THE BIOLOGY OF *PHTHIRUS PUBIS*.

By GEORGE H. F. NUTTALL, F.R.S.

(*From the Quick Laboratory, University of Cambridge.*)

(With 9 Text-figures.)

CONTENTS.

Introduction.

Most of what has been stated with regard to the main features in the biology of *Pediculus humanus* (see p. 82), likewise applies to *Phthirus pubis*. The habits of the latter species differ, however, in one particular which requires special mention, i.e. the insect is relatively immobile when upon the host, remaining attached and feeding for hours or days on one spot without removing its mouthparts from the skin into which it has bored them.

Geographical distribution: The available data regarding the distribution of *Phthirus* are few, and I shall be grateful to any readers who may communicate information to me on the subject. Van Beneden (1889, p. 126) is certainly wrong in stating that crab-lice have "only been found on white races," as the sequel shows:

Europe: Crab-lice occur apparently throughout Europe, but so far I have only seen examples from England, France and Germany. The following records relate chiefly to specimens received or examined by me. *Asia:* (N. 242) Nits taken from the eye-lashes of a Samper boy, aged 7, at Kasauli, India, 1917, by J. L. Mitter; the latter informs me that he failed to find the active stages. *Africa:* (N. 219)[1] from natives, Fort Jameson, N.E. Rhodesia, 1910, S. A. Neave; (N. 221)[1] ditto, from Zomba, Dr H. S. Stannus, and (E)[1] Blantyre, Nyasaland, 1910, Dr J. E. S. Old; (N. 220)[1] from axilla of *dog*, S.E. shore of Lake Nyasa, 1910, S. A. Neave; Mr Claude Fuller informs me that the species occurs in Natal. Mr W. M. Aders (I. 1918) writes from Zanzibar that crab-lice are rare among African negroes owing to their cleanly habits; they shave their armpits and pubes. They are found on negroes who allow their pubic hair to grow, and Mr Aders has taken them from various Indians including Parsees. *America:* (N. 74) from man, Baltimore, Md., U.S.A., 1885, G. H. F. Nuttall; (N. 227) ditto, New Orleans, La., U.S.A., 1917, M. B. Mitzmain; (N. 238) from man and *dog*, from Panama, 1917, C. B. Williams. Mjöberg (1910, p. 171) records crab-lice from Cuba. *Australia:* According to Nicoll (1917, p. 280), who was stationed at Townsville, Queensland, the species is common in Tropical Australia.

I. PREVALENCE AND MODES OF DISSEMINATION.

Prevalence on Man.

Reference has already been made to Greenough's statistics (p. 84) wherein ca. 3 per cent. of verminous persons admitted to hospital in Boston, Mass., were found to harbour *Phthirus*, this figure representing their relative prevalence only. I have been unable to discover any record of their incidence on a population as a whole. It has been stated that the insect is more commonly present on individuals leading an active sexual life, and this may be true, since in the opinion of those best competent to judge, in most cases, infestation takes place through coitus. Prostitutes of the lower class are considered by like authority to be the most commonly infested class. On the other hand, owing to

[1] Received from the Imperial Bureau of Entomology.

infestation occurring from man to man, as has frequently been observed in barracks, soldiers may very frequently become infested. Lieut. A. D. Peacock, R.A.M.C. (Ms. Report, I. 1918), among soldiers selected at random, found two out of thirty men of the R.F.A., and one out of twenty-five men of the R.A.M.C. to be infested with crab-lice. The occurrence of the parasites on old people and children is relatively rare.

Occurrence on other Hosts than Man.

To my knowledge *Phthirus* has not hitherto been reported as having been found on another host than man. I have two instances to record of its presence on the dog (see under geographical distribution, p. 384). In one case ten adults were collected from the axilla of a *dog* by Mr S. A. Neave on an expedition undertaken for the Imperial Bureau of Entomology. The number of parasites present in this situation on the dog renders it evident that the insect had found a fairly suitable habitat. The second case is that supplied by Mr C. B. Williams of the Agricultural Department, Trinidad, W.I., who kindly sent me a mounted specimen that had been found on a dog at Bocas del Toro, Panama. It would be of interest to determine if *Phthirus* can be raised experimentally upon the dog.

The Distribution of *Phthirus* on Man's Body.

The parasite is *usually confined to the pubis and peri-anal region* as common experience shows. It may, however, spread upward on the abdomen and breast and down the thighs, or it may become disseminated practically all over the body. Its spread is doubtless facilitated by scratching which may be unconscious or the reverse. Occasionally in young children, rarely in adults, the louse may be found localized upon the head, especially upon the *eyelashes*, eyebrows, more rarely on the scalp and then only along the margins of the hairy parts and occasionally in the beard. Linnaeus (1761, p. 475) states of crab-lice "Habitat in hominum immundorum pube et ciliis," and Fabricius (1775, p. 805) writes "Hospitatur in hominis immundi pube, rarius in superciliis." I append some case records culled from various sources:

Cases of General infestation in adults.

Woman, aged 23, active stages and nits present on the hair of the head about the occiput and on the temples, in the axillae and on the pubis (Waldeyer, 1900, pp. 494–9).

Woman, aged 22, many lice present on the pubis, in the axillae and on the head (Rona, *Monatsh. f. prakt. Dermatol.*, XXVI, 105). Patient in hospital, with lice on body and head (Dyer, *ibid.* p. 270). Both of these authors are cited by Waldeyer.

Arab, aged 45, lice very numerous on beard, moustache, eyelashes, eyebrows, head (a dozen being easily found). The lice appeared to be flourishing and plenty of nits were found in these situations (Brault and Montpellier, 1914, p. 78). A case of the kind is recorded apparently by Dyer (1897, p. 23).

Two cases, men in Dublin, generalized infestation including eyelashes and eyebrows, but none on the scalp (Knott, 1905, pp. 188, 189).

In 1915 I had occasion to examine several soldiers who were infested to a varying degree. One of them had active stages and nits present in hundreds all over his body excepting only his head, hands, and feet. The soldier was not unusually hairy. The lice and nits were found even on the back and sides of the trunk, etc., where the hairs were very far apart.

Cases of infestation confined to the head.

(*a*) Infants and young children:

Three cases, little girls, wherein the hair of the scalp was infested; in one the lice also occurred on the eyebrows. One of the girls, aged 7, bore 30 lice on the eyelashes, 10 on the eyebrows, many on the hairy margins of the scalp. All stages of development from nit to adult were found in these situations (Grassi, 1881, p. 433).

Three cases, children aged respectively 1½, 2 and 3 years, on whom nits occurred on the eyelashes only (Bleicher, 1882, p. 976).

Infant of 5 months, infested upon the eyelashes only, through its wetnurse (Trouessart, 1891).

Infant of 14 months, infested with many lice on the eyebrows, eyelashes and hair of scalp (Heisler, 1892).

Infant a few months old, the lice present in swarms on the head; had become infested through the mother. After the infested child had reposed for a short time in the same cradle with another infant, the latter's eyebrows became infested (Monier, 1892, *Rev. biol. Nord de France*, No. 6).

Boy of 5½ years, with lice upon eyelashes and head; the father found to be infested (Gallemaerts, 1893, *Journ. malad. cutan. et syph.*, p. 526).

Family consisting of a mother and five children aged 3, 5, 7, 9 and

12 years, all infested on the hairy scalp. The father was probably infested (Grindon, 1893)[1].

(*b*) Adults:

Man, aged 27, previously treated successfully for pubic infestation; the lice afterwards appeared on his eyelashes.

Man, aged 18, with lice on the eyelashes, head, and in axillae. (These two cases are described by Brault, 1906, p. 707.)

Woman, with normal hair, bore lice on the eyelashes, forehead and occiput, with maculae at the back of the neck. The active stages were found clinging very closely to the lashes of the upper lids only, the lashes being heavily charged with nits. With the exception of one nit found in the pubic region no lice or nits could be found elsewhere, but maculae were discovered on the abdomen (Fischer, 1910, pp. 115–118).

Furthermore, Railliet (1895, p. 828) cites Denny as having found crab-lice in the ears; an observation which appears to be unique as far as I can judge from the literature. Further instances of infestation of the head and eye-lashes by *Phthirus* will be found by reference to the following authors: Hooper, 1853, p. 354; Hilgenberg, 1854, p. 154; Stelwagon, 1881, p. 301; Hansell, 1883, p. 119; Ring, 1885, p. 647; Rosenmayer, 1886, p. 145; Schweinitz, 1888–9, p. 353; Jullien, 1891; Schwenk, 1891, p. 381; Schweinitz and Randall, 1891–2, p. 137; Burdin, 1892–3; Guyard, 1893–4; Marzocchi, 1908, p. 150 and 1910, p. 150. (See Bibliography.)

Infrequency of head infestation.

Crab-lice occur very rarely on the head (scalp and eyelashes) in adults. Fischer (1910, pp. 115–118) cites Jullien (1892) as having observed it but once in 50,000 cases of phthiriasis in adults. The eyelashes are more commonly infested in children and infants and in one-fifth of the cases the insects also occur on the eyebrows. It is not so easy to discern the active stages upon the eyelids and they may be overlooked; a clue to the presence of *Phthirus* in this situation is afforded by the nits on the lashes making these appear dusty. Harkness (cited by Fischer) believes that the lice spread from the body to the head, and Blaschko is stated to have seen this occur. Pinkus (1915, p. 239), in a six years' practice among Berlin prostitutes, but once observed crab-lice on the scalp hair at the back of the neck; only two nits were found, the lice disappearing after two days.

[1] The cases cited, beginning Trouessart and ending with Grindon, are abstracted from Waldeyer (1900, pp. 494–9), and Dubreuilh and Beille (1895, p. 133).

Why does Phthirus infest the head so rarely?

In view of the frequency with which man harbours crab-lice it is of interest to find an explanation of why it so uncommonly infests the head. According to Waldeyer (1900, p. 496), this cannot be due to the influence of light, for the lice may occur on the eyelashes and eyebrows. It cannot be due to the odour of the secretions about the genitalia and axillae being more attractive (Fischer, 1910, p. 118), because the insects occur elsewhere on the trunk and limbs. Waldeyer advances the reasonable hypothesis that the site of parasitism is determined by the distribution of the hair on the skin, although he believes that the insect perhaps finds it easier to cling to the flat crinkled hair of the pubis and axilla than to the hair of the head which is finer, straighter, and round or oval in cross section. As Wihofe found, the number of hairs upon a square $\frac{1}{4}$ inch of scalp averages 223, whereas there are but 34 hairs upon a similar surface of pubic skin. Waldeyer's enumerations show that the number of hairs on the head is 6–10 times greater than upon the rest of the body. *Phthirus* does not run about like *Pediculus humanus*, its legs, when stretched apart, span a distance of 2 mm. and this indicates that it will best cling to hairs that are further apart than on the head. The distance between the hairs of the head is about 1 mm., whereas the body hairs occur 2 or more mm. apart. Waldeyer believes that *the distance between the hairs on the skin is the factor which governs the distribution of Phthirus upon man's body.* This also explains why the insect, when present on the head, occurs in situations where the hairs are sparsest.

From what I have observed of the behaviour of crab-lice on the body, I believe that Waldeyer's explanation is correct. I would note, however, that whereas the adults and larger larvae are usually found clinging to two hairs, each hair being grasped by the legs of one side only, the first stage larvae often cling to a single hair with the legs of both sides (see p. 401). Under such circumstances the young larva feeds best when grasping a thick hair, because it can hold it more firmly and it affords better support. I have seen a larva try in vain to feed whilst anchored to a thin hair, whereas it succeeded at once in doing so when transferred to a thick hair.

Mode of Dissemination and Infestation.

Although the crab-louse is usually spread by coitus, there appear to be many exceptions to the rule. As the evidence of the occurrence of the parasite on infants indicates (see cases cited on p. 386), the insects

may be innocently acquired; the infants, or a whole family of small children may become infested through a verminous mother, father, or other adult, or the parasite may be transmitted from child to child. Similarly, when persons live in close contact with one another, as soldiers do in barracks or billets, there is no question again but that infestation may arise innocently.

A certain number of insects become scattered through the frequent scratching that accompanies infestation, so it is possible for an individual to become infested through contact with clothing, bedding, the seat of the W.C., and possibly public vehicles and benches, and there is no doubt but that this occurs more often than is generally supposed. Apart from direct personal contact then, the parasite may be spread indirectly.

In the course of my experiments, I several times observed *the shedding of single hairs bearing freshly laid eggs*, and it therefore appears to me that this probably constitutes the more frequent mode of dissemination, although it has hitherto been completely overlooked. Any adult person can convince himself readily that pubic and body hair is shed under ordinary circumstances, by examining the floor of the tub in which he has bathed and from which the water has drained away. These hairs are continually being shed upon the underclothes, and they are more plentifully shed in the act of coitus or through scratching. It therefore needs little imagination to understand how the parasite can be conveyed either directly from person to person, or indirectly by means of shed nit-bearing hairs which may become entangled in the pubic or other hair of a clean individual.

Whereas the nit, and usually the first stage larva during the first day or two after hatching, is found attached to a single hair, the active stages cling as a rule to the bases of two hairs, therefore it is less likely that the older lice will become detached when the hair is shed, although it is of course possible that older larvae and adults may occasionally be set free.

Again, owing to its much greater structural adaptation to a parasitic life than is the case in *P. humanus*, the crab-louse is a very helpless creature when it is removed from the hair to which it normally clings. If placed upon cloth or any surface devoid of hair, it can make practically no progress. If a hair is brought near it under such circumstances it at once grasps it firmly. Under natural conditions it clings continuously to hair, shifting from hair to hair when disturbed, without relaxing its hold upon one hair before seizing the next. To detach the crab-louse without injury, it is necessary to slide it along the hair from base to

apex, the grasp of the individual legs being comparable to that of a threaded needle whose eye is incomplete. Direct efforts to pull the insect away may result in a leg or two being torn off, the limb being left clinging to the hair. That such maiming takes place in nature is evident from specimens I have collected[1].

The accompanying illustration (Fig. 1) shows that the front legs of *Phthirus* are relatively feeble and sharp-clawed, the second and third leg-pairs being on the contrary stout, their claws terminating in a

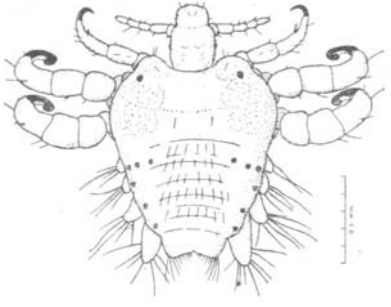

Fig. 1. *Phthirus pubis* ♀, dorsal aspect.

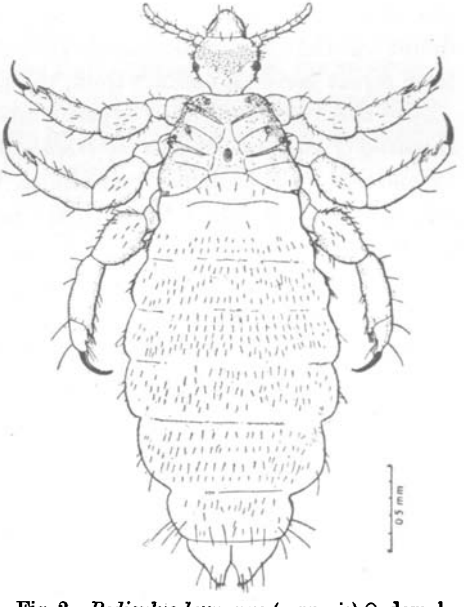

Fig. 2. *Pediculus humanus* (*corporis*) ♀, dorsal aspect.

rounded knob. The difference between *Phthirus* and *Pediculus* in respect to the leg structure will be seen at a glance by comparing Figs. 1 and 2 in which I have shown the claws in black. The sharp and less incurved claws of *Pediculus* explain why it can progress readily on hairless surfaces, and the corresponding structures in *Phthirus* show why it is so helpless when removed from hair, the four hind legs being adapted solely for locomotion on hair, whilst the feeble first leg-pair play a very inconsiderable part in progression. In short, the crab-louse, as its

[1] In a maimed specimen (♀ D) that was raised experimentally, two lost legs (pairs I and II) were not regenerated during metamorphosis from the (injured) second stage larva to adult.

anatomical structure would indicate, is more prone to be disseminated passively than is *Pediculus*.

The fact that *Phthirus* in most cases remains confined to the pubic region already proves that it does not tend to wander actively. This tendency to remain localized upon a limited area of the host's skin is well exemplified in the graphic records (Figs. 7 and 8) relating to a couple of insects raised by me experimentally, neither of them in the course of their active lives wandering beyond the borders of a rectangle of skin measuring 16 × 10 cm.

II. METHOD OF RAISING *PHTHIRUS* EXPERIMENTALLY.

Having failed to find any evidence in the literature that crab-lice have hitherto been raised experimentally, I append a brief description of the method that was employed by me successfully.

Hairs bearing single nits were removed from an infested soldier, and the nits were examined microscopically to see that they were suitable for experiment. After trying to let them hatch upon the leg by tying the nit-bearing hairs to leg-hairs, it was found more satisfactory to allow the eggs to hatch in a tube carried next to the skin in the inguinal region, the young larvae, as they emerged, being transferred to the base of a hair on the leg by means of a camel hair brush. The latter procedure was preferred because the nits were found to slip off the cut hairs when the first method was employed and the larvae often became entangled in the stocking and died without having fed. On the other hand, when the lice were carefully placed near the base of a hair so that their heads were directed toward the skin, the young larvae transferred from the tube, at once proceeded to feed and gave no further trouble. As newly emerged unfed larvae were found to die or grow feeble in a few hours after emergence, the tube in which the eggs hatched was therefore subjected to frequent inspection so that the larvae should be placed on the leg as soon as possible after hatching out.

The larvae, having been allowed to anchor themselves, the leg was covered by a closely woven black cotton stocking that was held in position by two garters placed above and below the knee. The exact spot where each insect anchored was charted by means of fixed points marked on the skin, a pair of compasses being used to register the spots on a daily record sheet. In this way the development and movements of each insect could be followed, the leg (my Laboratory Assistant's) being examined one or more times a day as occasion required, a hand

lens or binocular microscope being used for observing the insects. We thus raised *Phthirus* through its life-cycle[1]. By employing a small number of insects of different ages, and observing them closely, there was no difficulty in identifying the individuals.

When the females began to oviposit, the eggs that were laid successively were marked by coloured inks and entered on the day chart, it being thereby possible in each case to determine accurately the length of time required for hatching. Occasionally the nit-bearing hairs were shed, or the larvae fell away from the skin and died upon the stocking, but, on the whole, the failures were few. As the charts (Figs. 7 and 8) show, *Phthirus* usually wanders little from the point where it first fixes itself on emerging from the egg. It stays on the same small area throughout its life. Doubtless the scratching of the skin by the host, as it occurs in nature, will tend to make the insect wander further afield, and the increasing population will thereby become somewhat scattered. There was no tendency to wander upward on the leg. The male that was raised to maturity became detached twice and gravitated downward on the leg, whence it was transferred to a spot near the females.

III. SPECIAL BIOLOGY OF *PHTHIRUS*.

Proportion of the Sexes on the Host.

In this connection I have but one observation to record. A total of 232 adults collected by me from a soldier, comprised 88 males and 144 females, i.e. the sexes were represented roundly in the proportions 38 per cent. male and 62 per cent. female. This is in remarkably close accord with Hindle's figures (40 per cent. male and 60 per cent. female) for *P. humanus* of which he raised 944 specimens to maturity (see p. 114). The three *Phthirus* raised by me were one male and two females. Further observations are required to establish the sex ratio, but so far the indications are that the females predominate.

Copulation.

The process of copulation is somewhat similar to that in *Pediculus*. On several occasions, when the hairs in the vicinity of a female were touched, I observed that, whilst continuing to feed, she raised her abdomen in a manner recalling the movement of *Pediculus* females

[1] Major Howlett has since informed me that he has also raised *Phthirus* on his leg and that of his assistant in India, likewise employing a stocking.

on the approach of a male. Once, when the stocking was removed, a pair were found to have apparently been disturbed in the act, for the male was found with the forepart of his body beneath the female. The latter was clinging to two hairs and feeding in the usual way, but her abdomen was raised, whilst the male rested freely upon the skin between the hairs, with the end of his abdomen turned upward. Three days later, Dr Keilin witnessed the act and made a rough sketch of the pair in copula. From this sketch, with the aid of specimens, I have attempted to represent what was observed in the accompanying illustration (Fig. 3). The male was almost hidden by the superposed body

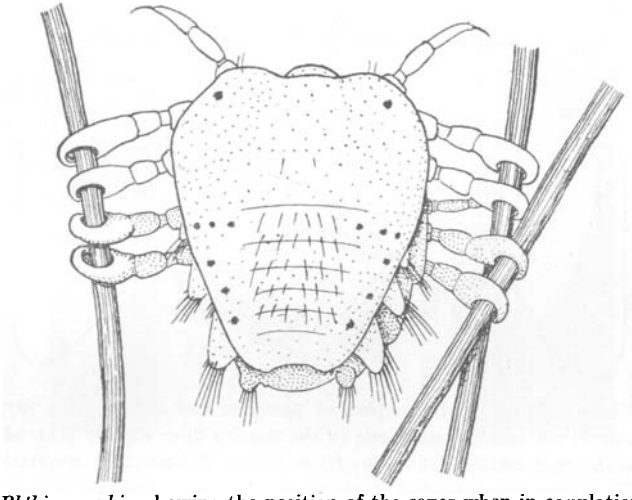

Fig. 3. *Phthirus pubis*, showing the position of the sexes when in copulation, the female being uppermost. The male grasps the hair behind the female and, contrary to *P. humanus*, does not seize her legs.

of the female. The posterior end of the male was bent upward but the copulatory organs could not be distinguished, therefore no attempt is made to represent them in the figure. Whilst the female grasped two parallel hairs, the male grasped but one of them, he grasped a third hair with his opposite leg-pair. In neither insect did the first leg-pair appear to perform any duty. The act was completed in ten minutes.

Whilst a description of the genitalia of *Phthirus* is deferred for consideration in the section on anatomy, I would note the salient feature wherein copulation differs in this species and *Pediculus* (see *Parasitology*, IX. 293). The *Phthirus* male does not grasp the female's legs, his first leg-pair are weak instead of strong and they appear to perform no

function in copulation; he seizes the hair or hairs, to which the female likewise clings, with his two hind leg-pairs thereby gaining the necessary support which enables him to keep the female in position, her mouth-parts being the while fixed in the skin.

The male we raised tended to wander further afield than the two females, which suggests that he wandered in search of females; he fertilized the only two to which he had access, one of these being maimed in two legs. The latter was killed and dissected six days after ecdysis, and the neck of her flask-shaped receptaculum seminis was found packed and dilated with a mass of spermatozoa.

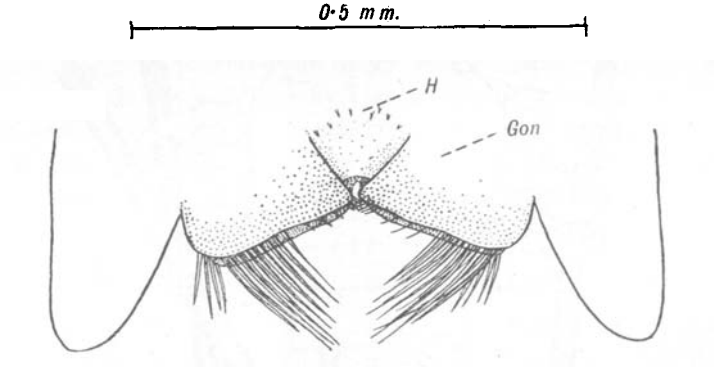

Fig. 4. *Phthirus pubis* ♀, ventral aspect of posterior end of abdomen showing (*Gon*) the gonopods converging posteriorly in the median line; slightly protruding behind them is the postero-dorsal margin of the body. Between the gonopods is (*H*) a spoon-like hollow bearing a few short spines. The hair, during oviposition, slides in the hollow between the gonopods. Compare the structures with those of *Pediculus* (p. 120, Fig. 4).

Oviposition.

The process of egg-laying has not actually been observed by me. The female *Phthirus* (see Fig. 4) possesses gonopods of a different form to those of *Pediculus*; they consist of two short, broad-based processes bearing hairs posteriorly and they cannot surround a hair so completely as do the gonopods of the other species. These structures are figured by Landois (1864 *a*, pl. III, fig. 5, postero-ventral part of abdomen of female) but their function has not hitherto been understood. Were it not that I had demonstrated the use of the corresponding, more highly developed structures in *Pediculus*, it would be difficult to explain the purpose of the somewhat reduced organs in *Phthirus*.

Since the mode of attachment, very close to the hair-base, and the orientation of the egg are similar in both species, it is certain that the process of oviposition must be similar in essential particulars (see *Pediculus*, p. 118). The difference in the form of the cement mass that characterizes the eggs of *Phthirus* and *Pediculus* (compare Figs. 5 and 6) is, in my opinion, doubtless attributable to the form of the gonopods in the respective females, this being a subject perhaps worthy of further study. As in *Pediculus*, usually but one egg is laid upon a hair, about 0·5 mm. from its base, but the eggs may be laid in succession on one hair, a dozen or more not uncommonly being present where the infestation is heavy.

Fig. 5. *Phthirus pubis* egg on hair, lateral aspect.

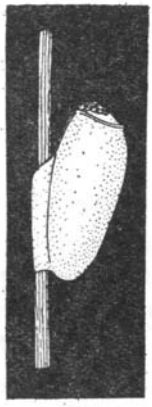

Fig. 6. *Pediculus humanus* (*corporis*) egg on hair, lateral aspect (ca. 1 mm. long; drawn to the same scale as Fig. 5).

The number of eggs laid by a female is stated to be 10 by Giebel (1874, p. 26), 10–15 by Blanchard (1890, p. 443) and Railliet (1895, p. 828), but there is no mention of whence these figures are derived, although they are frequently quoted by various authors. Possibly the statements are based on guesswork.

It is certain that *Phthirus* (as with *Pediculus*) lays many more eggs than has hitherto been supposed. One female that I raised laid 26 eggs, and I suspect that she died prematurely. It would not surprise me to learn that a female may lay 50 eggs or more, but further experiments are required to determine what is the full complement. The maximum number of eggs laid by a female per day was three.

Hatching.

The period required for the hatching of the eggs is given as 6–7 days by Blanchard and Railliet (*loc..cit.*), as 6 days by Brumpt (1910, p. 550).

Of nine eggs laid on my Assistant's leg, beginning 25. v. 1917, and of which accurate records were kept, six hatched in 7 days and three in 8 days. Of ten eggs of undetermined age removed from a patient and carried in a tube against the skin of the groin, five emerged in 7–8 days, none subsequently.

Influence of temperature on hatching.

Very poor results attended my efforts to hatch out eggs in the thermostat at 30–32° C., owing to there being a large percentage of deaths, even when the air was kept damp. Marzocchi (1913, p. 314), who observed hatching under these conditions, adds that he obtained negative results at 18–20° C. The influence of temperature of *Phthirus* is therefore in accord with what has been stated for *Pediculus* (see p. 143).

Developmental changes in the egg and mode of emergence.

These are essentially the same as in *Pediculus* (*q.v.*); the much less transparent egg-shell in *Phthirus*, however, considerably impedes direct observation.

Development from Larva to Adult.

Fifteen days is stated to be the period required according to authors (Blanchard, Railliet, Brumpt, *loc. cit.*) but none mention the number of moults that occur.

Timed from the hatching of the first stage larva (Day 1) my observations gave the following results:

	Moult occurred overnight between days			
	♂	♀	♀	
1st moult	5–6	5–6	5–6	2nd stage larva emerged
2nd „	9–10	11–12	11–12	3rd „ „ „
3rd „	13–14	16–17	15–16	Adult emerged.

It is noticeable that the last two moults took place earlier in the male than in the females. The males in *Phthirus* are usually smaller than the females.

The process of *moulting* is similar to that in *Pediculus*, the old skin showing corresponding lines of cleavage. The cast skin remains clinging to the hair in the same manner as the living insect.

Record relating to the development of a male and female *Phthirus* from the egg to the adult stage, and ending with their death.

5. v. 1917 Day	MALE (see Fig. 7)
1.	Emerged as *1st stage larva* before 8.30 a.m. Placed at base of single hair at 10.30 a.m. and started to feed at once.
2.	Had not moved, body swelling.
3.	,, ,, ,,
4.	,, ,, ,,
5.	,, ,, appeared somewhat shrivelled.
6.	Moulted to *2nd stage larva*, shifted 15 mm. Now and henceforth grasping two hairs with its hind leg-pair.
7.	Shifted 45 mm.
8.	Had not moved.
9.	Shifted 14 mm.
10.	Moulted to *3rd stage larva*, shifted 4 mm., wandering.
11.	Shifted 9 mm.
12.	,, 5 ,,
13.	,, 6 ,,
14.	Moulted to *adult*, shifted 9 mm.
15.	Had not moved at 8 a.m., but by 11.30 a.m. had shifted 50 mm. up leg. Appears well fed, body dark, ca. 1·2 mm. long, claws of hind leg-pair 2 mm. apart.
16.	Had not moved.
17.	Shifted 100 mm., wandering down leg on stocking, transferred up to near ♀ B.
18.	Had not moved.
19.	Shifted 34 mm. Copulated 19–20th day? with ♀ B.
20.	,, 51 ,,
21.	,, 8 ,, [1st fertile egg laid by ♀ B.]
22.	,, 15 ,, [1st egg laid by ♀ D is infertile.]
23.	,, 26 ,,
24.	,, 40 ,, Found wandering, put near ♀ D. Sides of male's body greenish
25.	,, 9 ,,
26.	,, 8 ,, Beneath ♀ D. copulated?
27.	,, 29 ,,
28.	,, } 35 ,, Copulated with ♀ B.
29.	,, }
30.	,, 5 ,,
31.	,, 10 ,,
32.	,, 3 ,,
33.	,, 4 ,,
34.	Had not moved.
35.	,, ,, Found dead; had lived 22 days as adult.

7. v. 1917 Day	FEMALE (see Fig. 8)		
1.	Emerged as *1st stage larva* at 11 a.m. 5 p.m., anchored on one hair and fed at once.		
2.	Had not moved, body swelling.		
3.	,, ,, ,,		
4.	,, ,, ,,		
5.	,, ,, ,,		
6.	Moulted to *2nd stage larva*, shifted 29 mm.		
7.	Had not moved.		
8.	,, ,,		
9.	Shifted 20 mm.		
10.	Had not moved.		
11.	,, ,,		
12.	Moulted to *3rd stage larva*, shifted 11 mm.		
13.	Shifted 3 mm., body flat, ca. 0·75 mm. long.		
14.	Had not moved.		
15.	,, ,,		
16.	,, ,,		
17.	Moulted to *adult*, shifted 40 mm., ca. 1·5 mm. long.		
		No. of eggs laid	
18.	Shifted 10 mm.	0	
19.	,, 10 ,,	1	
20.	,, 40 ,,	2	
21.	,, 3 ,,	1	
22.	,, 20 ,,	2	
23.	,, 33 ,,	3	
24.	,, 59 ,,	2	
25.	,, 13 ,,	3	
26.	,, 53 ,,	2	
27.	,, 89 ,,	3	Sides of ♀ B's body greenish.
28.	,, 22 ,,	2	
29.	,, 15 ,,	1	
30.	,, 17 ,,	2	
31.	Had not moved	2	
32.	,, ,,	0	
33.	Found dead; had lived 17 days as adult	26	Total eggs laid by ♀ B.

N.B. The movements having been recorded but once in 24 hours, the chart naturally does not represent all the changes of position that took place. When it is stated that the insect "shifted" a certain distance, the measurement is given arbitrarily in a straight line from the last point of attachment to the new, irrespective of the wandering that took place from point to point. That such meanderings took place is evident from the female's chart, wherein the position of the eggs laid on hairs in a hypothetical order is denoted by clear circles as opposed to black spots denoting anchorages. (See charts, next page.)

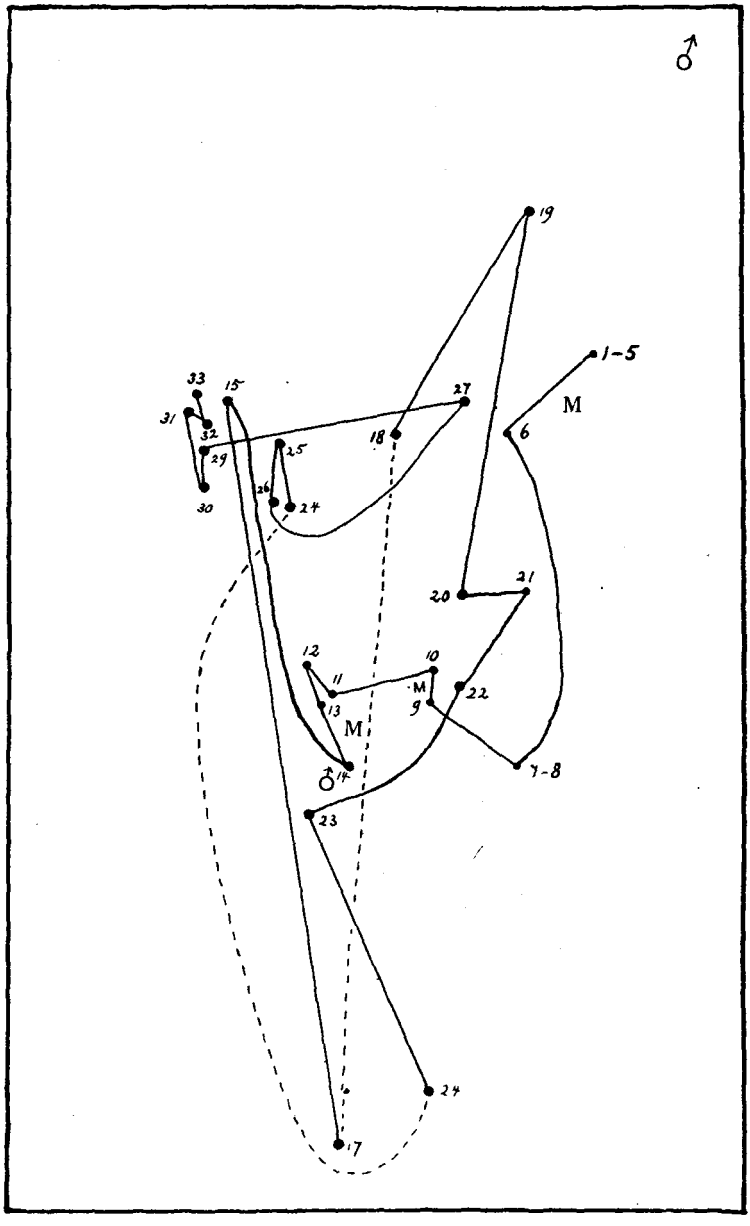

Fig. 7. Chart showing the positions occupied on successive days by a *Phthirus* ♂, from the day it hatched out and anchored itself as a first stage larva (Day 1) until it died (Day 33). The black spots denote the anchorages, M the three successive moults ending in ♂ where it became adult. The dotted line shows where the male was transferred higher up the leg. The quadrangular contour indicates the actual area of skin in which the movements took place (natural size). The movements of the female in the identical area are recorded in Fig. 8.

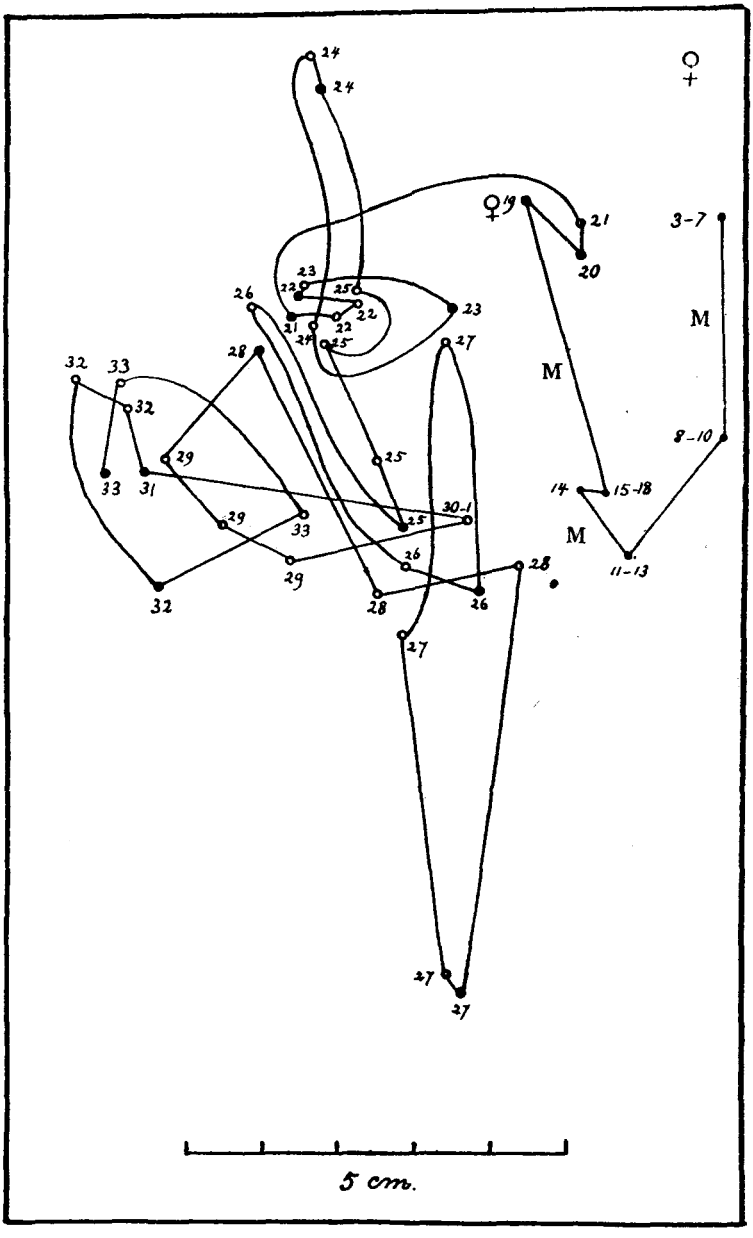

Fig. 8. Chart recording the movements of a *Phthirus* ♀ in the same way as described for the male in Fig. 7. To make the day-numbers synchronize, the female having hatched two days after the male, her day of emergence as a first stage larva is charted as Day 3 (instead of Day 1), and the day of her death is given as Day 33 (instead of Day 31). The numbers therefore correspond in point of date in both charts and the relative positions of the sexes can be compared on any given date. The *open circles* (°) along the track of the female denote where *eggs* were laid at the bases of hairs.

Duration of the Life-cycle.

Judging from my two reared females, the life-cycle is completed in 22–27 days made up as follows:

Hatching takes	6– 8 days
Development to adult	15–17 ,,
Pre-oviposition period	1– 2 ,,
Life-cycle completed in	22–27 days = Egg to egg period.

This affords no support to the assertion of Piaget (1880, p. 630) that *Phthirus* "seem to reproduce more rapidly than pediculi," on the contrary, in *Pediculus humanus* (*corporis* and *capitis*) raised by me on the body, the cycle was completed in 16–17 days (see p. 161). It is conceivable, however, that the life-cycle of *Phthirus* may be completed somewhat more rapidly on the pubis than on the leg.

Longevity.

(*a*) Unfed, in vitro.

On dampened pubic hair placed in a corked bottle that was carried in the pocket near the body, Marzocchi (1913, p. 314) found that the insects mostly died in 10–12 hours. They died more rapidly in open vessels exposed to light. Although Galli-Valerio (1913, p. 501) states that *Phthirus* died in two days at 20° C., it appears to me probable that they died sooner than he records.

The following experiments were made by me with adults and large larvae that were kept in the dark.

Lot collected on	No. of lice tested	Conditions in vitro	Result
1. viii. 15, 1 p.m.	20	16° C. moist	3/20 alive after 20 hrs.
,, ,,	20	16° C. dry in room	all dead ,, 20 ,,
2. viii. 15, 3–4 p.m.	200	30° C. moist	,, ,, 20 ,,
,, ,,	hundreds	20° C. dry in room, damp weather	2 dead after 17 hrs. 8 alive after 26½ hrs. all dead ,, 42½ ,,
		20° C. moist	many feeble in 17 hrs. 1 moving after 26½ ,, all dead ,, 42½ ,,
		20° C. very moist	2 dead after 17 hrs. 1 moving after 26½ hrs. all dead ,, 42½ ,,
3. viii. 15, 4 p.m.	many	20° C. dry	,, ,, 19½ ,,

(*b*) When fed.

Of the two specimens I raised experimentally, the male lived 22 days, and the female 17 days, as adults. The insects will doubtless live longer.

Feeding Habits.

When a newly emerged larva is placed upon a hair, close to its base, it immediately punctures the skin and proceeds to feed. It differs in its feeding habits from *Pediculus*, for it remains for days upon the same

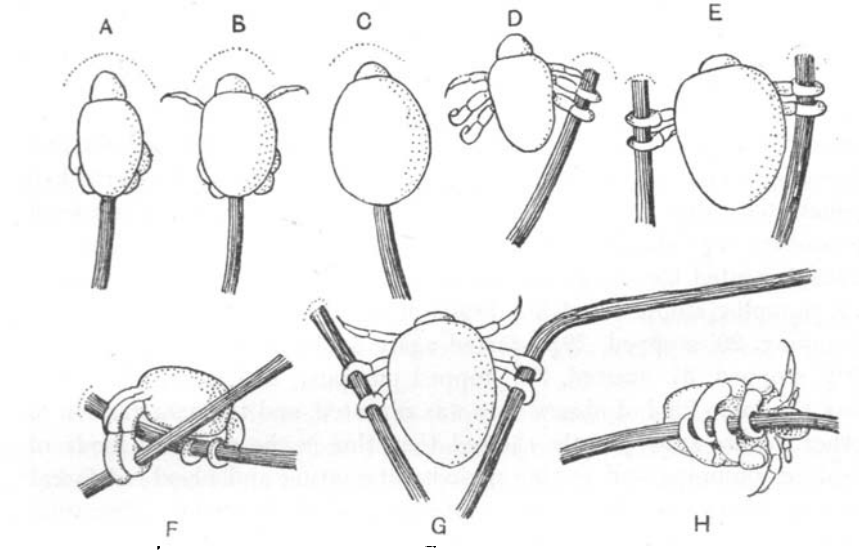

Fig. 9. *Phthirus pubis*, larvae of the first stage. A–D grasping a single hair, E, F, G, grasping two hairs; all of them drawn from life in the act of feeding. H, ventral aspect of larva killed by immersion in alcohol and mounted in balsam; it shows the manner of grasping a hair. A and B represent the same larva when respectively one and two days old, C another larva three days old, E and G others four days old, D is one day old, and F two days old grasping crossed hairs. G shows how a hair, whose root is at some distance, is bent by the insect's grasp. E shows the usual position in all stages when grasping two hairs. The arched dotted line indicates the border of the hair-pit in some instances.

spot without appearing to withdraw its mouthparts, whilst a microscopic examination shows that it pumps blood intermittently at frequent intervals. On one occasion only did I find an insect with its mouthparts withdrawn, but they were soon reintroduced. During the first day, or for two or more days, the young larva as a rule grasps but a single hair with its four strong posterior legs (see Fig. 9), whilst its body gradually

swells. After this it may extend its legs so that it comes to grasp two hairs with the legs of each side as the later stages almost invariably do. The larva moults in situ and then shifts its position a short distance, and immediately resumes feeding. The following stages behave similarly. It is relatively uncommon to find the insects wandering excepting immediately after a moult; or after they attain sexual maturity, and even then they are usually found feeding. Gorging, as observed in *Pediculus*, is never seen in the crab-louse. Two tusk-like, retrograde processes, situate antero-laterally and ventrally upon the head, serve as an additional means of fixation of the mouth-parts to the skin, such processes being absent in *Pediculus* which feeds rapidly.

As an example of the manner of feeding, the following record may be cited. It relates to a hungry adult which I placed on my arm and observed microscopically. Its pharyngeal pump was seen to act and blood appeared in the gut diverticula 8′ after the mouth-parts had penetrated; after 11′ a blood droplet issued from the anus. The record proceeds: 18½′ stopped pumping, 21′ pumped, 23′ stopped pumping, 24′ inspissated blood issued from the anus and pumping recommenced, 25′ pumping stopped and five beads of blood were voided, 27′ started pumping, 29′ stopped, 29½′ started again and voided a drop of blood, 30½′ stopped, 37′ started, 38′ stopped pumping, and so on. The next day the same kind of observation was repeated, and the examination of other insects subsequently showed that this is the ordinary mode of feeding, pumping and resting periods alternating and blood-red faecal matter being voided at short intervals. This frequent defaecation renders their surroundings very filthy in a short time. Their filthiness in this respect is much more observable than in *Pediculus* because defaecation is so localized. Merely because the faeces are more scattered, *P. humanus capitis*, relatively speaking, appears to produce less evident filth, whilst *corporis*, favoured by its retreats in the clothing, ranks third in this respect.

The habit of what practically constitutes continuous feeding which characterizes *Phthirus*, sufficiently explains why it dies so quickly from hunger and drought when removed from the host.

Reactions to Light and Heat.

On short exposure to light, when feeding, *Phthirus* frequently shows signs of restlessness, but it does not release its hold and wander away. As Howlett (1917, p. 188) showed, the insects are little affected when a

tube containing hot water is brought near them whilst feeding, but otherwise they "become greatly excited and move with remarkable eagerness and rapidity," and if placed on their backs on a table and a hot tube approaches them, their "wild efforts to reach it attain an intensity which is almost pathetic."

Although the pubic and peri-anal and axillary regions are the sites of selection for its parasitism, there is no evidence that these habitats are chosen because of their higher temperature and moisture. The selection of these regions seems to depend only upon the character of their hairiness.

SUMMARY AND CONCLUSIONS.

Although *Phthirus pubis* occurs in Europe, Asia, Africa, North America and Australia, and is found on negroes as well as whites, as herein recorded, further data are required relating to the geographical distribution of the species and the races of man it infests.

The crab-louse occurs less frequently on man than does *Pediculus* and appears to be parasitic chiefly on persons leading an active sexual life. It has, so far, only been twice recorded on another host than man, i.e. the dog.

Whilst the crab-louse is usually found confined to the pubic and peri-anal region, it frequently spreads upward upon the abdomen and breast, and may infest the axillae severely, or it may spread downward along the thighs. Generalized infestation is rare, in such cases only the hands and feet are spared, although the head and neck are as a rule also free from parasites. The crab-louse has occasionally been found localized upon the head in infants, being either confined entirely to the eyelids, the nits being encountered on the eyelashes, or occurring also upon the eyebrows and hairy portions of the scalp. In adults, the parasite occurs much more rarely in these situations; a case is recorded of an Arab in whom, in addition, the beard and moustache were infested. Such cases are rare in children, very rare indeed in adults.

Apparently the head is so rarely infested because it is less suitable as a habitat. As Waldeyer points out, the head is probably not a suitable habitat because the scalp-hairs are crowded close together and finer than on the pubis and in the axillae. The majority of the active stages are found clinging to two hairs on the regions of the body they most infest, and where the hairs are sparser than on the head. In these parts, the hairs are 2 mm. or more apart. The reach between the extended two

hind leg-pairs of the adult insect is about 2 mm., these legs being the ones that are used for grasping the hair.

Whilst infestation usually takes place through coitus, there are many exceptions to the rule as proved by the occurrence of crab-lice on infants. The latter may become infested by their parents or other adults. The insect may pass from one infant to another through their sharing a cradle, or it may pass from soldier to soldier when crowding occurs in barracks or billets. Scratching of their persons by infested individuals no doubt aids in the spread of the parasite upon them and the dissemination of the insect further afield. Both the act of coitus and scratching promote the shedding of hairs, and these, when bearing nits or young larvae, may be of considerable importance in disseminating the parasite. Such hairs, and no doubt occasionally active stages of the louse, are shed on clothing, bedding, the seat of the privy, etc., and readily become entangled with the pubic or other hair of clean persons who may come in contact therewith. A detached louse promptly clings to any hair with which it comes in contact. Therefore, whilst *Phthirus* is commonly conveyed directly, it may also be acquired indirectly. It is a helpless creature when removed from the hair to which it clings continuously upon the body, where it moves about by shifting from hair to hair; it is therefore much more likely to be conveyed passively from host to host than is *Pediculus*.

Unless disturbed, the parasite remains confined throughout its life to a limited area upon the host's skin as I have demonstrated experimentally.

The females appear to preponderate over the males in number when upon the host, their relative proportion being about 3 : 2. In copulation, the male does not seize the female as in *Pediculus*; he seizes the hairs to which the female clings, using these as a support. Oviposition occurs as in *Pediculus*. A female that was raised experimentally, laid up to three eggs per day, laying a total of 26 eggs. The hatching period (on the leg) lasted 7–8 days. Like *Pediculus*, the crab-louse passes through three moults (there being as many larval stages) before it attains sexual maturity. When the adults are about 10 days old they exhibit to a well-marked degree the greenish coloration of the fat-body which is seen by transparency at the sides of the abdomen in the living insect. The life-cycle, from egg to egg, is completed in 22–27 days (on the leg).

Young unfed larvae usually die within ten hours of emergence. When removed from man, they survive longer at 16–20° C. than at 30° C. and die much more rapidly in a dry than in a moist atmosphere;

none of the numerous lice of all stages that were tested were found to survive up to 42½ hours, when maintained under different conditions. Living on man a male survived 22 days, a female 17 days, but the insects can doubtless live longer.

The feeding habits of *Phthirus* recall those of Ixodidae in being practically continuous, and, like *Boophilus*, they stop feeding to moult upon the host. After moulting they promptly proceed to feed again, shifting but slightly to a fresh feeding ground. On emerging, the young larva clasps a single hair and feeds at its base, and after a day or more it may clasp two hairs as the later stages do usually. The habit of continuous feeding explains why the insects die so quickly when removed from the host.

Whilst a brief exposure to light renders the insects restless but does not cause them to wander away whilst feeding, a warm body brought within their sphere promptly produces great activity in *Phthirus* when it is removed from man.

REFERENCES.

See Bibliography, pp. 1 *et seq.*, and supplementary Bibliography to follow.

CORRECTIONS.

p. 44, lines 1–3. *Delete* the passages ", as the investigations.....latter disease," and *substitute* "Typhus." [The investigations of Sergent on relapsing fever did not inspire Nicolle's researches on typhus. The deleted passage was written by me under a misapprehension.]

p. 173, lines 4–5. *Delete* ", possibly those of Bacot,"