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Pediculosis: Biology of the Parasites

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HEAD LICE AND BODY LICE

The earliest scientific studies of louse biology were made on small colonies kept, more or less constantly, on the body of the investigator. This was the method used by myself and colleagues 30 years ago. About 1946, mass-rearing methods were developed in the U.S.A., with lice kept in incubators but fed daily on paid donors. Both methods were unpleasant but the human host was considered essential. A remarkable advance was achieved when human body louse colonies were adapted to feeding on rabbits,[8] but this involved considerable trouble; it was never developed for head lice or crab lice.

Because of these difficulties, human lice have never been popular subjects for research. Most of the work was done during the two World Wars, in response to increased threats of louse-borne disease. At present, few research centers maintain louse colonies. The Gainesville work on lice has concluded; but Dr. Gerberg of Insect Control and Research in Baltimore retains the susceptible colony. At the London School of Hygiene and Tropical Medicine we maintain this and a resistant strain, but cannot guarantee to do so indefinitely.

It is not surprising that there have been few recent experimental studies of louse biology; and little can be added to the review I made at a Washington Symposium on Lice and Louse-Borne Diseases in December 1972.[6]

Status of the Head Louse and Body Louse Forms

While the crab louse, *Pthirus** *pubis* is a distinct genus and species, there is some doubt about the status of the two forms of *Pediculus humanus*.

It is highly probable that the head louse represents the ancestral type, from which the body louse evolved to occupy the new niche provided when man began to wear clothes. Such evolution of parasites on the same host is known in other genera, for example, the lice of sheep of which there is one species on the head and shoulders and another on the feet. The problem is, how far this evolution has proceeded in the human lice. The extreme views are represented, by the Russians Alpatove and Nastukova[2] who consider them to be merely labile varieties, and by Dr. W. Eichler of East Berlin, who believes them to be distinct species.

My own (1948) studies showed them to be similar in bionomics, and I could find no absolute morphologic differences between them.[5] In the measurements I selected, I found that the smaller head louse dimensions overlapped those of the larger body louse (Fig. 25-1). Lice however, are elastic creatures, so that measurements of the softer parts are unreliable. Thus, Schöll[16] found distinct differences in the material he studied (Fig. 25-2). He and I agree that the differences are genetic and not due to environment (*i.e.*, head louse characters persist in colonies reared on the body).

Since, however, I found that the two forms are interfertile, with no evidence of type-specific mating choice.

It would be interesting to know if interbreeding occurs naturally on people infested with both forms. Such individuals are rare in Europe and North America (though this was not true 60 years ago, according to Hase).[13] Head lice tend to occur on children, often quite clean; whereas body lice are found on dirty, adult vagrants. On a recent visit to Ethiopia, where pediculosis is common, Commander Lance Scholdt (U.S. Naval Medical Research Unit No. 5) kindly supplied me with pairs of collections from a series of six double infestations.

Bionomics of Lice

My 1948 studies provide fairly detailed quantitative bionomics of lice reared on human blood with varied opportunities of feeding from 3 to 24 hours per day (Table 25-1). The U.S. mass rearing method involving daily feeds on human hosts gave similar results (Culpepper, 1946). Sub-

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*The correct name for the crab louse is Pthirus pubis (Phthirus is a widely dispersed error).

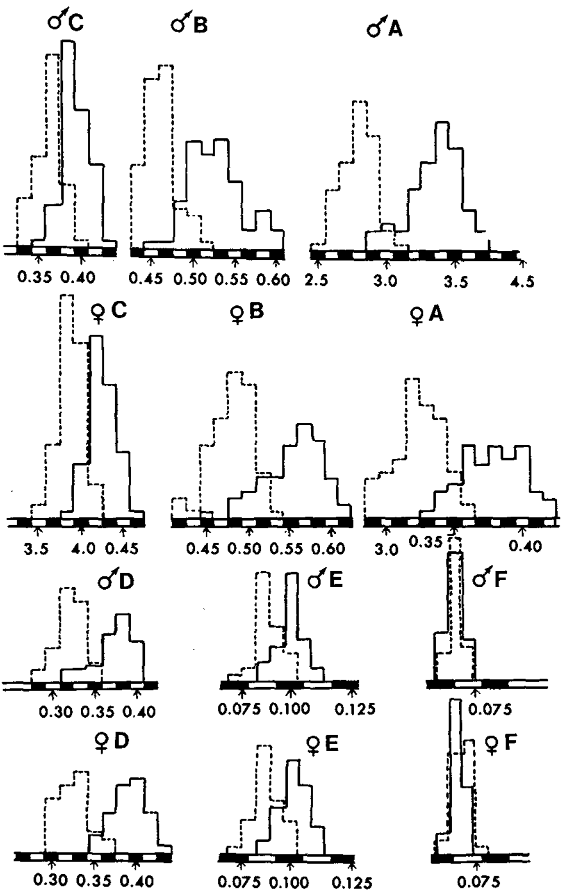

Fig. 25-1. Histograms showing distribution of sizes (in millimeters) of various dimensions of head and body strains of lice. A = total length; B = length of head; C = width of head; D = length of distal four segments of antennae; E = length of third antennal joint; F = width of third antennal joint. Solid lines represent body lice and dotted lines represent head lice. After Busvine (1948).

Table 25-1. Bionomics of Head and Body Lice Reared on Human Blood.[a,b]

		Averages for							
		Head lice				*Body lice*			
Worn on body	(hours/day)	24	12	2×3	3	24	12	2×3	3
Nymphal	days	8.5	12	18	23	8.3	13	18	24
period	% mort.	15	35	32	97	0	9	9	64
Adult life	males	10	—	—	—	20	30	30	13
(days)	females	9	22	17	—	20	21	25	15
	per female/day	6.3	2.5	1.3	—	5.5	4.7	2.9	1.0
Eggs	totals	57	56	22	—	110	98	75	15
	% hatch	88	76	64	—	94	91	78	0

[a]Lethal starvation of head lice is 55 hours and of body lice 85 hours at 23°C. and of head lice 24 hours and of body lice 45 hours at 30°C.
[b]From: Busvine (1948)

sequent data obtained on rabbits are perhaps only of technical interest.[10,12] (Flemings and Ludwig, 1964; Goding, 1963).

From such data Buxton[7] (1948) made some interesting calculations of the expected population growth of body lice, if unchecked under natural conditions. He calculated that, under favorable conditions, the progeny of a single female would grow to between 4,000 and 5,000 in three months, and under unfavorable conditions to between 400 and 500.

If we compare these estimates with actual numbers of body lice (or head lice) found on infested people, there is an obvious inconsistency. Even under squalid conditions of general lousiness, most people carry small numbers, of the order of a dozen or so. Smaller numbers of infested people are found with populations up to several hundreds, while infestations of thousands are rare. Some population check must exist. It is unlikely that this could be competition for food, which is virtually unlimited; 1,000 adult lice would only consume about 1 ml. of blood per day. Another important regulator of insect populations is also inoperative; that is, adverse climatic conditions. Lice living permanently close to the human body, experience favorable, equable conditions largely independent of changes in the general climate. Thus, Buxton's experiments in Iran showed rather uniform temperatures under clothing (28° - 32°C.) despite wide variations in the external temperature in summer (34° - 37°C) or winter (16° - 20°C.). Analogous experiments of mine in England showed temperatures near the scalp to be 30° - 33°C., either indoors at 18.5° or outdoors at 13°C.

Buxton reviewed other causes of louse death, some of which are evi-

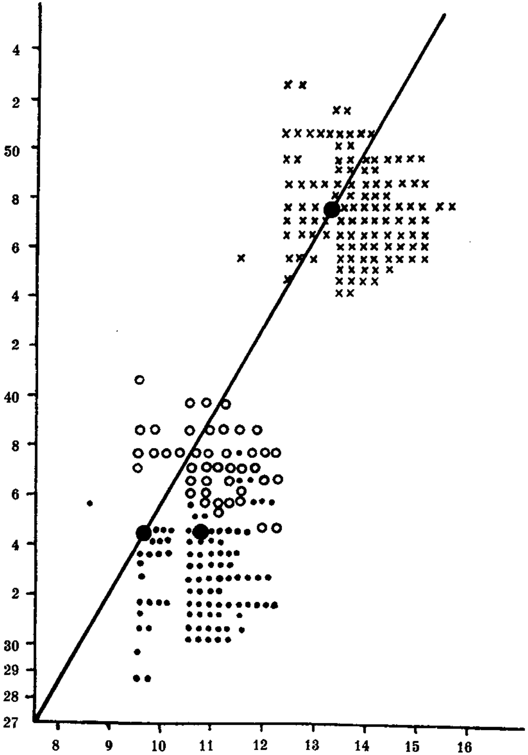

Fig. 25-2. Relations between a thick tarsal bristle length (abscissa) and total tarsal length (ordinate) of 2nd leg of cultured body lice (crosses), "wild" head lice (points) and cultured head lice (circles). Arbitrary units equal to 43μ each. (After Schöll, 1955.)

dent to those who have maintained colonies. A small number die with ruptured guts, so that the contents escape into the hemocoele; the cause is unknown. Some females seem to suffer occlusion of the oviduct (perhaps owing to intrusion of the cement used to fasten eggs) and become enormously swollen and die. First-stage larvae often find difficulty in feeding, even on bare skin; this may be more prevalent on some people than others and also on the part of the body chosen for the first meal.

Lice are virtually unaffected by arthropod parasites or predators; there is little evidence of significant mortality from microorganisms, even in crowded colonies.

It appears that the main population check is from the delousing operations of man. Buxton points out two characteristics:

1. Man does not act regularly, killing a small proportion daily; on the contrary, he selects a particular day for washing his shirt or taking some sort of drastic action. The mortality that he produces is exceedingly irregular.
2. On the whole, man's activity will be more intense as the population of lice rises, so that the mortality produced will tend to be a function of the density of population.

The second point must be beneficial to lice in the early stages of transfer to a new human host, since the transfer must presumably involve only a few specimens and represent a vulnerable period. On the other hand, there is another difficulty that very small groups of lice are liable to encounter in founding a new colony: the propensity of the offspring of single pairs to consist largely of individuals of one sex or the other. The reason for this is not known.

Survival Away from the Host

At Normal Temperatures

From eons of close associations with man, lice have become extremely dependent on his close proximity and, in contrast to many other blood-sucking arthropods, soon die from starvation or temperatures a little removed from optimum. This is illustrated in Figure 25-3, which also shows the narrow range within which eggs will hatch. From the combined data it is evident that infested clothing away from the host for a month could not possibly harbor living lice, even if long-surviving adults laid eggs just before dying. The period of complete extermination must normally be much shorter than this.

High Temperatures

For short exposures to high temperature, the most resistant stage of the life cycle is the egg (Fig. 25-3). But even eggs succumb after five minutes at 53.5°C or 30 minutes at 50°C. It is possible to delouse clothing or blankets by immersion in hot water (as for 10 minutes at 60°C). This is most inconvenient, since it demands facilities for drying the fabrics afterwards. The use of hot air presents the difficulty that the lice are mostly protected by layers of insulation. As a result, an exposure to still air at 70°C for an hour is necessary, though this period can be reduced by air circulation.

Low Temperatures

Louse eggs are also the most tolerant stage for exposure to low temperature. A temperature −20°C. for five hours or of −15°C for ten hours is fatal. But even longer exposures or lower temperatures are necessary to

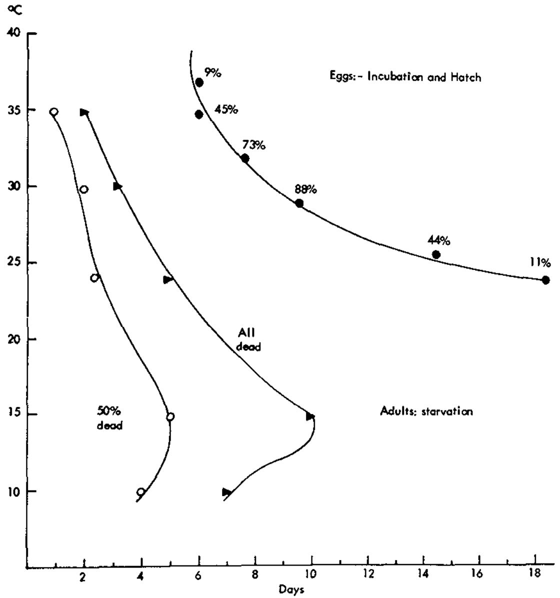

Fig. 25-3. Effects of environmental temperature on incubation period and hatch percentage, and on survival of adults without food. Data from Buxton (1948).

kill louse eggs protected by insulation, which render the method highly impractical for control purposes.

PTHIRUS PUBIS

Recent evidence of rising incidence in crab louse infestations[1,9] should draw attention to the scanty knowledge of the biology of this insect. Because it is unlikely to be an important vector of disease and because it is either unpleasant or else difficult to rear, there have been few studies of its bionomics. The most thorough was that of Nuttall;[14] his data were derived from small numbers. Payot[15] repeated and confirmed some of his observations. A graduate student at the London School of Hygiene and Tropical medicine added a few more data in his unpublished dissertation (Burgess, 1970).[3]

Anatomy and Habits

P. pubis mainly infests the pubic region, but can spread out over the trunk and legs and invade the axillae. Infestations on the head are rare and confined to the margins of the scalp, the eyebrows and eyelashes.

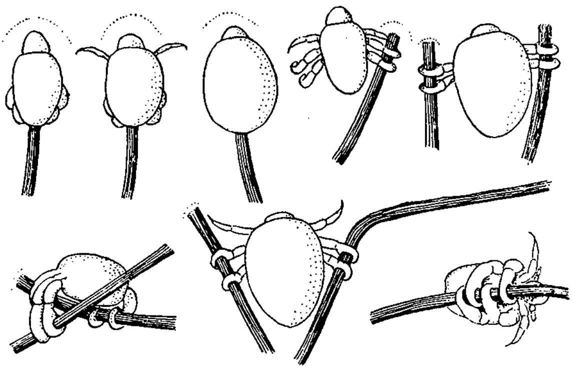

Fig. 25-4. First instar nymph of *Pthirus pubis* showing use of widely spaced legs in grasping pubic hairs. (After Nuttall, 1918).

The reasons for their choice of habitat seem to be anatomic, in that the claws on the last two pairs of legs are adapted for grasping widely spaced hairs (Fig. 25-4)

Pubic lice are more sedentary than body lice. Nuttall and Payot (*loc. cit.*) recorded maximum movements of about 10 cm. in a day. Body lice may wander as much as 35 cm. in two hours.[4] Transmission from one host to another is mainly during close contact (as in sexual contact) or perhaps rarely by fomites, which could explain head infestations in children.

Crab lice are generally considered to be highly specific to man, though Frye and Furman[11] record an infestation on a sheep dog which shared a bed with its master. No one has tried to rear experimental colonies on laboratory animals, which is curious, since Payot[15] notes that the insect could take blood meals from rats, rabbits, guinea pigs and dogs. Burgess[3] made preliminary attempts to feed *P. pubis* on blood covered with various membranes, with only moderate success.

Bionomics

Recorded observations on speed of development and longevity are assembled in Table 25-2. The usual complete life cycle is about three weeks (from egg to egg).

Table 25-2. Duration of Various Stages of the Life Cycle of *Pthirus pubis* (in days) According to Various Authors.

	Nuttall (1918)	*Payot (1918)*	*Burgess (1970)*
Egg, incubation	6 - 8	6 - 8	—
1st instar	5 - 6	7	5.0
2nd instar	4 - 6	5	4.25
3rd instar	4 - 5	4 - 5	4.2
Pre-oviposition	1 - 2	2 - 3	—
Adult life	17 - 22	c.28	—

Few data on oviposition are available. Nuttall kept a female which laid 26 eggs (maximum 3 per day); he considered that higher numbers would be normal in nature.

Survival Away from Man

Nuttall and Payot (*loc. cit.*) found that all stages died rather soon from starvation, when removed from man. Survival at 25-37°C. was only 9-11 hours in dry conditions, 10-14 hours in moist air. At 15°C. survival was prolonged to 24-30 hours in dry air and 40-44 hours in moist conditions.

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