in leg and claw sizes may be regulated by the demands of the environment; those of head lice being related to grasping hairs. Sikora (1944) suggests that the slimmer head louse shape is needed to move rapidly through close set hairs and she points out how difficult they are to extract by finger tips. She further suggests that head louse nutrition is somehow inferior to that of body lice and that their environment is cooler; both circumstances leading to smaller insects. In my opinion, however, the head louse food supply is more constantly available than that of the body

louse, which cannot easily feed when the host is moving about and not at all if clothes are removed at night. These difficulties may have favoured the selection of an insect capable of taking less frequent but larger meals. I have, in fact, shown that body lice are more resistant to starvation. I also found the scalp temperature tends to be a degree or two lower than that under clothing. But is is generally found that insects reared at a lower temperature tend to be larger, not smaller.

Conclusions

This study of specimens of head and body forms of lice (which should, I think, be described as sub-species) has taken the matter a little further forward. More definite conclusions would seem to demand experiments by someone prepared to study their behavioural characteristics. This would require the use of recently captured lice and probably of their release on the human body.

Acknowledgements

I am indebted to Cmdr. Sholdt for his assistance and hospitality in Ethiopia and for collection of the specimens used.

References

BUSVINE, J.R. (1948). The 'Head' and 'Body' races of Pediculus humanus L. Parasitology 39, 1-16.

FAHRENHOLZ, H. (1915). Läuse verschiedener Menschenrassen. Z. Morphol. Anthropol. 17, 591-602.

FERRIS, G.F. (1922/1935). Contributions towards a monograph of the sucking lice. Stanford University publ. biological Sci.

HASE, A. (1915). Beiträge zu einer Biologie der Kleiderlaus. Flugschr. dtsch. Ges. angew. Entomolog.

SCHOLL, S. (1955). Kopf- und Kleiderlaus als taxonomisches Problem. Parasitologische Schriftenreihe Heft 1, 58 pp.

SIKORA, H. (1944). Meine Erfahrungen bei der Läusezucht. Z. Hyg. Infektionskr. 125.

Author		Head strains	Body strain	% difference
Fahrenholz (1915)	♂ ♀	2.56 3.10	3.23 4.20	21 26
% difference		18	23	
Busvine (1948)	♂ ♀	2.68 3.18	3.32 3.81	19 20
% difference		17	13	
Scholl (1956)	♂ ♀	2.96 3.69	3.99 4.51	25 18
% difference		20	12	
This investigation	♂ ♀	2.91 3.55	3.79 4.42	23 20
% difference		18	14	

Table 1. Total mean lengths of head and body lice recorded by different investigators (in mm), with percentage differences.

	Head strain	Body strain	% difference
Head ♂	6.42	7.67	16.4
" ♀	6.78	8.52	21.6
% difference	5.3	10.0	
Thorax ♂	8.89	11.04	19.5
" ♀	9.22	11.46	18.7
% difference	3.5	3.6	
Abdomen ♂	22.47 ± 1.39	30.33 ± 1.90	25.9
" ♀	30.07 ± 2.00	37.30 ± 2.91	19.4
% difference	25.3	18.7	
Total ♂	37.78 ± 2.01	49.21 ± 1.79	23.2
" ♀	46.07 ± 2.28	57.33 ± 2.91	19.7
% difference	18.0	14.1	

Table 2. Means (and standard deviations) of body length and parts thereof, of samples of lice from hair and clothing. In micrometer divisions: 1 div. = 0.0115 mm. (% differences based on larger value).

	Head strain	Body strain	%difference
Claw ♂	18.61 ± 1.36	21.62 ± 0.82	14.0
" ♀	18.32 ± 0.94	21.44 ± 0.97	14.6
% difference	1.6	0.7	
Tarsus ♂	16.19 ± 0.81	20.77 ± 0.94	22.1
" ♀	16.35 ± 1.13	21.21 ± 0.93	23.0
% difference	1.0	2.1	
Tibia ♂	25.33 ± 1.59	36.63 ± 1.99	33.0
" ♀	25.74 ± 1.67	36.96 ± 1.63	30.4
% difference	1.6	0.9	

Table 3. Means (and standard deviations) of portions of mid-legs of sample of lice from hair and clothing. In micrometer divisions; 1 div = 0.0077 mm. (% difference based on larger value).