Evidence from double infestations for the specific status of human head lice and body lice (Anoplura)

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ABSTRACT. Samples of head lice and body lice obtained from Ethiopians suffering from double infestations were mounted onto microscope slides and measured. The mean length of body lice (ϕ 4.4 mm; δ 3.8 mm) was greater than that of head lice (ϕ 3.5 mm; δ 2.9 mm), but the best discriminant was the length of the tibia of the middle leg (ϕ 425/296 µm; δ 421/291 µm). No intermediate specimens were found in these double infestations, although intermediates can be produced experimentally by cross-mating. Since populations of head lice and body lice remain distinct it is concluded that they represent two distinct species, Pediculus capitis De Geer and P. humanus Linnæus.

Introduction

The relationships between human head lice (Pediculus capitis De Geer) and human body lice (P. humanus Linnæus) have several claims to our attention. The two forms are responsible for widely different problems of public health, though they are clearly closely related biologically. The question of the relative taxonomic status of these two taxa has been discussed repeatedly, without a consistent conclusion being reached (Ferris, 1935, 1951; Busvine, 1948; Schöll, 1955). Opinions range from that of Ferris, who describes them as merely transient types of a polytypic species, to that of Freund (1924) and W. Ficher (1925, in lit.), who considered them to be separate species. Of considerable interest is the possibility that they represent species recently adapted to different sites on the same host, which is not uncommon in insect genera of lice. In this case, the obvious connection with human loss of body hair and adoption of clothing, introduces an anthropological continuum.

The purpose of this paper is to introduce some evidence of a kind not previously examined, namely the comparison of specimens from individuals with simultaneous infestations of head and body lice. Such double infestations are now rare in Europe though, according to Hase (1915), they were quite common in Eastern Europe some 60 years ago. At present in Britain, head lice are characteristically found on children, who are often quite cleanly in most respects, whereas body lice are mainly restricted to the druggist, often elderly and socially inadequate, who sleep in their clothes.

In double infestations, as pointed out by Keilin & Nuttall (1919), opportunities for interbreeding of the two forms may well occur, so it would seem of interest to discover how distinct they remain in these circumstances. An opportunity to investigate this followed a visit to Ethiopia, where double infestations are still quite common. Cmdr L. Schildt, of the U.S. Naval Medical Research Unit No. 6, collected the specimens which were preserved in alcohol and later examined by me in London.
Material studied

Series 1. Small samples of adult lice were collected from the head and clothing of Ethiopians attending hospital in Addis Ababa. The patients were from various tribes (Table 1), and, except for one 14-year-old girl, all were young men. The imbalance of sexes was because fewer women had double infestations, but also because they were less willing for their hair to be shaved off. The weight of hair removed ranged from 14 to 40 g. The clothing, which was generally dirty, was largely of European type. However, most of these people wore a shamma, a toga-like garment which was 5-10 ft long, draped over the shoulders, arms and often the head.

Series 2. A smaller number of louse specimens was available from some remote villages in the south-west of Ethiopia. These were collected from tribes (Amuka and Nuers) having little contact with foreigners. The people were largely unshod but body lice were collected from head necklaces and from the sleeping cloths used at night. The numbers of lice were low, but adequate for the transmission of relapsing fever, which had been prevalent during the previous two years.

Series 3. These specimens had been preserved in 70% alcohol at the time of an earlier investigation (Buxton, 1948). They comprised head lice and body lice collected in London, but reared in captivity for thirty-three generations. They also included some of the F, hybrids of a cross between the two forms.

Methods

The most obvious character used to distinguish head and body lice is the gross size difference. Therefore measurements were made of total body length and also of the head and thorax. Whole lice were mounted in Faure’s gum chloral medium on microscope slides and measured by a micrometer in the eyepiece of a dissecting microscope. Total body length, however, tends to be unreliable, because of the elastic nature of the integument. Well-fed lice are liable to have the abdomen extended telescopically, and the same effect can be produced by the pressure of a coverslip when the lice are mounted on slides. This unreliability is reflected in the divergence of mean values for both types recorded by different investigators (Table 2).

The various alternative measurements made by myself in the earlier (1948) investigation did not seem entirely satisfactory, in that all of them resulted in considerable overlap between small body lice and large head lice. I therefore took advantage of the parameters evaluated by Scholl (1955) and used these dimensions of the second pair of legs, which, according to his figures, give the greatest degree of discrimination (Fig. 1). To obtain these measurements 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, thus helping to avoid errors of parallax. The sizes were measured by a micrometer in the eyepiece of a compound microscope.

The average tibial length of the second leg, according to my measurements for male lice, were 0.39 and 0.42 mm for head and body lice, respectively. These compare fairly well with Scholl’s figures of 0.35 and 0.41 mm.

Results

The data were recorded separately for the various human hosts and examined for possible indications that some individuals had larger or smaller lice than others. No such trends were found, and therefore the measurements of lice from various hosts were combined according to origin (head or clothing) and sex. The mean body lengths of lice collected in Addis Ababa are set out in Table 3 and the measurements of parts of the middle leg in Table 4.

Sex comparisons

It is well known that female lice are generally larger than males (cf. Table 2). From Table 3, however, it is evident that most of this difference is due to the larger abdomen of the female. In contrast, measurements of tibiae, tarsi and claws show no significant sex difference (Table 4), whereas the differences between head and body lice are highly significant ($P < 0.01$).

In speculating about these findings, one presumes that the larger abdomen of the female are required for the development of the ovaries, whereas the similarity of the leg and claw sizes may be due to the demands of the environment, those of head lice being related to grasping hairs.

Head louse/body louse comparisons

The range of size, distribution and possible overlap of measurements of head and body louse populations can best be illustrated by histograms. Fig. 2 shows these data for the Addis Ababa lice and it will be seen that the
two forms remain remarkably distinct in these double infestations, with comparatively little overlap. There are, however, certain very distinct exceptions; notably two male and seven female lice found on heads, which fall well into the body louse range. All of these lice conformed in general appearance (colour and shape of abdominal segments) to the body louse type. In addition, there were two females found on clothing which fell into the head louse range but which conformed to the body louse type.

The mean measurements of the parts of the body of lice are given in Table 4. The most distinct separation of head and body louse types is given by measurements of the tibiae, while the difference in the tarsi is less and still smaller in the claws. This order 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 30.29 and 14.7 in my results.

Because the measurements of tibiae provide the best discrimination between head and body forms, they were used for subsequent comparisons. Their distributions are shown by the histograms in Fig. 3. The lower diagrams (A and B) relate to the Addis Ababa lice. Of eighty-five males and 167 females taken from clothing and forty-three males and sixty-three females taken from hair, the general impression is an even sharper separation of the two forms than by body length measurements. The two female lice found on clothing, but falling into the length range of head lice, were found to have tibiae of normal body louse length. It is possible that their short length could have been due to immaturity, in contrast to the other lice which had well-developed ovaries. There remain, however, the nine aberrant specimens (two males, seven females) collected from clothing, but falling into the body length range. These were the same specimens noted as exceptions in the body length measurements.

It is interesting to note that similar findings apply to the smaller number of specimens collected from the Nuers and Annaks (Fig. 5). Again, the typical head and body louse measurements were strikingly separated (though both were smaller than the lice collected in Addis Ababa). Here again there were exceptions; more indeed, since head louse type were found on the body as well as body louse type on the head.

It seems that the most likely explanation of the aberrant lice is that they were simply due to accidental contamination. In this connection, Cmdr Sholdt comments: 'We did nothing special as far as undressing the individuals. Their clothing was removed and their heads shaved as soon as they were admitted to hospital. Both men and women had to pull some article of clothing over the head to undress. If that article was heavily infested with lice, it is not unlikely that some lice might be transferred to the hair'. He also points out: 'The practice of wrapping the shamma about the head made me wonder early on if this might facilitate interbreeding of individuals with double infestations; especially as our surveys had shown shammis to be often heavily infested with lice.'
The behavioural character which impels head lice to seek the scalp and body lice to the garments is clearly a critical one, but little is known about it. Studies have shown that the mode of body lice being put on the head of a man and subsequently being found in his underwear, and she herself conducted an experiment in which fourteen male head lice were put in the neck and shoulder region of a woman. Eight were later recovered from the lice by combing, and the remaining lost. Still less is known about the mode of attachment of these to the host. Howlett (1917) recounted some tests done in India in which he and an assistant released some head lice in their clothing. These showed a distinct tendency to migrate to the head, and had to be put back again at intervals, but this character was markedly modified in their offspring, some of whom showed no definite tendency towards the body. The eggs of these (F1) individuals were mostly laid on clothing; a few (in my case) on the heads of the body lice. The F2 generation usually appeared, and a few individuals showed it to some extent it was much less definite than in their grandparents. The majority did not show it at all. Howlett and colour were also greatly modified in the 'corpus direction'. Howlett was writing 4 or 5 years after the actual experiment and it is not easy to assess these observations adequately in the absence of further details (nor do I know of any one eager to repeat the tests). They point, however, to the principle of hybridisability and the specificity of the two forms; that is the alleged "transformation of head lice into body lice". Howlett (1917) was the first to report this about a strain sent from the Mutter Museum. In three or four generations she noted a 22% increase of male body length and 37% in females. Kelin & Nattali (1919) also briefly mention the same phenomenon in regard to samples of head lice reared for 20 years (1917) in India. More recently, Alpago & Nastukova (1955) described experiments with head and body lice collected from natural infestations.
interbreeding between individuals on the neck and those conditioned for the adjacent areas of back and wings. The presence of sympatric genera and species normally found amongst the Mallophaga can be explained by isolation and later reunion of parts of the louse populations... and probably to a lesser extent by secondary infestations.

The case of human lice is further complicated by being bound up with human loss of hair and adoption of clothing. It would be rash for me to speculate on the cause or even the sequence of these events, but it seems not unreasonable to suppose that they were in some way connected and, accordingly, roughly contemporaneous. It is conceivable then, that in one region the original head-dwelling lice retreated to the scalp, while in another area they invaded the clothing. Subsequently, after a degree of differentiation, not involving complete genetic incompatibility, the human hosts of the two regions began to mingle and become infested with both forms.

A few additional remarks may be made on the causes of the size difference between head and body lice. Sikora (1944) plausibly suggested that the smaller size of head lice is advantageous in allowing them to slip easily through the dense hair of the scalp and escape capture, but I think this erred in ascribing the larger size of the body louse to better nutrition or a temperature difference. The latter is not great and, according to my 1948 data, it is slightly cooler in the hair which should result in larger specimens. In regard to nutrition, it could well be argued that the more robust body lice have been selected by the relatively adverse nature of their environment. Unlike head lice, which can feed at any time, they cannot feed while their host is active because of the shifting garments, and in some cases clothing is removed at night. Consequently, they tend to take fewer but larger meals. The "pampered" head lice more readily succumb to starvation and are less adaptable to the unusual circumstances of artificial rearing.

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The eggs, repugulum, and larva of Byus albistigma (Neuroptera: Ascalaphidae): morphology, behaviour and phylogenetic significance

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ABSTRACT. The external morphology and habits of the larval instars of the Central American ascalaphid Byus albistigma (Walker) are described for the first time, and its eggs and repugulum (abortive eggs) are compared to those of a Brazilian Byus sp. described by New (1971). In most respects, all immature stages of Byus are shown to be much like those of another neuroptynine (entire-eyed) owlfly, Ascalopteryx furciger (McLachlan). However, larvae of Byus are arboreal rather than terrestrial and possess a number of important morphological characters that are more primitive than those seen in Ascalopteryx. Shared features of the two genera that may constitute the ground plan of the Neuroptyninae are discussed in some detail and are weighted according to their primitive or derived status.

For which no larva has previously been known. The eggs and larval instars of Byus albistigma (Walker), collected in Panama and reared in the laboratory, are described in detail with respect to both external morphology and habits. The significance of the work lies not so much in the characterization of an undescribed larva as it does in the formulation of the ground plan of immature Neuroptyninae for comparison with that of the better known Ascalaphinae. Toward this end, the larva of only one other neuroptynine genus, Ascalopteryx, has been positively identified and described (Henry, 1972, 1976). This form, together with the larvae of the six ascalaphid (split-eyed) genera known from the literature (summarized by Henry, 1976), will serve as the basis for comparison with Byus in the discussion.

Methods and Materials
A gravid female was captured on 23 May 1976 at "light" on Batro Colorado Island, Canal Zone, Panama, by R. E. Sibergeld and A. Aiello. I later identified this insect as Byus.