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LICE AND THEIR MENACE TO MAN

LIEUT. LL. LLOYD, RAMC(T)

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LICE AND THEIR MENACE TO MAN

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FIG. 1.—*PEDICULUS HUMANUS* VAR. *CORPORIS*. Adult female. ($\times 45$.)

LICE

AND

THEIR MENACE TO MAN

BY
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WITH A CHAPTER ON TRENCH FEVER

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PREFACE

THIS book is intended for the general reader rather than for the specialist, and its chief purpose is to introduce the main facts concerning the lice of man which have been brought to light in the last few years. It is somewhat amazing that, though the louse lives in a closer association with man than any other insect does, it should still be the subject of so much erroneous information. Even those who should have been best informed knew little of its detailed habits, when the hardships of war made it so necessary that means should be devised for combating it. To-day we are in a much better position to deal with it than we were four years ago, and this is owing to the closer attention which scientists have bestowed upon it, often at great personal discomfort. In this country its habits have been especially studied by Professor G. H. F. Nuttall, of Cambridge, and Mr. A. Bacot, of the Lister Institute of Preventive Medicine, while in France Captain A. D. Peacock, R.A.M.C., gave us much exact information of its mode of spread among troops in the field. These three workers also, with

others, among whom may be mentioned especially Captain H. Orr, of the Canadian Army Medical Service, and Captain J. T. Grant, R.A.M.C., have devised means for reducing lice in the armies. It is due, not to any fault in the methods suggested, but to the excessive difficulties of applying them under campaigning conditions, that lice continue to exist among the troops. Meanwhile many superstitions still surround the insect, and an effort has been made to dispel some of these.

Since Sir Patrick Manson, Sir David Bruce, and Sir Ronald Ross first showed that insects could play so important a part in the spread of diseases much advance in knowledge has been made, and it has been shown that malady after malady is conveyed by them, until to-day we know that insects are responsible for a large proportion of the ills from which man suffers. It would have been strange if the louse, this little pest which shares our clothes and lives on such intimate terms with us, had not been incriminated. In the space of a very few years it has been found so guilty that it now ranks with the mosquitoes and the rat-fleas in its malign influences. Typhus, one of the most dreaded epidemic diseases of man, is entirely due to its activities. The same remark applies to relapsing fever over the greater portion of the world, including Europe and Asia. This knowledge we owe to Doctor Nicolle and Doctor Sergent and their co-workers. The im-

portance of their work, in this country at any rate, has not received the recognition which it deserved, probably owing to the absorbing interest of other things which followed so soon after their discoveries were made public. To most the ill reputation of the louse remained still due to the fact that it is a disgusting, irritating creature, a symbol of filth, and not to the fact that its presence is a very real danger to the community. During the present year still a third disease, trench fever, has been placed to its discredit, and possibly even now the full extent of its guilt is not known.

One of the most urgent sanitary problems of the present and the future is therefore the destruction and prevention of lice. Now sanitary problems concern not only the Medical Officer of Health but each one of us, for it is only by individual effort, working in harmony with public regulations, that a really hygienic state can be attained. This is especially true of personal hygiene. Public instruction is therefore necessary concerning lice, to correct the errors which exist to-day and to disseminate the knowledge of them which the last few years have produced.

Those who desire a fuller and more detailed account of the habits of lice, and of the means of combating lousiness, should refer to Professor Nuttall's papers on the subject published in *Parasitology*, Volumes IX. and X. Here also a full bibliography of the subject will be found.

x LICE AND THEIR MENACE TO MAN

I wish also to express my indebtedness to Professor Nuttall for permission to reproduce Figures 4, 7 and 8 from the work to which I have referred.

LL. LLOYD.

HAMPSTEAD, LONDON,
October 1918.

CONTENTS

CHAPTER I

INTRODUCTORY	PAGE 1
------------------------	-----------

CHAPTER II

THE STRUCTURE OF THE BODY-LOUSE	11
---	----

CHAPTER III

THE LIFE-HISTORY AND HABITS OF THE BODY-LOUSE	21
---	----

CHAPTER IV

THE DISSEMINATION OF THE BODY-LOUSE AND LOUSINESS	34
---	----

CHAPTER V

DISINFESTATION	44
--------------------------	----

CHAPTER VI

THE HEAD-LOUSE (<i>PEDICULUS CAPITIS</i>)	69
---	----

CHAPTER VII

THE CRAB-LOUSE (<i>PHTHIRUS PUBIS</i>)	76
--	----

CHAPTER VIII

THE INCREASED MIGRATION OF BODY-LICE IN FEVERS	PAGE 84
--	------------

CHAPTER IX

RELAPSING FEVER	100
-----------------	-----

CHAPTER X

TYPHUS FEVER	108
--------------	-----

CHAPTER XI

TRENCH FEVER	120
--------------	-----

INDEX	131
-------	-----

ILLUSTRATIONS

FIG.	PAGE
1. <i>Pediculus humanus</i> var. <i>corporis</i>	Frontispiece
2. Photograph of the Back of a Soldier showing the Bronze Mottling often caused by Louse-bites	8
3. Diagrammatic Section through an Adult Female Louse	13
4. <i>Pediculus humanus</i> laying an Egg on Hair	21
5. Egg of Body-Louse attached to Fibres of Cloth	22
6. Egg of Crab-Louse on Pubic Hair	22
7. The Larva of <i>Pediculus humanus</i> emerging from the Egg	24
8. Cast Skin of Body-Louse	26
9. Fragment of Sewing-cotton fouled by Louse Excreta	31
10. The "Stammers" or Serbian Barrel	54
11. Improvised Disinfestor	56
12. The Crab-Louse (<i>Phthirus pubis</i>)	76
13. Claw of Third Leg of Crab-Louse grasping Pubic Hair	77

CHARTS

I. Illustrating the Migration of Lice from an Afebrile Man (P.H.) to an Afebrile Bedfellow (S.H.)	95
II. Illustrating the Migration of Lice from a Febrile Man (P.H.) to an Afebrile Bedfellow (S.H.)	96
III. Illustrating the Effect of Fever on the Migration of Lice	98
IV. Curves of the Incidence of Typhus and Relapsing Fever in the Second Roumanian Army, showing the Association between two Louse-borne Diseases	107

CHAPTER I

INTRODUCTORY

THERE are two groups of insects to which the general name "lice" is applied. These somewhat resemble each other in form and in the habit of living among the hair or feathers of their hosts. They are mostly small, pale insects, coloured in various shades of white to brown, and are broad and flat. The two groups are called the Mallophaga, or biting lice, and the Anoplura, or sucking lice. The Mallophaga have mouths with which they are able to chew and eat the scales of the skin and fragments of hair or feathers of the animals they frequent. The majority of these insects infest birds, and none of them are found on man. They are all too familiar to those who handle domestic birds, especially pigeons, and though one may occasionally get on to a person while he removes the feathers from a dead bird, and may even bite at his skin, they never remain on him. They cannot suck blood, but in heavy infestation there may be raw surfaces caused on the skin by their continuous nibbling. The

2 LICE AND THEIR MENACE TO MAN

Anoplura, on the other hand, have mouths so modified that they are able to take only one form of food, namely blood. This they obtain by piercing the skin of their host and sucking at the wound thus made. They do not eat one another nor yet other insects, as an American doctor recently stated they did, the form of the mouth absolutely prohibiting this.

Some blood-sucking insects, such as the mosquitoes, horse-flies, and tsetse-flies, are very catholic in their tastes, taking their meal from any warm-blooded, and sometimes even cold-blooded, animal which happens to be convenient when they are hungry. Others, such as the fleas, are more particular, being in general confined to one or a very few different kinds of animals, but on occasion biting another sort if they chance to get on to it. Thus when a rat dies of plague its fleas leave it and may happen to get on to man, on whom they will feed and thus infect with plague, though they are not normally associated with him. The human flea, on the other hand, also normally infests the badger. The sucking lice, however, are very highly specialised and are rarely found on more than one kind of host, though there are records of the human body-louse being found on pigs and monkeys. Such cases are almost certainly accidental. This specialisation affects several characteristics of the lice, such as the adaptation of the grip of their feet to hair of a definite calibre

and the modification of their mouth-parts to skin of a certain character and thickness. They are also very sensitive to what has been aptly called the climatic conditions of the skin, that is to say its temperature and humidity. There are three kinds of lice found upon man, the head-louse (*Pediculus capitis*), the body- or clothes-louse (*Pediculus corporis*, or *Pediculus vestimenti*, as it is often called), and the crab-louse (*Phthirus pubis*). It is with these three and mainly with the second that we shall deal in the following pages, and wherever "louse" or "lice" without the prefix "head-" or "crab-" are mentioned, the body-louse must be understood.

In reference to the systematic names of the head-louse and body-louse, Linnaeus recognised only one species, which he named *Pediculus humanus*. His species was split up into *P. corporis* and *P. capitis*. Both Nuttall and Bacot consider that these are merely racial varieties of one species, so that the systematic names are really *P. humanus* var. *corporis* and *P. humanus* var. *capitis*.

Before the war the head-louse was the only one with which the average person in this country was at all acquainted. It occurs most frequently on children, and they become infested occasionally in even the best-regulated schools. The body-louse was almost, though not entirely, confined to the poorer, congested parts of towns and to agricultural districts. In such places it was

4 LICE AND THEIR MENACE TO MAN

tolerably common. In mediaeval times it was much more widely distributed, so that every one, from the highest to the lowest, was all too familiar with the pest, while it was accounted a virtue in certain holy men that the lice swarmed so thickly upon them uncontrolled. It was an ostentatious manifestation of their humility that they were unworthy to kill this, one of the most disgusting products of creation. Like the spider it took hold with its hands and was in kings' palaces. Apart from references in literature we have the evidences of "the scratching sticks" that in times past it was no shame to be lousy. These were of various patterns, the handle being about twelve inches in length and having at its end a little carved ivory hand with the fingers bent in a scratching position. It was a convenient implement to slip under the garments to alleviate itching in otherwise inaccessible places.

As civilisation advanced and the frequent changing of underclothing became a more pronounced habit, body-lice became scarcer until many people were unaware of the existence of such an insect. The idea of lice became associated with that of dirt, and it was popularly thought that only dirty people could become lousy. The unfortunate who picked up a louse in a tram or train treasured his secret in shame, afraid to mention it to his closest friend. Worse still, a person might become infested and feeling the biting would look for a flea, never thinking

of making the closer examination of the clothing necessary to reveal lice. An unsigned letter, evidently from a woman, recently related that she had got into this condition and remained infested for months until, thinking she was suffering from a skin disease, she consulted a doctor, who revealed to her the cause of the trouble and the remedy. An artisan informed us recently that he had had lice upon him for three years and had never even told his wife, who was doubtless concealing the same condition from him. He had become despondent about it, and as his frequent changing of underclothing, baths, and searches over his underclothing had failed to free him, he had come to believe that the lice bred from his skin owing to his weak state of health. This sense of shame is a very grave mistake. Lousiness is a disease as influenza is a disease, and should be as readily confessed to. Its origin is just as innocent, and though only people of unclean habits in civil life can become heavily infested, it is quite possible for a person with the habits of an ordinary English household to harbour a few lice over a very long period if unaware of the simple methods necessary to completely free himself.

Lice breed neither from the skin nor from dirt. However unclean in habit a person may be, unless he comes in contact with one who is lousy, or picks up a louse which has left such a one, he cannot become infested with them. In the time

6 LICE AND THEIR MENACE TO MAN

of the Pharaohs the idea seems to have prevailed that dust could become lice. "And there were lice upon man, and upon beast; all the dust of the earth became lice throughout all the land of Egypt." The same belief was held by our soldiers in the Boer War. After a wet night the men would spread their blankets in the sun to dry, and the heat would make the lice on them become active and restless, so that what had appeared to cursory inspection to be a clean blanket had apparently become lousy owing to its contact with the ground. Our troops in India speak also of "ground lice" which appear among them on the march and which they think originate from the earth. In barracks with their cleanly habits the men are almost free from lice and do not notice the few. Under the harder conditions of the march, when garments are less frequently changed, these scanty lice increase and the men notice their presence for the first time, hence mistaking their origin. Lice hatch only from the eggs of lice, and the eggs are always closely cemented on to the hairs of the body or the clothing.

The irritation caused by the bites of lice varies much in different people. It is possible for a person to become heavily infested and yet to be quite unaware of his condition. This is especially the case with the crab-louse. Immunity to the sensation of the bite may be natural or may be acquired after longer or shorter infestation.

Others are so irritated by the itching that they will scratch away large surfaces of skin, leaving bleeding wounds. Generally speaking, the bite is less irritating than that of the flea or the bed-bug, but to a few people, to whom the bites of these are a matter of no account, louse-bites are a source of real annoyance. This varying reaction of different people to bites is general with all blood-sucking insects. The first effect of a bite is a small red mark, usually not raised, about an eighth of an inch across. This usually disappears and cannot be seen after an hour or so. Later it may reappear and begin to itch, or it may not be seen again. The actual bite sometimes causes a slight pricking sensation if the wound is near a nerve-ending. If a number of lice bite near together the flushing of the skin may be fairly extensive. Occasionally at the position of each bite a small watery blister appears the following day. After a day or two this collapses, leaving a brown bronze scab, which persists for days before it finally peels off. Bronzing of the skin may follow the bites without any previous blistering. By repeated and extensive biting large areas of skin may be discoloured in this way, becoming very dark and retaining the colour for a long time. The condition into which a person may be brought by this is shown in the photograph (Fig. 2), which represents the back of a soldier evacuated from France with trench fever. The whole surface of the trunk was

8 LICE AND THEIR MENACE TO MAN

mottled over with bronze patches from the louse-bites. This skin condition is sufficiently common

FIG. 2.—PHOTOGRAPH OF THE BACK OF A SOLDIER SHOWING THE BRONZE MOTTLING OFTEN CAUSED BY LOUSE-BITES.

to have earned itself the name of “Vagabond’s disease.”

The itching and the irritating movements of the lice on the body may produce sleeplessness

with resulting neurasthenia. Scratching with unclean fingers may cause the bites to suppurate, and the multiplication of the sores may adversely affect the general health. Lousiness is often the cause of eczema in children with the consequent serious glandular trouble. Lice have also been shown to carry on their bodies the germs of ophthalmia and no doubt contribute to the spread of this disease. These malign effects, though serious enough in themselves, do not constitute by any means the real danger of lice. In recent years it has been shown that three serious epidemic diseases, typhus fever, relapsing fever, and trench fever, are conveyed by them. They have no direct connection with dirt or famine, as was formerly supposed to be the case with the first two. Without lice these diseases would cease to exist throughout the greater part of the world. Our own armies have fortunately been spared the ravages of typhus and relapsing fever during the present war, but have had a considerable amount of trench fever, while prisoners in the frightful prison camps of Germany have in many cases been infected with the two former diseases. We are therefore faced with the certain introduction into this country of numerous sufferers from one louse-borne disease and the possibility of the introduction of two others. In the absence of lice they would spread no further. It therefore behoves us, for our own safety and that of future generations, to wage a

10 LICE AND THEIR MENACE TO MAN

relentless war against the louse. This can be done successfully by the efforts of public sanitary bodies and by individual effort. The latter is a very useful adjunct to the former, and indeed is most necessary, and the public should be instructed in the danger of being lousy and in the simple methods of cleansing themselves thoroughly. To this should be added the careful and frequent inspection of school children, and attention to the homes from which the infested ones come. Much of this inspection is already carried out with most beneficial results, but too often the cleansed child is allowed to return to the home where younger brothers and sisters or even parents are in a similar verminous condition and ready to reinfest them at once.

CHAPTER II

THE STRUCTURE OF THE BODY-LOUSE

THE louse is an elongated oval creature, varying in colour from white to brown, while the red or black colour of the blood in the gut can be seen through the skin. When young and newly fed it appears to be bright red and is then known in the soldier vocabulary as a "red-back." As the blood becomes darker in digestion it is called a "black-back" or "grey-back" and is often thought to be a different kind. The full-grown female louse measures about one-sixth of an inch in length and one-fifteenth of an inch in breadth, while the newly hatched one is about the size of a pin's head, all intermediate stages existing. Its skin is leathery, and it is not very easily crushed, except when quite young or just after it has "cast its skin." It is covered all over with a smooth coat of a substance known as chitin, which corresponds to the dead horny layer of our own skin. It is sparsely covered with fine hairs. In the young stages a fresh layer of chitin grows under the old layer, which

12 LICE AND THEIR MENACE TO MAN

splits and allows the louse to creep out. It is naturally very soft when it first emerges from its old skin, and is white and semi-transparent. It soon hardens and takes on in parts a sepia tint, which varies much in density, being darker on the lice which infest dark-skinned races. Often it appears to have a sepia-coloured border running all around the edge of its body.

In the following description of the adult louse reference should be made to Fig. 1 and to Fig. 3. The latter is a diagram representing some of the more important organs of a female louse which would be seen if the insect were cut clean down the middle line and one half removed. Where an organ is paired, only those of the right side of the body are thus represented.

The body is divided into three regions, the head, the thorax, and the abdomen. The head is attached to the thorax by a very narrow neck and has a considerable power of independent movement, up and down and from side to side. Between the thorax and abdomen, at the waist, there is hardly any constriction at all. The head is rather pointed in front and rounded behind. It bears at the tip, and just below it, a circular opening, the mouth, which is surrounded by a ring of pliable tissue, the *haustellum*, which bears a number of hooks (Fig. 3, 1). At the sides of the head are attached the antennae or feelers, which are composed of five joints. The antennae bear hairs which have a sensory

FIG. 3.—DIAGRAMMATIC SECTION THROUGH AN ADULT FEMALE LOUSE. (For explanation see text.)

14 LICE AND THEIR MENACE TO MAN

function, of which we know nothing definite except that they guide the movements of the insect. Behind the antennae are the black eyes, which are simple, in contradistinction to the eyes of higher insects such as the house-fly, the eyes of which are compound and made up of many elements, to each of which the simple eye of the louse corresponds. The latter is probably able to see no more than is necessary to enable it to distinguish shades of light. The thorax narrows from behind forwards and bears the six legs. The legs are jointed and end each in a single large claw which has a slightly serrated edge; the first pair being larger in the male than in the female. The claw has a similar movement in relation to the rest of the leg as the blade of a penknife has to the handle, but does not close so completely down on it. In the space between claw and leg hairs or fibres are gripped tightly by the insect when it is walking, and it is by means of them that it clings to cloth and hair even after death. There are never any wings, and the louse is quite unable to jump. The abdomen is divided into a number of segments by means of slight constrictions at the sides and rings round the body which can be faintly seen. In the adult female the abdomen is broader and heavier than in the male, while the tip turns slightly down and is slightly forked. In the male it is more barrel-shaped, cylindrical, and the single-pointed tip is turned up. The

anus is at the end of the body, and just below it lies the genital opening. In the female this is a wide pouch, and in the floor of this are a pair of stout peg-like organs the tips of which overlap and which work against one another like a pair of pincers, gripping the hair or fibre of cloth on which the egg is being laid. These are called the gonopods (Fig. 3, 18). The copulatory organ of the male is a kind of bag which when at rest is inverted inside the body. On this is a strong pointed organ and a small inconspicuous penis. The former organ can be easily seen through the skin of the lower side, lying near the end of the body.

To turn to the digestive system : the mouth has no biting jaws, but in its lower part is situated a long very sharp stylet which cannot be seen when it is retracted inside the head. This stylet (Fig. 3, 2), or stabber as it is usually called, is formed of three long elements which are attached parallel to each other in such a manner that they form a tube with an extremely fine bore. It is with this hollow stabber, which can be thrust out of the mouth opening, that the louse makes the wound in the skin when it feeds. The mechanism of feeding is described elsewhere. Above the stabber a short broad tube leads out of the mouth into a chamber, the pharynx (Fig. 3, 3), which has muscular walls and which is the sucking pump. From this a long very narrow oesophagus (Fig. 3, 4) runs to the fore-

16 LICE AND THEIR MENACE TO MAN

gut (Fig. 3, 5), which is a wide tube and corresponds to the stomach of higher animals. It has two capacious pockets (Fig. 3, 6) which lie one on each side of the oesophagus and seem to act as storage chambers for the blood, which can be seen in them with the naked eye through the body wall of the louse. The walls of the gut contract and expand in waves, causing the contents to flow backwards and forwards and to keep circulating so that they are thoroughly mixed with the digestive juices and come continually in contact with the wall, where the nutriment is absorbed. These peristaltic movements are a very noticeable feature in the louse, in which insect the width of the gut in proportion to its length is exceptional. Most insects have the gut narrow and the necessary absorptive surface is obtained by an increase in the length, the gut being thrown into many coils like that of a mammal. In such a gut the food passes fairly continuously backwards, absorption proceeding as it moves. In the louse it moves to and fro, and by this means the same effect is obtained with the wide short gut. The fore-gut narrows behind to form the hind-gut (Fig. 3, 11), which runs forward again, forming an S-shaped loop. Into this open the four long thin tubules, the Malpighian tubes (Fig. 3, 10), which are supposed to function as kidneys, to pass into the gut waste products, which thus find their way to the exterior. Farther back the hind-gut

becomes the rectum (Fig. 3, 13), on which is a swollen portion or ampulla (Fig. 3, 12), which has a thick wall and apparently expels the faeces. The rectum opens to the exterior at the anus (Fig. 3, 14), which is at the end of the body. There are two pairs of salivary glands, which are always prominent organs in insects, their secretion having a wider scope than that of the organs of the same name in mammals. One pair are trouser-shaped (Fig. 3, 7) and lie on the fore-gut, closely attached to its surface. The other pair are kidney-shaped (Fig. 3, 8) and lie on either side of the oesophagus. Each of the four is connected with the pipe of the stabber by means of a very fine duct (Fig. 3, 9), which carries away the secretion.

The nervous system consists of three central masses, from which the nerves run to the various organs they serve. These are, firstly, a large mass or brain (Fig. 3, 15) which lies in the head above the oesophagus; secondly, a smaller mass (Fig. 3, 16) lying below the stabber base and connected with the brain by means of a nerve cord on each side running round the gut; thirdly, a large mass (Fig. 3, 17) lying in the thorax below the gut, and from which nerves run to the legs and backwards into the abdomen. This third mass is connected by a nerve cord with the second.

The louse, like all other insects, breathes through a system of tubes, or tracheae, which are

18 LICE AND THEIR MENACE TO MAN

really ingrowths from the skin, so that the inside of the tubes is part of the outside of the body. This system opens to the exterior by means of small pores called spiracles which are situated along the sides of the body on the thorax and abdomen. The spiracles are round and are protected by a ring of teeth which filter the air and prevent gross particles entering. Nor can water enter owing to its high surface tension, but fluids, such as oils, which have a lower surface tension than water are able to enter and thus clog up the pores and choke the insect. Each of the spiracles is connected by means of a short passage with a horse-shoe-shaped tube, the curve of which is towards the hinder end of the body. From this branching tubes run and ramify right through the body of the insect, forming a network over all the organs, so that no part is left without a supply of air. The system has thus not only the function of our lungs but also one of the main functions of our circulatory organs. Air is forced in and out of the system by contraction and expansion of the body wall with a bellows-like action.

There are no circulatory organs in insects as we know them in higher animals, and no true blood. The main function of these is taken on by the respiratory system described above. The nutriment from the gut is carried about the body by the fluid of the body space, or haemocoel, which is a cavity extending all through the insect

even into the hollows of the main hairs. In this fluid are cells corresponding to the white corpuscles of the blood of higher animals, but none corresponding to the red corpuscles. This fluid is kept circulating by means of an open contractile tube which is, for convenience, called a "heart," and which lies above the gut. Such an organ remains to be described in the louse. The extensive contractions of the gut mentioned above will aid materially in the circulation of the coelomic fluid.

The internal organs of generation of the female louse consist of a pair of ovaries, where the eggs originate and grow, and a tube connecting these with the exterior. Each ovary (Fig. 3, 23) is made up of a bunch of five tubes which look like strings of sausages in which each sausage is much larger than the one in front of it. The swellings which give them this appearance are due to the growing eggs inside. The oldest egg is near the base and the youngest one is near the tip in each tube. As the eggs become fully developed they pass one after the other (Fig. 3, 22) into the central tube or oviduct (Fig. 3, 21). Here the egg receives the mass of cement (Fig. 3, 20) which surrounds its base when it is laid and fixes it on to the hair or cloth to which it is attached. The cement is poured into the oviduct from the large glands (Fig. 3, 19) which secrete it. It is probable that the eggs are fertilised while in the oviduct, but there is a little gap in our knowledge

20 LICE AND THEIR MENACE TO MAN

here. A short vagina leads to the exterior from the oviduct.

The internal male organs consist of a pair of testes, each of which is in two parts. Each testis is connected by a fine tube with a wide seminal vesicle which meets its fellow at the base, where the two pass off into a narrowing duct which carries the male elements to the penis and so into the female during coitus.

The remainder of the body space is filled up by the muscles and the cells of the fat body. The latter is highly developed and serves to store the food among other functions; but the detailed physiology of insects is not well known, and it would be useless here to describe special cells and attempt to ascribe to them functions largely hypothetical.

CHAPTER III

THE LIFE-HISTORY AND HABITS OF THE BODY-LOUSE

Development.—The eggs or nits of the body-louse are laid attached to fibres of cloth or sometimes to the hairs of the body. In shape the egg (Fig. 5) is ovoid, about one-twenty-fifth of an inch in length, with rather straight sides, and closed at the top by means of a cap or operculum

FIG. 4.—*PEDICULUS HUMANUS* LAYING AN EGG ON HAIR. The gonopods (*gon.*) grasp the hair and direct the alignment of the egg. (After Nuttall.)

which is sculptured over part of its surface by a circular area of small nodules. It is firmly fixed in position by a hard cement which surrounds the base of the egg and the strand to which it is attached. According to Nuttall (1) the female louse in ovipositing grasps the fibre or hair on which it is laying the egg by means of its gonopods (Fig. 3, 18, and Fig. 4), and by this

22 LICE AND THEIR MENACE TO MAN

means orientates the egg so that the cement flows round the particular anchorage with which it is dealing. If this should be a hair the result is that almost invariably the egg lies with its axis parallel to that of the hair and consequently it

FIG. 5.—EGG OF BODY-LOUSE ATTACHED TO FIBRES OF CLOTH. ($\times 50$.)

FIG. 6.—EGG OF CRAB-LOUSE ON PUBIC HAIR. ($\times 60$.)

is less liable to be dislodged. The eggs are generally laid in clusters, for there is a well-marked tendency for the insect to return to the same spot to lay, though it may wander far in the meantime. The egg is white in colour and has a pearly sheen. It is rather translucent when

newly laid, but becomes more opaque later as the young louse develops inside it. The empty shell is hard and brittle and remains attached after the louse has emerged; the top fraying away, but the base and cement remaining. On the bristles of brushes the empty shells of the eggs of the hog-louse (*Haematopinus sui*) are sometimes seen in large numbers. They are of course harmless in themselves, but are unsightly, and at any rate afford evidence that the cleaning of the bristles has been none too thorough.

It is difficult to tell whether the egg is empty or full without the aid of a lens. At the temperature which ordinarily exists between the skin and the clothing the eggs hatch in from seven to ten days, but if kept in a cooler atmosphere the incubation period is lengthened. Thus when a garment is put off at night hatching is retarded in proportion to the coolness of the bedroom. It is not essential to the hatching of the eggs that the garments which hold them should be worn, as the young will emerge if they are incubated at any temperature above 72° F., and below that which destroys them, provided that the air is not too dry. At temperatures below 72° F. the young will not emerge. Nuttall (1) describes the hatching of the egg. The inside of the shell is like that of a deep smooth chalice, and the young louse completely fills it and has its legs folded back along its body. The mechanism of its emergence is remarkable. Air passes through

24 LICE AND THEIR MENACE TO MAN

the cap and is taken in by the insect at the mouth and passed out behind it. As this increases a growing cushion of air is formed in the bottom of the shell which pushes the louse forward as a bullet is pushed out of a rifle, though the movement is slow. The head pressing against the cap thrusts this up and the louse comes into the world like a jack-in-the-box until its front legs are free and it can grasp surrounding objects and pull itself out (Fig. 7).

FIG. 7.—THE LARVA OF *PEDICULUS HUMANUS* EMERGING FROM THE EGG. The louse passes air through its body into the shell behind it and thus blows itself out until it can grasp surrounding objects and draw itself free. (After Nuttall.)

The newly emerged louse is white and fragile. Under ordinary circumstances it feeds within the first hour of its active life and then looks like a bright red speck and is very conspicuous. Unless able to feed within the first twenty-four hours of its life it dies. From the first it is easily recognisable for what it is, being much like its parents. As a comparison, the larva which emerges from the egg of a flea is a small white active grub, nothing at all like the adult, which runs about on

the ground or in the nest of its host feeding on organic debris. When this is full-grown it spins a cocoon, inside which it turns into a resting stage, the pupa, which is in shape somewhat like the adult flea but is white and soft. Inside this pupa the adult is formed, and from the cocoon emerges the brown familiar flea. Such a development is known as a "complete metamorphosis." The development of the louse is by "incomplete metamorphosis"; that is, the food and form of adult and young are similar and there is no resting stage. The growth, however, is not a continuous unbroken process like that of a man, but takes place in a series of three jumps, each represented by the casting of the old chitinous covering and the development of a new and larger one. Chitin is not a very elastic substance where it is thick, and so this moulting process is necessary to enable growth to take place. Crabs and lobsters grow in the same way by casting off the old coat, which will not stretch, and developing a new one, and the soft dog-crab which has just moulted is a familiar object on the sea-shore. The young louse moults for the first time when about two days old. The skin splits along the back of the thorax, along the neck and the top of the head. The insect then expands and forces up its back, draws out its head and legs and then pulls itself free of the old skin (Fig. 8), which remains attached to the cloth. It is a flimsy object very easily seen on a lousy

26 LICE AND THEIR MENACE TO MAN

garment. In this process not only the outer skin is cast, but also the inside of the mouth with the stabber, and the main tubes of the tracheal system. The insect which emerges is now called a nymph, or sometimes second-stage larva, and is more robust than the first-stage, but is other-

FIG. 8.—CAST SKIN OF BODY-LOUSE. (After Nuttall.)

1. Eye.	3. Stabber.	5. Spiracles.
2. Antennae.	4. Claws, incurved to grasp cloth.	6. Tracheae.

wise much like it. At the end of two or three days it moults once more in the same manner and becomes the second-stage nymph or third-stage larva. After the elapse of about three days more it moults for the third and last time, and is now an adult. The adult louse is rather less barrel-shaped than the earlier stages and shows the external evidences of its sex for the

first time. From the time of hatching to its becoming full-grown the louse under the most favourable conditions occupies about eight or nine days. Allowing a period of eight days in the egg, we see that from the time that the egg is laid to the time when the louse is ready to begin breeding there is a period of about seventeen days. This obtains only when the louse is in continual contact with the body, and is prolonged by adverse conditions, such as its cooling at night owing to the putting off of garments.

Feeding.—Under normal conditions the louse feeds about four to six times a day, preferring to do so when its host is at rest, sitting or sleeping. It does not leave the clothing and creep on to the body to feed. All that is necessary is for it to be able to touch the skin with its mouth. If lice are put on to small fragments of cotton and these on to the skin, they will be seen to feed in all positions, some at right angles to the surface, and some even with their backs to it, the head being thrown backwards till the mouth touches the skin, while the legs feebly grip the cotton or even wave in the air. For this reason lice bite mostly those parts of the body, such as the hips, shoulders and neck, and fork of the legs, where the garments press closely against the skin, and avoid more the parts where the clothing is slack. Soldiers who wear body-belts often find that they are intensely irritated by bites in this locality. This habit of not leaving the clothing to feed is

28 LICE AND THEIR MENACE TO MAN

distinctly advantageous to the louse, since man scratches at his skin and not at his garments, and if he feels the movement of the louse he instinctively feels on the skin for it and not on the clothing over the spot where he felt it move. The only purchase which a louse needs for feeding is the grip given by the teeth which are on the haustellum, and this purchase is the fulcrum against which the stabber works. The haustellum around the mouth, being closely pressed against the skin, forms a circular air-tight cushion, and into the area thus enclosed the stabber is forced down into the tissues. Salivary juice now flows down the hollow stabber into the wound, and as this acts a slight pink flush may be seen around the position of the bite owing to the increase in the blood at the spot caused by the action of the fluid which is being injected and which also retards the clotting of the blood.

The salivary juice is thus mixed with the blood, not in the mouth but in the tissues of the person on whom the louse is feeding. This is a vastly important fact in connection with the transmission of disease by many blood-sucking insects, since the fluid has become the conveyer of the infection. The virulent organisms of malaria and of sleeping sickness are thus injected into man by the insects which carry them by means of the salivary juice. It is possible that the typhus infection is conveyed by the louse through the same medium.

To return to the feeding louse : there is a pause while the salivary juice acts on the blood and then sucking commences. In one in which the chitin is fairly transparent the pumping pharynx can be seen expanding and contracting with a rapid movement which is almost a flicker, and the blood can be seen collecting in the gut. At the same time waves of contraction are seen to pass along the alimentary canal. The louse is a slow feeder and may occupy half an hour or more in completing its meal, and it is rarely that it finishes in under fifteen minutes. This slow feeding is unusual in blood-sucking insects, but is more than paralleled by the African tick (*Ornithodoros moubata*), which has the nocturnal habits of the bed-bug, and often occupies two or three hours over its meal.

Of blood-sucking insects those which cause most pain by the actual operation of biting are the flies belonging to the genus Tabanidae : the horse-flies, chegs, blind-flies, etc. These insects alight on the skin and with their powerful jaws make gashed wounds from which blood flows. This they imbibe quickly, and the wounds often continue to bleed after they have left. It is not often that such an insect obtains a full meal from a man at the first attempt, as he strikes at once at the position of the bite if his hands are unoccupied. In these cases, however, there is usually no subsequent irritation from the bite, so that the salivary juice, if such is injected, has

30 LICE AND THEIR MENACE TO MAN

no poisoning effect, or the nature of the wound made may obviate the necessity for its injection. Insects such as mosquitoes and fleas, if they do not draw blood at once from the place they choose, move quickly and try in another spot; but the louse very rarely does this, generally waiting patiently for the blood to collect. It is essential that such an insect should cause little pain during the actual process of feeding, so as not to attract the attention of its host to its ultimate cost.

The blood when recently taken in shows very distinctly red in the gut, but soon takes on a black colour owing to the action of the digestive juices. As the feeding louse approaches repletion it usually begins to defaecate. It is a wasteful feeder, and sometimes blood almost unchanged can be seen passing out of the anus while it is still gorging itself. The excreta has been shown to be of very great importance in relation to the disease-conveying capacity of the insect. The amount passed is considerable, a well-fed adult louse excreting as much as seventy to eighty-five granules a day. It is sometimes ejected in rough masses and sometimes in a long spirally coiling thread, or again in a fluid condition which quickly dries up. In bulk, for in experimental work it can be collected in surprisingly large quantities, it has the appearance and colour of finely ground coffee. Under the microscope it is seen to consist of rough black granules and smooth red pieces. It is very easily blown about and can be

carried by the wind. On the garments of a lousy person the excreta may be seen stuck on to fibres of the cloth, especially about the patches of eggs, than which they are more conspicuous and which they may sometimes serve to indicate. Fig. 9 is a drawing of a fragment of sewing-cotton which was removed from one of the experimental boxes of lice. The masses and fragments of excreta may be seen on it. The larger masses all ultimately break up into fine granules. In the armpits of infested men dirty brown patches

FIG. 9.—FRAGMENT OF SEWING-COTTON FOULED BY LOUSE EXCRETA. ($\times 30$.)

are often seen where these louse faeces have dissolved in the sweat.

Breeding.—The female louse commences to lay eggs on the second day after the last moult. She does this whether she has been fertilised by the male or not, but only if she has been fertilised will the eggs hatch. Copulation takes place frequently, and in the operation the male creeps underneath the female and the genital openings are placed in apposition. Nuttall (2) has recently described the process in detail. The female pouch is held open by means of the pointed chitinous organ of the male which is known as the dilator and which can be seen through the

32 LICE AND THEIR MENACE TO MAN

skin of the lower surface of the body. The inverted bag of the male is now everted, rolling inside out into the vagina of the female, and the spermatozoa pass through the small penis, which is thus thrust well into the vagina, and fertilisation is effected.

The eggs are laid at the rate of eight to ten a day, and this continues for twenty-five to thirty days, so that each pair of lice produce about three hundred offspring of the first generation, and many of these will have started to breed before their parents die. Bacot (3) states that a female louse under conditions ideal from her point of view might have about 4000 offspring during her lifetime. Conditions would of course never be ideal. Some of the eggs would probably fail to hatch, and many of the young would die from one or other of the many catastrophes which are liable to befall the louse. As an actual instance of breeding capacity the following may be quoted. Into one of the small experimental boxes used in the laboratory a hundred young larval lice were placed. The box was about three-quarters of an inch in diameter and of the same depth. It had a glass bottom, while the other end was covered with chiffon, through which the lice could not escape but could easily feed. The insects were fed twice daily by being bound on to the forearm for half an hour for each feed. Between their meals they were kept in an incubator at a temperature of 86° F. After forty days the box was

opened for the first time. It was full of lice, alive and dead, and the cast skins, which, together with the piece of flannel contained in the box, formed a compact mass ; 507 living lice of various ages were counted, while there were innumerable eggs. The conditions had of course been by no means ideal for the lice, for it was difficult to understand how they had been able to move about in the confined space.

Death.—Death is of course usually accidental owing to crushing or starvation as the result of the louse losing contact with its host, either through the putting off of the garment containing it or to its own wandering. The average life of a louse which does not meet with one of these accidents is from forty to forty-five days ; a very short period compared to that of a flea, which may survive a year. Towards the approach of death the louse becomes very thin and anaemic-looking. It ceases to breed or feed, and may continue to exist for several days in this senile condition before death overtakes it.

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CHAPTER IV

THE DISSEMINATION OF THE BODY-LOUSE AND LOUSINESS

Dissemination.—A problem which faces every animal and plant is how it shall distribute itself. Each is always seeking new worlds to conquer ; each is to itself the most important thing in creation ; each has the ambition, latent or obviously expressed, to inherit the earth. Except for this tendency to migrate any individual species in a given locality would tend to choke itself out by exhausting the food supply. This is, in fact, going on around us every day. The organisms of a disease enter the human body and multiply enormously till at last their host dies of exhaustion or their poisonous effect, and the parasites die with their host unless the death is merely their means of distribution. It is not the racial ambition of any species to exhaust its food supply, or for the parasite, except in special and exceptional cases, to kill its host, a proceeding which would ultimately lead to its own destruction. Parasitic insects have solved

the problem of distributing themselves in a vast variety of ways. Some, such as the bot-flies, are in one stage immobile parasites, and in another active flies which are able to seek out and place their eggs on a fresh host. Some, such as certain species of the hippoboscids, which have a louse-like habit, are able to fly in one stage and cast their wings, for which they have no further use when they reach their fresh prey. Certain species of fly, the maggots of which live in the skin of mammals, have become still more ingenious and lay their eggs where a mosquito may accidentally pick them up and carry them to another mammal. There are others, to which group lice as a whole largely belong, which rely more on the habits of their hosts for their dissemination rather than on any active habits of their own. If man radically changed his habits in one or two particulars his body-lice would cease to exist. This has already been indicated in the history of civilised countries, for it was the growing habit of constantly changing underclothing and paying more attention to the toilet that reduced body-lice to so small a frequency before the War. Now that stress of circumstances has caused many millions of people to revert in these respects to the habits of mediaeval times, lice have come into their own once more.

The spread of lice is due, to some extent, to their own active habits, for when their host is

36 LICE AND THEIR MENACE TO MAN

in warm surroundings, so that the temperature outside his clothing approximates to that inside, they are liable to migrate from him and pass on to another near. This takes place especially in beds where two people are sleeping together (see Chapter VIII.). To sleep with one who is infested with lice is a certain means of becoming verminous. Lice, as will be shown later, are also liable to leave their host when the skin becomes too hot for them, as when he is in a fever. They also leave at his death and scatter over his bedclothes and surrounding objects, and are very likely to be picked up by any one coming in contact with these. They may be dislodged by brushing and fall to the ground, and it has been stated that they have been blown off by the wind and carried to a distance. They may also of their own accord leave discarded garments.

Lice spread abroad by any of these means may be termed stray lice, and they are in a very helpless condition for finding fresh prey as compared with the human flea or the bed-bug. The flea jumps into the air when disturbed by a sudden draught of wind, such as is caused by a foot moving near it, and grasps anything it meets with in its course, thus finding its temporary host. The hungry bed-bug hunts down its victim, probably guided by his scent, often travelling long distances to find him. The stray louse can only wait till a fresh host comes in contact with it, or wander aimlessly about on

legs not very well adapted for travelling on anything except rough cloth or hair. Peacock (1) showed that it is improbable that they are attracted to man in any way by his smell, since they took no notice of a sweat-impregnated shirt placed near them. They are guided in their movements, to some extent, by a sensitiveness to light. When well fed they creep into dark places, but hunger drives them towards the light again. This habit, however, helps them little in their search. They are very sensitive to heat, being adapted to the temperature which exists between the skin and the clothing, 86° - 90° F., and what guidance they get in finding a new host they probably obtain from this faculty alone. Stray lice in a bed very quickly find a man who sleeps in it. The temperature of their surroundings has a profound influence upon their movements and vitality. At 104° F. they are extraordinarily active, running round and round with the rapidity of bed-bugs. At 90° F. they are moderately active, and if unable to feed, digest what food is in them and succumb about the second day from starvation. At the temperature of a warm room, about 70° F., their activity is little marked, and their vitality is so reduced that they may survive a week without food. At still lower temperatures they become moribund and die slowly, some having been known to survive ten days at the freezing-point, and this is the longest period which lice have been known to live

38 LICE AND THEIR MENACE TO MAN

without food (Warburton). While they remain active the distances that they are able to travel are somewhat surprising, their movements though slow being fairly persistent. A well-fed female louse was observed to walk along a stretched thread of cotton for a distance of four feet in thirty minutes in a warm room, the impulse to walk being given by placing it on the end of the thread near the window. Peacock observed two travel a distance of five feet in an hour where they had apparently no particular stimulus to guide them. By such wanderings the louse is no more likely to find a fresh host than by remaining where it happens to fall. If it is on a smooth surface, such as a board, and a cloth surface brushes over it, it immediately attaches itself to the cloth. The author has occasionally made use of this habit when lice have accidentally fallen on the laboratory floor by passing a Turkish towel over the place where they fell and at once recovering them. Again, if the insect is on a cold cloth surface and a warmer one is pressed against it, it will immediately leave the former for the latter. In this way lice may be picked up in public conveyances with cushioned seats. As these chances do not happen very often it is certain that the vast majority of stray lice die without finding a new host. The more congested the community the more likely are they to be picked up. It also follows that when lice are on a discarded garment the best chance for

them is to remain where they are in the hope of the article being again worn. This is what the majority do, though, as mentioned above, a few are prone to wander. A stray louse, when it finds a new host, can, of course, only multiply if it happens to be a fertilised female. A male or an unfertilised female would die without producing young. A single louse, however, is enough to cause an attack of a louse-borne disease, should it be an infected one, and we have a record of an officer who received a single louse upon him, scratched himself, and in due course developed trench fever.

An unoccupied dwelling cannot be infested by lice in the manner in which it may be by bed-bugs or fleas. The presence of lice denotes recent occupation, and after it has been vacated for ten days it may be considered as absolutely safe. Peacock (1), who studied the dissemination of lice among our troops in France, discusses in detail the reputation which certain dug-outs get of being lousy. He comes to the conclusion that this is due to the presence of infested men and not to any inherent quality of the habitation. The ones with the worst reputation were the largest ones in which most men congregated.

Bedding, however, is a most important source of spread, and it is courting disaster to sleep in that recently used by an infested person. Most convincing figures in proof of this are quoted by Nuttall (2). Dr. Hamer of the London County

40 LICE AND THEIR MENACE TO MAN

Council caused the beds in some common lodging-houses, which were largely used by people of the tramp class, to be examined weekly. Throughout a year, in the different months, from 12 to 31 per cent of the beds were found to contain lice ; the numbers being higher in winter and lower in summer. Incidentally the result of his inspection over a number of years was to reduce these percentages to less than five, owing to the increased care engendered in the keepers of the houses. There is no reason why lice should not lay eggs on blankets, since they do so on the outer garments to which blankets correspond during the night. Peacock (1) records an instance of seeing a nit in this position. Beds unused for several weeks might therefore harbour lice, since the hatching of the eggs may be retarded by cold and the incubation completed later.

Lice also spread by means of garments, and this is probably the main source of spread in armies, where clothing is largely communal property. It has been repeatedly noticed that when lousy garments are discarded the lice are liable to congregate outside them and these are very likely to get on to clean clothing which comes in contact with them. They have also been observed to creep out of the necks of kit-bags and may in this way pass on to clean kits. The ordinary processes used in a laundry do not necessarily kill lice and their eggs, since the water is often not of the lethal temperature and soaking

in cold, or only warm, soapy water does them no harm unless the immersion is very prolonged. Garments reputedly clean from dirt may therefore harbour vermin and commence infestation in one who assumes them.

Lousiness.—If garments containing lice are worn continually day and night the vermin increase and multiply in a remarkable manner. Cases are on record where single garments have held thousands. These are unusual cases and indicate, in the infested person, either extreme helplessness or, what is more likely, utter indifference to the filthy condition. In attempting to arrive at an average estimate of lousiness in troops Peacock (1) excluded these extreme cases. He found that where 95 per cent of the men had lice upon them the average number was twenty lice a man, the range being from ten to thirty. In another series of men he found about 3 per cent with more than 350 lice each, while one shirt he examined was estimated to contain 10,428 lice and 10,253 eggs.

It has been already stated that lice tend to bite more especially in the regions of the body against which the clothing presses. When not feeding they congregate, especially along the seams and in folds of the clothing. They are markedly gregarious in their habits, being often seen in masses and giving rise to the soldier's term of "lousy lice," that is lice with lice upon them. They and their eggs may be found on

any garment of the infested person, either inside or outside, but they are most prevalent inside the shirt or undershirt, and trousers or drawers. They are particularly liable to creep into deep crevices such as the folds of a kilt or the waistband of pyjama trousers.

It is important to remember in inspecting people for lousiness that the eggs of this louse may be laid on the hair of the body. In this position they are very difficult to see, but if the inspection is carried out carefully and in a good light they will often be revealed. It is practically impossible to say whether isolated eggs found in these positions are those of this or the head-louse, the only difference between them being the very elusive one of size. The matter has therefore been the subject of some controversy, as some observers, perhaps unaware that the head-louse may infest the body hair, have recorded the nits of the body-louse in these positions in large numbers. That body-lice do lay eggs on the body hair we finally proved in the experiments described in Chapter VIII., where men were artificially infested with body-lice for a night. In one experiment we found a dozen freshly laid eggs on the pubic hair of one of the men who was, of course, louse-free before the experiment. To make quite certain that they had been laid during this night, the eggs, after they had been cut off, were incubated and in due course lice emerged from them.

Body-lice are found on man all over the world, and there is probably no tribe free from them. They are, however, less prevalent in tropical than in temperate and cold climates, and in temperate regions are less numerous in summer than in winter. This is in correlation with the different habits of people in the winter. Then under-clothing is more likely to be of wool than of cotton, and lice prefer the former material. It is also the custom with many people in this country, for some reason that is difficult to understand, to change woollen garments less frequently than cotton ones. Among certain classes in winter the day clothing is also worn at night. People also at this time keep more indoors and crowd together over stoves. All these habits are in favour of the spread and increase of lice, and there is no creature in creation more ready to seize Time by the forelock.

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CHAPTER V

DISINFESTATION

By disinfestation is meant the freeing of the body and clothing of lice and their eggs or nits. This may be done in a variety of ways.

Hand-picking.—The most natural, and incidentally the least effective, method to adopt is the mechanical one of removing the lice by means of the fingers. The word “lousing” was used by old English writers to denote this process, when, as to-day, lice were so common as to be a matter of interest to every one, and now that they may again be mentioned without bating the breath the somewhat disgusting word has been revived. This is the method adopted by monkeys, which may be constantly seen searching in one another’s hair and devouring all the vermin they find. Primitive peoples often do the same thing, even to the eating, with apparent pleasure, of the lice removed. More civilised folks have neither the time nor the patience to practise this hand-picking with any thoroughness, and very good eyesight is required to detect the young lice and every nit. Moreover, many of the nits and even

the lice themselves are so deeply embedded in seams of the clothing that they cannot be reached by means of the fingers.

Brushing.—Brushing the clothing with a very stiff brush has been recommended, especially in localities where the nights are very cold. In such places if the clothing is discarded during the night the lice are torpid in the morning and many can be removed by means of the brush, but the eggs are not affected. The operation has therefore to be carried out daily and over a long period of time, and precautions have to be taken that the lice do not fall where they may again have the opportunity of creeping on to people. These mechanical means of disinfestation for body-lice are tedious, unsatisfactory, and not to be recommended if other methods are available.

Ironing.—An advance on hand-picking is the method of killing the vermin by means of heat applied locally to the clothing by means of hot irons. This has been used to some extent in the armies in the field. The irons should be heavy ones and should be as hot as possible without scorching the clothing. They should be passed slowly over the whole surface of the garments, inside and outside, and should linger along the seams to allow the heat to penetrate. The Germans have modified this method by providing iron sheets, heated from inside, against which clothing may be pressed. It should be obvious that it is difficult to free of vermin a set of garments

46 LICE AND THEIR MENACE TO MAN

by these means, owing, once more, to those embedded in the seams, which often cannot be reached by sufficient heat to destroy them without damaging the fabric thereby. The soldier in the field will often take off his shirt and pass the lighted end of a cigarette over the lice and eggs where they most thickly congregate, killing all that are touched. This is the method of despair, but unfortunately in the past has often been the only one available.

Dry Storage.—Clothing may be freed of lice by the slow method of storing it in a dry atmosphere until all are dead. The warmer and drier the air the more quickly will this be accomplished. As indicated previously, the eggs of lice will not hatch if the temperature at which they are kept is below 72° F. The object of this storing should be to make the eggs hatch quickly or else dry up and die. Whatever the temperature the lice will all be dead at the end of ten days, but if the air is moist, eggs might still be alive at the end of this period and lice might emerge from them if the garments were then worn again. Nuttall (1) advises that clothing so stored in a dry atmosphere should be left for at least two to three weeks, and may then be considered quite safe.

Heat.—The most practical method of freeing clothing from lice in all stages is by means of heat. In the Army the idea has become prevalent that it is a very difficult matter to kill lice by this means. A man may say that he *boiled* his shirt

for half an hour, and after assuming it, it was as lousy as ever. Others will assert that, after their clothing had been officially disinfested in the ovens, in a day or two they were as bad as before. Such tales, arising from misapprehension, spread about among the civil population will give them too an idea of the difficulties of destroying the pest. The explanation of these statements is that often in the past disinfestation has not been thoroughly carried out. At first it was the custom to treat shirts only, leaving all the other garments untouched and often very verminous. Later the importance of treating all the clothing was realised, but no attention was paid to the bodies of the men, the hair of which might harbour both lice and nits, most of which were undamaged by the bath which always accompanies the treatment. In the new era of things the bodies as well as the clothing are beginning to be cleaned, and great improvement may be expected. Moreover the heating of the clothing at times may have been faultily or carelessly done. The clothing may have been packed so closely in the hot chamber that though the specified time was allowed to the load the heat has not had time to penetrate throughout the mass. Another fault has often been that it was considered impracticable to treat all the men who associated closely together at one and the same time. Thus cleansed men might sleep close to one who had not been treated, with the result of immediate

48 LICE AND THEIR MENACE TO MAN

reinfestation. All this has led often in the past to disinfestation falling into disrepute among the men.

Momentary immersion in boiling water of an individual louse or egg kills it at once. It would be as impossible for a nit to hatch after this as it would be for a chicken to emerge from a boiled hen's egg. Boiling the most verminous garment for one minute will render it completely harmless, and there can be no better or safer treatment for an article the fabric of which would not be damaged by this drastic process. As, however, woollen garments shrink under this treatment, it is necessary for them to use a lower temperature and to allow a longer time for the penetration of the heat. An analogous case is the boiling of a hen's egg. If this is immersed in boiling water for four or five minutes it becomes "hard-boiled." If it is placed in water at a temperature of 165° F. for a sufficiently long time its contents coagulate equally and it becomes "hard-boiled." In the first case where much heat is available penetration is more quickly attained than in the latter, where there is less heat available, but the result in the end is the same. So with lice far lower temperatures than that of boiling water may be used to kill them, but an increasing time must be allowed for the operation the lower the temperature used.

It makes little difference to the result whether the heat is dry or wet, that is, whether the opera-

tion is carried out in a steamer or an oven, as far as the lice alone are concerned. When it is necessary to guard also against the infectivity of their excreta, which always cling to the fibres of infested garments, a steaming heat must be used. The infecting power of the excreta of lice infected with trench fever is not destroyed by the dry heat to which garments are usually exposed. A garment which has been worn by a lousy person who has trench fever, if freed from lice by dry heat as ordinarily used, is liable to cause an attack of the disease in a healthy man who wears it, as the still virulent excreta may enter small scratches (see Chapter XI.). Exposure to wet or dry heat at a temperature of 130° F. (55° C.) for twenty minutes or 140° F. (60° C.) for fifteen minutes will kill all lice and nits, provided that the time is calculated from the moment when penetration of the garment containing them has been completed by the heat. It should not be calculated from the moment at which the garments are put into the chambers. So far as our knowledge at present goes, to destroy the trench fever virus of the excreta and render them harmless a steaming atmosphere of a temperature of 60° C. for twenty minutes is necessary, and this should be the minimum used. Knowledge of the time necessary for the thorough penetration of the garments being treated can only be gained by experiment with the type of hot chamber used.

50 LICE AND THEIR MENACE TO MAN

A number of perfectly satisfactory disinfectors for civilian purposes are on sale by various sanitary engineers, and one or another pattern is to be found at the municipal cleansing stations now established in some places. The proper course for the unfortunate civilian who becomes lousy is to obtain access to one of these, if available, and have his garments treated by experienced hands. In the home it can be done in the baking oven or in a steamer used for boiling clothes. In the former case it is unlikely that there can be any standard of the temperature, and care would have to be taken that the heat was not so great as to scorch or burn the garments. The process would be most safely carried out after the fire had been withdrawn and the oven was cooling, when the articles could be left in overnight. If a boiler or "copper" is used, a wooden stool may be placed in the water so that the seat comes just above the surface, and the clothing may be loosely piled on that. After steam issues freely round the lid the operation should proceed for an hour. Moist heat damages leather goods, and for them dry heat should be used.

As in these operations the heating standard has not been recorded, the appearance of dead lice and nits should be known so that it may be told by inspection whether the vermin on the treated garments are really destroyed. Lice under adverse circumstances, such as immersion in water not sufficiently hot to kill them, have

a habit of becoming unconscious, exhibiting no movement, and the uninitiated may wrongly assume that they are dead. A louse that has been killed by dry heat becomes dark-coloured and brittle, while the egg collapses and turns brown. When killed by wet heat they both become opaque and white. If there is any doubt as to whether the lice are dead or not a few should be placed in a vessel of glass or china, out of which they are unable to crawl, and should be placed in a warm place for a few hours. If alive they may then be seen moving the legs and trying to walk. It is a difficult matter for the inexperienced to decide whether the eggs are killed or not, and it is advisable to be generous with both heat and time in the treatment and so "make assurance double sure."

Cleansing by means of heat is the method most employed in all the armies. In disinfestation of the armies in the field there have been many very real and great difficulties to overcome. One of these was the failure to recognise how essential to the well-being of the troops it is that they should be louse-free, to the benefit of their health as well as their comfort. The disorganisation which wholesale disinfestation caused was therefore considered to be unwarranted. Cleansing stations were often so far removed from the trenches that it was actually impracticable to bring the men to them except when they were resting near a station. These difficulties are not insurmount-

able and much improvement has taken place. If the men cannot be taken to the cleansing stations these should be taken to the men. Each unit should be supplied with a simple cleansing apparatus which should be as mobile as a field kitchen and considered almost as essential. The hot chambers designed by Captain Orr of the Canadian Medical Service, and by Captain Grant and Captain Peacock of the R.A.M.C., which have been found to give such satisfactory results, could easily be modified and put on wheels.

A very simple and portable apparatus which has been found satisfactory is that known as the "Stammers' Serbian Barrel," while another mobile improvisation is the disinfestation train. Early in 1915, when the British Medical Sanitary Mission under Colonel William Hunter, C.B., A.M.S., was sent to Serbia to assist in controlling the terrible epidemics of typhus and typhoid fever which were raging alike in the Serbian Army and among the civil population, it was found necessary to employ disinfestation on a vast scale. No elaborate disinfestors were available, nor the materials from which such could be constructed. Out of what material was to hand these two very effective disinfestors were devised by Lieutenant Colonel G. F. Stammers, and they have been used since in stemming with good effect the outbreaks of relapsing fever in Egypt, which threatened to assume serious proportions. In both the train

and the barrel the effect of current steam is used to destroy the lice. In the case of the train the steam is obtained from the engine, which delivers a generous supply under a pressure of 60-110 lbs. The steam is led by pipes into ordinary iron goods vans, into which it is discharged. The vans are little modified, being merely provided with shelves on which the articles under treatment are stacked. The men whose garments are to be treated bind them all in a bundle in the blanket, and these are placed on the shelves and on the gangway between the shelves, the steam nozzles being left unimpeded. The steam is then turned on and the door closed. The temperature quickly rises to 105° C., and this penetrates right through the bundles, as has been shown by means of thermometers placed in the least accessible parts. The van is not made air-tight, so that little pressure is caused and the excess of steam escapes under the door. At the end of an hour the current of steam is stopped, the door is opened and the kits removed. Since the moisture which at first condensed in the clothing has again become converted into steam, a shake in the open air is all that is necessary to dry the garments, and within two hours of their arrival at the train the men are able to leave with a louse-free outfit. It may be remarked in parenthesis that during this period their bodies should have received attention. A busy fortnight for such a van disinfestor is thus described by Colonel Hunter. "A most striking

illustration of this mobility was afforded in one instance, where a van disinfector, which had just disinfected a division of 18,000 troops in twelve days in one area, went off about 500 miles to a centre in Southern Egypt, where some cases of

FIG. 10.—THE "STAMMERS" OR SERBIAN BARREL.
An improvised disinfector. (After Hunter.)

a, heavy stone; *b*, escaping steam; *c*, wooden grid; *d*, sand-bag collar to conserve steam.

typhus had occurred among the native labourers. It disinfected the whole of the troops and labourers (1500 in number) in three days, and was back at work again in its former area disinfecting another division on the fourth day" (2).

The barrel disinfector was devised three days

after the arrival of the Mission at Nish, and the following week was destroying lice wholesale. It has this great advantage that any small body of men may have a private disinfestor always with them at a very small cost. It consists of an ordinary large wine barrel (Fig. 10), in the bottom of which a number of holes are bored. This is placed over an open boiler (an empty paraffin drum will suffice) in such a manner that the steam can pass freely through the openings into the barrel. A circular sand-bag piping is placed between the boiler and the barrel to prevent the waste of steam. A little distance above the perforated base a wooden grid is constructed, and on this the articles to be treated are placed. The whole is then closed by means of a heavy wooden lid which is weighted down with stones. A barrel of a capacity of sixty gallons will deal with four complete kits or seven blankets at a time. After the steam escaping round the lid is too hot to be borne by the hand an hour is allowed for the thorough treatment of the load.

Ordinary galvanised iron sanitary bins (Fig. 11) were also used in Serbia. A foot of water with an iron grid over it is placed in the bin and the whole over a fire. It is then worked in precisely the same manner as the Stammers' barrel.

The steam disinfestation chamber which was first used in the Canadian Medical Service consists of a chamber with an inner lining of sheet asbestos and an outer layer of corrugated iron

56 LICE AND THEIR MENACE TO MAN

or brick, there being a space of two inches between the lining and the outer wall in order to conserve the heat. By the side of the chamber is a vertical boiler which supplies the steam. The whole structure is built on a concrete floor. From the boiler runs a system of radiator pipes,

FIG. 11.—IMPROVED DISINFESTOR.

An ordinary galvanised iron sanitary bin. (After Hunter.)

a, escaping steam ; *b*, wire grid.

which pass along the sides and roof of the chamber, and a second series run along the floor. From the latter system live steam is allowed to enter by a number of jets. The water condensed flows away by means of a drain in the concrete base. There is a wooden grid raised a little above the floor to allow the operators to move about in

comfort when they load and unload. The material treated is hung loosely on a number of pegs, the garments being turned inside out. In the routine working this chamber is kept constantly hot by means of the radiator pipes. When the operation commences the doors are closed and steam under pressure is allowed to enter through the jets in the floor system of pipes, and the lethal temperature for the lice is quickly attained in all parts of the chamber, the time necessary for this varying with such factors as the size of the chamber, the quality and amount of the load, the size of the boiler, and the steam pressure. This heat is maintained for as long as is necessary, the higher the temperature attained the shorter the period required. A check is kept on this by means of a maximum thermometer, which is wrapped in several thicknesses of blanket and placed in that position which experience shows is the coolest. For the exact working of the machine so as to avoid the waste of fuel caused by supplying more heat than is necessary, a knowledge of the particular type in use must be gained by a series of experiments. At the end of the operation the steam is shut off at the jets, the door is slightly opened, as is also the outlet of the drainage system in the floor, and the dry heat supplied by the radiator system is allowed to act for a few minutes to partially dry the contents.

Although disinfestation by wet heat must, for

58 LICE AND THEIR MENACE TO MAN

reasons given above, be considered the ideal method, among the armies in the field it is not found practicable to use it for the treatment of garments in the winter in Europe, owing to the difficulty of drying them. For this reason hot-air chambers are mainly used now, and an effort is made to raise the temperature in them as high as may be done with safety. One of these is of the form known as the "Russian pit," in which the chamber consists of a large hole dug in the ground in which braziers are placed, the roof being heavily earthed up. Another type consists of a chamber of corrugated iron with a double wall and roof which is built over a pit. The braziers are placed in the pit and the hot air passes through holes in the floor up into the chamber.

The thermometers placed in the chambers record only the highest temperature attained, and not the length of time that the lethal heat has been maintained. Instruments which would do this are too costly and delicate to issue for routine work. There is scope for the ingenious here to invent some simple instrument which would record the necessary data. Bacot has suggested that a piece of paraffin wax of known melting-point and of such a size that it would just entirely melt in the requisite time should be used. Thus if the machine should maintain a temperature of 60° C. for twenty minutes the melting-point of the wax would be 60° C. and a

piece which would just melt entirely in twenty minutes at this temperature would be used, being put into the coolest part of the chamber. If, when the chamber was opened, this was seen to have entirely melted it would be known that the load had been safely treated. If a piece remained floating in the melted wax it would be obvious that there was some flaw in the working of the machine. The same piece of wax, kept in a vessel, could be used time after time.

An ideal disinfestor for army purposes has yet to be invented. Its requisites are: that it should be rapid in operation, attaining the necessary temperature quickly; it should be easy to load and unload; it should be inexpensive in initial cost and in operation; it should be portable. With many patterns there is much time lost in loading and unloading, since the chamber must cool to some extent for the operators to enter, and thus heat is lost. Some of this time would be saved if each chamber was fitted with an extra wooden rack for the clothing, which could be loaded while the machine was operating on the other, and when the latter was finished it could be withdrawn for unloading and the other thrust into its place. An oven of this type would operate nearly twice as quickly as one with a single rack. Such an idea is incorporated in one of the chambers most used in France. In any type the hot air or steam should circulate and not be stationary, as by this means an even

temperature throughout the mass of clothing is more quickly attained.

Treatment by Chemicals and Greases.—Chemicals may be used in relation to lice in two ways: to destroy the lice and nits on clothing and hair, or to repel them and prevent them from establishing themselves. The latter expedient would of course never be used by the person going about in ordinary civil life, as all are disagreeable, but may be found of use to those, such as sanitary inspectors and district nurses, who are particularly liable owing to their vocations to come in contact with lousy people. For the poisoning of lice the type of substance most commonly used is either an oil or a grease, with or without some other active ingredient. Any greasy substance which kills lice may be regarded in a way as a repellant, in that it would destroy any louse which obtained access before it could establish a colony, though it might be able to feed first. Strongly smelling oils such as eucalyptus, certain coal-tar products such as naphthalene and carbolic acid, and some creosoty wood oils such as birch tar oil, are all to some extent repellant in their action on lice. As Bacot (3) showed, they exert only an effect over quite a small radius, and for this reason the wearing of a belt impregnated with such substances, or one or more small bags of them slung in different positions about the body, cannot be expected to be of much use, as their action would be only local and lice could

live and thrive within a few inches of them. It is therefore imperative in using repellant substances to either smear the body over with them or to impregnate the clothing. Several are suitable for this. The naphthalene paste described below may be smeared over the inside of the underclothing, especially along the seams. N.C.I. powder as used in the Army has also a repellant action on lice. One or other of these substances should undoubtedly be used generously by any one whose duty it is to work amongst the sick in any louse-borne epidemic, even if louse-proof overalls are worn. In their absence any grease is an advantage, even rancid butter being used by some people.

Very many substances have been recommended from time to time for the destruction of lice on clothing and the body, and a few of these will be mentioned here.

Lysol is a well-known standard disinfectant which may be purchased from any chemist or prepared by heating together for half an hour equal parts of crude carbolic acid and soft soap. This is used in a 2 per cent solution (1 tablespoonful in $2\frac{1}{2}$ pints of water) for the destruction of lice. At all ordinary temperatures this kills nits in half an hour if the garments containing them are steeped in the solution. The lice, however, survive if the temperature of the fluid is below blood heat, and it should therefore for safety have a temperature of about 104° F.

62 LICE AND THEIR MENACE TO MAN

(40° C.); that is, it should be distinctly hot to the hand, to make certain of the complete destruction of the pest. If it is cooler than this, some of the lice are liable "to come to life" again even after the elapse of twelve hours. The advantages of this treatment by solution instead of by heat are that the necessary standard is more easily attained in ordinary household use, and it may be safely employed for articles which would be damaged by great heat, such as woollen garments, feathers, brushes, etc. For wholesale disinfestation it cannot be said to compare with heat in convenience. Lice killed by this means turn black quickly, while the nits turn brown and shrivel up.

Paraffin (kerosene) and petrol destroy lice and the nits. They are somewhat dangerous in use owing to their inflammability, and petrol is, of course, prohibitive at present. They are for various reasons less satisfactory for the treatment of garments than lysol solution. Clothing should be steeped in them for half an hour to make certain of the destruction of all the vermin.

Naphthalene and soft soap was recommended by Bacot and Copeman, and is used in the Army. The unrefined form of the naphthalene is most effective and is known as "crude unwhizzed naphthalene." Four parts of this are mixed with one part of soft soap, resulting in an unpleasant dirty ointment which is very efficacious. It should be rubbed on the inside of underclothing

and the effect will last several days. It will be found to be equally useful for the head- and crab-louse. It should not, however, be made to supersede treatment by heat. It is an additional remedy and not an alternative one when heat is available.

N.C.I. is a powder composed of crushed naphthalene with 2 per cent creosote and 2 per cent iodoform. It has been used in the Army, and Peacock (4), who carefully investigated its effect, spoke very favourably of it. It should be dusted inside the underclothing, and its killing and deterrent action lasts for several days. It causes a little irritation where the skin is moist.

Vermijelli is a proprietary name for a refined form of a remedy recommended by Professor Maxwell Lefroy, who states that the formula is crude mineral oil $5\frac{1}{2}$ pints, soft soap 3 lbs., water about $\frac{1}{2}$ a pint. This is rubbed all over the body and inside the underclothing. Its action is probably the same as that of any other grease, namely that it runs into the breathing holes of the insects and smothers them. It is less unpleasant in use than most remedies.

Sulphur has an entirely false reputation as a louse-destroyer. It is used by people in the East End of London and amongst hop-pickers, who carry a lump of it in the pocket as a talisman against the pest. A person can, however, eat sulphur, as we have proved, until the odour from the skin is perceptible at a distance of a

64 LICE AND THEIR MENACE TO MAN

couple of feet and until his health begins to suffer, and yet lice fed upon him thrive. It may be considered useless.

Mercury in the form of various ointments has been much used, especially the blue mercurial ointment for crab-lice. It is certainly efficacious, but is rather dangerous to use owing to its absorption by the skin. The naphthalene ointment mentioned above will be found equally effective and perfectly safe.

General Remarks on Disinfestation.—The great principle in all disinfestation is to be thorough. All articles of clothing and bedding which have come in contact with a lousy person should be treated with either heat or solution as described above. The reinfestation of these should be avoided, and care should be taken that they are not laid after cleansing in the spot where they were before the treatment. While these are being treated the body should receive careful attention at the same time. It should be remembered that though a hot bath may alleviate lousiness it is not a cure for it. If a person is liable through his occupation to repeated infestation, as in the case of the armies, it is advisable to remove the body hair. The inconvenience resulting from this has been exaggerated. In this process care should be taken not to lacerate the skin as the trench-fever virus may enter through the cuts. This did indeed happen amongst a body of men in the German army.

Where several people in the same house, or in a class of a school, or an army unit, require disinfestation, the whole process should, as far as possible, be carried out at one and the same time, or the uncleansed may reinfest the cleansed. Every effort should be made to persuade the infested to report their condition to the proper authorities. Soldiers in the field or in training should be instructed to inspect themselves. The author has seen men in hospital with the pubic and axillary hair swarming with lice, and their invariable remark is that they knew nothing of it, and this was the case, as their real disgust at the revelation revealed. The merest glance at themselves, however, would have shown them their condition. Ignorance of their own state is a poor excuse.

Lastly, it cannot be too strongly urged that the louse problem in civilian life is not the same as in the armies, though the remedies are the same. It is simpler, in that cleanliness is more easily attained; that contact of people is less close; that disinfestation disorganises nothing of any importance and need not be hurried. It is more difficult, in that there is less control over the individual, and the unclean pestiferous person, if he can avoid institutions, may spread his vermin far and wide. For these reasons it is better not to pay too much attention to the tales of the returning soldier about the impossibility of getting rid of lice. The problem in the armies is hedged

round with many real difficulties which the authorities are endeavouring to overcome. In civilian life any individual can rid himself of the heaviest infestation in a few hours, and there are many institutions, such as public cleansing stations (though there should be many more), which are provided to give him any help he may need.

Prophylaxis against Louse-borne Disease.—Modern scientists tend more and more to study the prevention of disease rather than its cure. It is difficult, often impossible, to eradicate the germs of a disease from the human body, since the necessary drugs frequently do more harm to the tissues than to the invading organisms. The treatments by means of vaccines and sera are available for only a relatively few diseases, and for many will perhaps never be available. How much better is it, therefore, to endeavour to prevent the initial entry of the organisms into the system than to attempt to eradicate them afterwards. The essence of the prevention of insect-borne diseases is to get rid of the insects which convey them from man to man.

We know that if a man is never bitten by a mosquito he cannot contract malaria; that if he does not allow a tsetse-fly to feed upon him he is safe from sleeping sickness; that if he can avoid rat-fleas he will never fall a victim to bubonic plague. We also know that it is a council of perfection to advise a man to avoid

these things who lives in a country where they abound. Be he never so careful, sooner or later he does get bitten by one of the insects, and if the one that bites happens to be infected with the disease he is liable to contract it. Sanitarians are endeavouring to find one means or another of destroying these insects, and in places with marked success. For example, the work on the Panama Canal was impeded and finally stopped by the two mosquito-borne diseases, malaria and yellow fever, until methods were adopted for preventing the breeding of mosquitoes, with consequent reduction in the incidence of the maladies. The work was then resumed and successfully completed.

The control of mosquitoes is a very difficult matter, involving vast schemes of drainage, and treatment of water that cannot be drained. The complete disappearance of this pest is never to be looked for. The preventive methods must be continued always, or the locality freed from them will become quickly invaded again by the immigration of others from neighbouring localities. The prophylaxis against the sleeping sickness of Africa is even more difficult, since the country involved swarms with large animals on which the tsetse-flies live, and the peculiar breeding habits of the flies make them most difficult insects to attack. In this case it has been found necessary to depopulate the areas where sleeping sickness most prevails, pending some more satis-

68 LICE AND THEIR MENACE TO MAN

factory solution to the problem. Bubonic plague, too, is a most difficult matter, and its solution lies in the complete destruction of rats as a means of getting rid of the great reservoir of infection from which the fleas carry the disease to man. Compared with these, prophylaxis against louse-borne disease is a simple problem, and the prospects of eradicating them from the world are bright compared with those of any other insect-borne disease. In any organised community where the will exists in the administration, lice can be completely exterminated with comparative ease, and their reintroduction may be guarded against by the examination of immigrants.

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CHAPTER VI

THE HEAD-LOUSE (*PEDICULUS CAPITIS*)

THE head-louse is the commonest of the three lice of man in the more cultured countries. It is rather smaller and more slender than the body-louse, with slightly deeper constrictions at the sides of the abdomen, but is otherwise so much like it that it is very difficult to say whether an isolated specimen is one or the other. The distinction between them is rather one of habit than of structure, and entomologists are beginning to regard the two as biological races of one species rather than as distinct species. Probably primitive man, who was much more hairy than his modern descendants, was infested by a louse more resembling the head-louse of to-day than the other, and this was the ancestor of the two races, which split off from one another at some time after the adoption of skins as clothing. Evidence of this is that the claws and gonopods are specially adapted for dealing with hair, not cloth. These two forms of lice will, as Bacot (1) showed, interbreed readily, the males of one variety crossing with the females of the other,

70 LICE AND THEIR MENACE TO MAN

and *vice versa*. This is evidence of their close relationship.

The curious scientist is able to distinguish between them by breeding them in pill-boxes under control, and for the rest it is sufficient to know their distribution on man and to name them one or the other according to their obvious habits. If the lice are found on the garments, and not, or only a few, on the body hair, they are body-lice. If they are in the hair of the head or in that of the body, with none, or very few, on the clothing, they are head-lice. Any on the body hair should, of course, be first distinguished from crab-lice, and this is easily done by the shape. Thirdly, if the lice are numerous on both the clothing and the hair, an infestation by both races is indicated. As with the lice, so with the eggs: if these are few on the body hair and numerous on the clothing they are probably those of the body-louse. If they are numerous on the body hair they are almost certainly those of the head-louse. Nuttall (2) showed that under artificial conditions, if both hair and cloth are available, the head-louse relatively infrequently lays on the cloth, while the body-louse seems to have little preference for one or the other.

Under normal conditions, far and away the most common site in which the head-louse is found is the head. Children are the most frequent sufferers, and, after these, old people. These are the two classes of the community who

are most careless in the care of the person. Females are more often infested than males, as the hair is longer, affording better concealment for the lice. While the insects may be found all over the head, the parts most frequented are the sides, over the ears, and back, rather than on the crown. The eggs are laid attached to the hair close to the scalp, but as the hair on which they are situated grows they become more distant from it, and hatched nits may be found quite a long way from the base of the hairs. It is possible that the eggs may occasionally be laid in hats, attached to the cloth of the lining. In correlation with the smaller size of the parent the eggs of the head-louse are somewhat less than those of the body-louse, and the fecundity is not so great. Otherwise there is little difference between the two races in their life-history and their responses to environment.

The spread of head-lice is by methods similar to those which obtain in body-lice. A person may become infested by stray lice; by coming in contact with a lousy person; by using the brushes or head-gear used by one who harbours the lice; by having had his hat in contact with one containing lice. The cloak-room system of our council schools, where hats are hung on pegs in close proximity, and often several on one peg, lends itself to the dissemination of this insect.

The presence of the first intruder is more likely to be noticed than in the case of the body-

72 LICE AND THEIR MENACE TO MAN

louse, since the scalp is very sensitive to any movement in the hair and a lot of scratching usually accompanies a head infestation. Some primitive tribes who have elaborately arranged hair often use special instruments for scratching the part which itches. The males of the Mashakalumbwe people of Northern Rhodesia work their hair into a kind of cone on the top of the head. This is prolonged into a stiff upstanding string of perhaps three feet in length, and ending in a brightly coloured feather, so that they can locate one another when hunting on the long-grassed plains on which they live. Once built up this head-dress is never taken down again day or night, and a skewer is used to alleviate itching. Many other African tribes carry wooden fork-like combs in their woolly hair, and may often be seen to remove them, use them for scratching, and replace them again.

The best precaution against head-lice is the keeping of the hair cropped very close to the head. It is undoubtedly on account of this manner of wearing the hair short that armies are to-day so little troubled by lice on the head. School children, boys and girls, should be treated in the same way until they reach that age when real cleanliness appeals to them. It is better to dispense with the attractiveness of long hair than to risk the health of the child being seriously damaged, not necessarily by one of the three epidemic diseases discussed in these pages, but

by scalp troubles, such as eczema, so often started by the effects of vermin. A second precaution that is useful is the use of pomades and oils for the hair. All lice hate grease, which runs over their bodies and chokes them. It is not necessary that any medicament should be added to the grease, and some of the so-called louse-destroying pomades are poisonous and dangerous in use.

Many primitive tribes have a habit of greasing heavily both their heads and bodies when fat or oil is available. In Africa, in most native gardens quantities of the castor-oil plant may be seen growing, and apparently the oil produced is used for no other purpose. The author has also seen them, when a hippopotamus has been killed, cut lumps of fat out of the animal and smear themselves from head to foot. Whether these precautions owe their origin to their beneficial results in regard to lice, it is hard to say, but at any rate the benefit accruing to them in this respect is very real.

Mechanical means are more effective for head-lice confined to the head than for the body-lice; but even with these patience is necessary, and it can hardly be expected that an established colony of them can be all removed by the comb at a single operation, as there is a limit to the patience of the sufferer if not to that of the operator. The comb used should have fine teeth, and a little while before the combing the hair and scalp should be thoroughly washed

with vinegar, which loosens the nits though it does not kill them. It has also been recommended by Howlett that the comb should be kept hot by repeated dippings in hot water, since head-lice, like body-lice, are irritated by heat above that of the body temperature, and the hot comb approaching makes them become active, so that they are more easily caught. The head should be held well over a sheet of paper, or better, a large dish, and all that is combed out should be emptied into a fire. Combing should proceed from the outer edge of the hair to the crown, and the instrument should press close against the scalp in each stroke. The successive strokes should not be made haphazard, but should pass gradually round the head, so that each hair from base to tip passes between the teeth of the comb. Where the skin is so much affected that sores have developed thorough combing is too painful, and gentler means should be employed to get rid of the vermin. Under these circumstances the first and foremost thing to do is to cut the hair very short, burning all that is removed. A few protracted washings with a hot solution of 2 per cent lysol (see p. 61) will then destroy any vermin left, and though this is painful it will do good rather than harm. In using hot lysol solution it is better to have the patient lying on the back with the bowl of fluid below the head, and to sponge upwards. The irritation is then less

Lysol is a very penetrating substance, and the fluid is likely to penetrate through the eyelids if it runs into this region.

An old remedy for head-lice is paraffin oil, and this is quite effective and safe, provided precautions are taken to avoid near contact with flame or fire. The hair should be thoroughly wetted with the oil, and then wrapped in a towel arranged turban-wise, or covered by a bathing-cap. After half an hour it should be well washed in warm soap and water, and afterwards combed free of dead lice and nits. As before, this is more readily done if vinegar is also used. This method, if properly carried out, is much more certain than combing alone, any vermin that may escape the comb having been killed, and so mattering little. The naphthalene paste, described in the last chapter, will also be found effective for head-lice if rubbed well into the scalp and hair. The best treatment for head-lice on the body hair is to shave off entirely that infested.

Lastly, in the treatment of this pest, all the head-gear which may have been worn during the infestation should be treated by one of the methods described for clothing in the last chapter, and should not be again assumed after the head has been cleansed until this has been done. The difficulty of getting rid of vermin in the head is often probably due to this precaution not being taken.

REFERENCES

(1) See Ref. (3), Chap. III.

(2) See Ref. (1), Chap. III.

CHAPTER VII

THE CRAB-LOUSE (*PHTHIRUS PUBIS*)

THIS abominable insect (Fig. 12) is very readily distinguished from the two previously discussed,

FIG. 12.—THE CRAB-LOUSE (*PHTHIRUS PUBIS*). Adult male. ($\times 45$.)

both by its shape and its habits. It is smaller

than either of them, speaking of course of the adults of each, its body being only about one-fifteenth of an inch in length and one-thirtieth in breadth, and while the body-louse is about three times as long as broad, the crab-louse in length measures rather less than twice its breadth. Moreover, while the legs of the body-louse are well separated and obviously adapted for balan-

FIG. 13.—CLAW OF THIRD LEG OF CRAB-LOUSE GRASPING PUBIC HAIR.

cing the body in locomotion, those of this species stick straight out, near together, awkwardly from the body. The first pair of legs are slender, while the other two pairs are correspondingly stout, with very strong claws (Fig. 13), most remarkably adapted for clinging on to hair. The inner edges of the claws are strongly serrated, much more so than in the case of the other human lice, and thus they obtain a firmer hold upon the hair as the

roughened surfaces of pliers strengthen so greatly their grip on a piece of wire. They are, in fact, the sloths of the insect world; for just as the legs of these animals have become so adapted for moving from branch to branch in the thick South American forests that they are helpless on the ground, so the crab-louse has become even more modified for its progression in a forest of hair and cannot progress on any other medium. It is indeed one of the most specialised of parasitic insects. To continue the comparison of this with the body-louse, its head is larger in proportion to its body, and there is less distinction between the thorax and the abdomen, there being no "waist" at all. There are three protuberances on each side of the abdomen, two pairs of which bear long hairs, and the insect is altogether more hairy-looking than the body-louse. Often these lice are so thickly encrusted with the dried salts of sweat, which quite obscure them, that they look more like small masses of dirt than insects.

Until very recently indeed little was known about the habits of the crab-louse beyond a few very obvious facts as to the parts they frequent and where their eggs are laid. They cannot be reared in boxes covered with chiffon, as are the other two species, for laboratory work; but Professor Nuttall (1) has recently shown that it is possible to rear them by confining them to the hairs of the leg on a space enclosed by a silk stocking with an elastic garter above and below

them. As a result of his studies he has taught us much about the pest.

Just as the head-louse is usually confined to the head but may establish itself on other parts, so the crab-louse usually frequents the hair of the pubis and peri-anal region, but may be found also, or alternatively, in the armpits, where it is fairly common; on the scattered hair of the trunk and limbs; on the beard and moustache; on the eyebrows and eyelashes; and on the scalp hair. The preceding positions are mentioned in the order of frequency with which the lice are found upon them. On the hair of the head it is very rare indeed, probably because this has such very different qualities from the body hair, such as abundance and calibre.

The eggs (Fig. 6) are laid cemented on to the hairs in a manner similar to those of the other species; but from these they may be distinguished easily, by means of a lens of low power, by their slightly smaller size, their darker colour, and the character of the cap or operculum, which in this species is more conical and symmetrically sculptured by prominent round nodules which cover its whole surface. The cement also covers a larger length of the hair, running considerably below the base of the egg. The eggs hatch in from six to eight days. The newly emerged louse moves at once to the base of the hair on which it was hatched out, and, clinging to this hair alone, buries its mouth parts in the skin and begins to

feed. It does not withdraw its mouth parts, but continues in this one position for about five days, sucking blood intermittently, and keeping itself continually gorged, while it defaecates in a disgusting manner. It moults three times, and after the first moult it moves occasionally for a short distance, but continues to take very protracted and generous meals. It now holds two hairs instead of one, and hangs with its body suspended between them. In moving it always retains a hair in the grasp of the legs of one side until it has established its grip on another by means of those of the other side. This sidling movement, and the ungainly shape of the creature, earned it its popular name. The growth of this louse occupies a little over a fortnight, and the adult female lays an average of about two eggs a day for about another fortnight, by which time it appears to have completed its natural span of life. The insect has therefore a lower fecundity than the others, but its eggs are nearly twice as large in proportion to the size of its body.

An idea is very prevalent that the young crab-louse burrows under the skin. This is not the case; the false impression is gained by its very close adherence to the surface and the difficulty of dislodging it with the fingers.

The spread of the crab-louse is usually by its passage in some form from one sex to the other during coitus, but it may be picked up by other means. It was thought that it was disseminated

by the migration of the lice themselves, and this doubtless does take place; but Nuttall (1) thinks that spread is mainly by means of the egg which becomes detached with the hair to which it is cemented. The hairs of the body are continually being shed and are particularly dislodged by scratching. The dislodgment is not a sudden process unless the hair is pulled out by force, as, when loosened, it remains at first entangled in the other hair and works free by a gradual process. In its youngest stage the louse holds a single hair, but it feeds continually so that if the hair to which it had attached itself came loose it would, if time were allowed, transfer itself to another, the base of which was still in the skin. In the older stages it holds two adjacent hairs, and if one worked loose it would grasp another so that it could keep its mouth against the skin surface. The louse is not therefore very likely to become dislodged with the loose hairs. The egg, however, remains attached to its single hair whether this is drawn out with force or becomes detached and works free slowly. The hairs are particularly liable to be shed about latrines, since the sudden change of temperature causes the irritation of the bites to increase and it is also an opportune moment for scratching. The crinkled shape of the hair makes it very likely to become entangled in other hair or in the clothing of others than the infested person. The lice may also be spread by means of the clothing of the infested

82 LICE AND THEIR MENACE TO MAN

if the garments are assumed by others, unless they have been treated first. After a person has been freed from the lice and the eggs have all been killed, he is liable to reinfest himself if he wears again the clothing untreated which he wore during the attack, since hairs with eggs on them may have been dislodged and remain in the fabric of the garments.

The most effective method of disinfection is to shave off all the hair from the parts affected, at the same time applying some louse-destroying ointment as an additional precaution. At the same time all underclothing worn during the attack should be treated by either heat or hot 2 per cent lysol solution as described for body-lice. Blue mercurial ointment was a very favoured remedy for these lice, but it is not necessary to use so dangerous a substance since the naphthalene paste (p. 62) will be found as effective. It should not be applied to eyelashes; lice and nits in this position should be pulled off with forceps.

Crab-lice have not been shown to convey disease, but this does not necessarily mean that they cannot do so. So far as the author is aware, no experimental work has yet been done with these insects on this line, probably owing to the difficulty of breeding them for experimental purposes. It is possible that they may be able to convey any or all of the diseases carried by body-lice. However, if the excellent case which

Nuttall (1) makes out of the mode of spread of the pest be correct, it could play little part in the development of epidemics. By analogy, young hatching from the eggs should be unable to cause typhus or trench fever, though if the parent were infected with relapsing fever the offspring might be able to convey that complaint (see p. 106).

It is recorded that when numerous these lice may cause a simple fever which disappears when the parasites are removed. It is therefore presumably caused by the action of the salivary juice injected and not by any organism. The bites often cause no itching at all, so that a person may be heavily infested and know nothing of it. In other cases the itching may be very severe, the variation being according to the individual peculiarities of the infested. A curious effect of the bite is that frequently blue patches appear on the skin at the spots where the insect has been feeding (2).

REFERENCES

- (1) NUTTALL, G. H. F. "The Biology of *Phthirus pubis*," *Parasitology*, vol. x. pp. 383-405.
- (2) NUTTALL, G. H. F. "The Pathological Effects of *Phthirus pubis*," *Parasitology*, vol. x. pp. 375-382.

CHAPTER VIII

THE INCREASED MIGRATION OF BODY-LICE IN FEVERS

SOME experiments to study the migration of body-lice from one person to another under certain conditions were carried out by Major W. Byam, R.A.M.C., and the author at the New End Military Hospital, Hampstead, in connection with the investigations into the etiology of trench fever. As the results of these experiments have not previously been published they are given in detail here.

Several writers have drawn attention to the unusual activity of lice when exposed to temperatures higher than those to which they are ordinarily accustomed. We observed that when lice in the glass-bottomed pill-boxes covered by chiffon were being fed on a man in a fever they did not remain on the chiffon against the skin, as they usually do after they have fed, but migrated into the upper parts of the boxes against the glass, as far away from the heat as they could get. What would be the behaviour of the lice

free on the body of a man who develops the fever of one of the louse-borne diseases appeared at once to be a most important question. These lice have obtained the infecting feed of blood either before the temperature has commenced to rise or as it rises. If the rising temperature then caused them to scatter, the spread of the disease would be increasingly accelerated.

Some of the soldiers under treatment at the hospital and the civilians who were allowing us to infect them with trench fever offered themselves for these exceedingly unpleasant experiments, being willing to spend highly uncomfortable nights in the interests of science. The experiments were carried out in a small room with distempered walls and boarded floor. It was not artificially heated, and the work was done in February, when it was cold and raw. A bed was made up on the floor of the room consisting of two mattresses placed side by side and covered by a white blanket, with ordinary pillows and pillow-slips, and four white blankets to cover the men. Into this bed the men, clad in flannelette pyjamas, went in pairs, and two hundred body-lice were released on the abdomen of one of them in the region of the umbilicus. The lice used were in each case adults and well-grown nymphs, since young larvae might have proved difficult to retrieve. The men were instructed not to get out of bed ; not to touch the insects ; to avoid scratching if possible ; to inter-

fere in no way with their roaming. They were also asked to note when and where they were bitten. At the end of each experiment all the bedding was passed through a disinfestor.

Every two hours the temperatures of both men were taken and notes were made as to the condition of their skins, whether moist or dry. Sometimes a brief observation was made on the scattering of the lice at the time of the visits, and the men were questioned as to the biting. The experiments were allowed to proceed for varying periods, generally about sixteen hours, and the lice were then again collected and their distribution on the men and blankets noted under the following headings: (1) outside of top blanket; (2) top, or third, blanket interspace; (3) second blanket interspace; (4) first blanket interspace; (5) blanket above men, under side, those above each man being recorded separately; (6) blanket below men, upper side, the lice below each man being recorded separately; (7) pillows of each; (8) mattresses, also for each man; (9) outside pyjama jacket of each; (10) inside pyjama jacket of each; (11) outside pyjama trousers of each; (12) inside pyjama trousers of each; (13) on the person; and (14) the missing lice which presumably had wandered right away from the bed and had probably crept into the cracks between the boards of the floors. It was found necessary in each case to rip along the tape holes of the pyjama trousers and to open any seams

into which they might have obtained access. In this way complete data of the migrations of the lice were obtained. Six of these experiments were carried out, in three of which the man upon whom the lice were released, called the primary host, was febrile, and in three he was normal. His bed-fellow, the secondary host, was normal in each case. The febrile men were in each case suffering from trench fever.

The details of these experiments are given below. The exact distribution of the lice is not included, to avoid laborious detail. The numbers of the lice in the various positions are given in percentages of the numbers recovered. Those marked "on or about" the host are the ones which were on the body, inside and outside the pyjamas, and on the inner side of the blankets immediately against the men. These also include the small numbers which were on the pillows and between the upper blankets. The lice were assigned to the man to whom they were nearer. Those marked "inside the pyjamas" include the few which were found on the body, an average of less than 1 per cent in the twelve cases, and the ones which were clinging to the garments on the inner side. In one or two cases the men wore undervests, and the lice upon them were included in the count of those inside the pyjamas, without any reference as to which garment harboured them. These results are summarised in the Table, in which are also included the

88 LICE AND THEIR MENACE TO MAN

approximate times at which the secondary hosts were first bitten. The migrations of the lice are also shown in a graphical manner in Charts I. and II. In each of these the successive points on the curves represent the percentages of the numbers of lice in the following positions: (1) inside the pyjamas of the primary host, including the ones on the body; (2) outside the pyjamas of the primary host and on the contiguous blanket surfaces, *i.e.* those which had left him but had not wandered far; (3) outside the pyjamas of the secondary host and on the contiguous blanket surfaces, *i.e.* those which had definitely migrated and which would have presumably passed on to the secondary host for their next feed; (4) inside the pyjamas of the secondary host, *i.e.* those which had migrated and already established themselves on him; (5) those which had wandered far, and for the time being lost themselves between the upper blankets and which might have passed back to either host had the experiment been more protracted; (6) those which were not recovered and which were either overlooked in the search or had left the bed. This last number was fairly constant. The number which had wandered far on the blankets was also fairly constant and very small, except in Experiment 3, owing to the restlessness of the men disarranging the bed, and in Experiment 4, owing to the blankets overlapping and not completely covering one another. It

will be seen that the successive points on the curves represent the relative distance of the migration of the various numbers.

SERIES A.—*In which both the Primary (P.H.) and Secondary Hosts (S.H.) were afebrile.*

Experiment 1.

Temperatures of P.H. :—98·4°-97·8°. Skin normal.

Temperatures of S.H. :—98·3°-98·4°. Skin normal.

The lice were released at 8 P.M., having been last fed five to eight hours previously. They were watched for about half an hour, during which time most of them fed but they did not scatter. In the third hour about twelve had crept outside the pyjamas of P.H., while the majority were still in the original position. S.H. had not felt any on him. In the fifth hour the lice had nearly all left the original site, a few being outside the pyjamas of P.H., who said he had felt them wandering all over his back. S.H. had felt none. In the thirteenth hour P.H. said he had felt them all over him all night and had slept little. S.H. had slept well and did not know he had been bitten till he awoke at dawn. He then felt them walking on his legs and was bitten there. In the sixteenth hour after the commencement the lice were collected, with the following result :

184=92 per cent of the 200 lice were recovered. Of these,

121=65·7 per cent were on or about P.H. ;

63=34·2 per cent were on or about S.H. ;

70=38·0 per cent were inside the pyjamas of P.H. ;

36=19·5 per cent were inside the pyjamas of S.H.

Experiment 2.

Temperatures of P.H. :—97·1°-98·2°. Sweated a little in the night.

Temperatures of S.H. :—98·4°-97·6°. Skin normal.

The lice were released at 7.30 P.M., having been fed

90 LICE AND THEIR MENACE TO MAN

four hours previously. In the third hour P.H. had been much bitten on the abdomen and flanks. Most of the lice were near the original site, a few only outside the pyjamas. S.H. had not felt them. In the morning S.H. said he had slept fairly well and had not been bitten much. He felt the first bite about six hours after the commencement. P.H. had not slept and had been bitten all over. In the seventeenth hour after the commencement the lice were collected, with the following result :

188 = 94 per cent of the 200 lice were recovered. Of these,

147 = 78.7 per cent were on or about P.H.;

41 = 21.2 per cent were on or about S.H.;

79 = 42.0 per cent were inside the pyjamas of P.H.;

10 = 5.3 per cent were inside the pyjamas of S.H.

Experiment 3.

Temperatures of P.H. :—99.0°-97.8°. Skin normal.

Temperatures of S.H. :—98.4°-98.2°. Skin normal.

The lice were released at 7.15 P.M., having been last fed seven hours previously. They showed no inclination to scatter but began feeding at once. In the third hour P.H. had a normal temperature, the rise to 99° being only temporary. Half the lice were in the original position on P.H., who had also been bitten about the body and on the legs. S.H. had not been bitten. In the sixth hour P.H. was being much bitten, while S.H. had felt none, though one or two were on the outside of his pyjamas. He was bitten for the first time very shortly after this visit. In the sixteenth hour after the commencement the lice were collected, with the following result :

159 = 80 per cent of the 200 lice were recovered. Of these,

128 = 80.5 per cent were on or about P.H.;

31 = 19.5 per cent were on or about S.H.;

65 = 40.9 per cent were inside the pyjamas of P.H.;

13 = 8.2 per cent were inside the pyjamas of S.H.

SERIES B.—*In which the Primary Host was febrile, the Secondary Host afebrile.*

Experiment 4.

Temperatures of P.H. :—99·8°, 100·2°, 99·8°, 99·0°.

Skin dry throughout.

Temperatures of S.H. :—98·2°-97·0°. Skin normal.

The lice were released at 8 P.M., having been last fed six hours previously. They showed no inclination to scatter before feeding, which the majority commenced to do at once. In the third hour none were in the original position. A large number were on the blankets and outside the pyjamas of P.H. Some had already bitten S.H. In the morning S.H. complained of being much bitten, especially inside the thighs. In the sixteenth hour after the commencement the lice were collected, with the following result :

167 = 83·5 per cent of the 200 lice were recovered. Of these,

90 = 54 per cent were on or about P.H. ;

77 = 46 per cent were on or about S.H. ;

29 = 17·3 per cent were inside the pyjamas of P.H. ;

16 = 9·6 per cent were inside the pyjamas of S.H.

Experiment 5.

Temperatures of P.H. :—101·4°, 100·4°, 99·8°, 98·8°.

Skin dry throughout.

Temperatures of S.H. :—98·4°-98·2°. Skin normal.

The lice were released at 9.30 P.M., having been last fed six hours previously. They showed no inclination to scatter but began feeding at once. In the third hour P.H. had been much bitten on the body and legs. S.H. had not felt them at the beginning of the third hour but was bitten before its close. In the fifth hour S.H. said he had been much bitten on the abdomen and legs, and several lice were on the outside of his pyjamas. There were none in the original site on P.H. In the seventh hour S.H. was being much bitten on the abdomen,

92 LICE AND THEIR MENACE TO MAN

back, and legs. In the fifteenth hour after the commencement the lice were collected, with the following result :

179 = 89.5 per cent of the 200 lice were recovered. Of these,

101 = 56.4 per cent were on or about P.H. ;

78 = 43.5 per cent were on or about S.H. ;

14 = 7.8 per cent were inside the pyjamas of P.H. ;

33 = 18.4 per cent were inside the pyjamas of S.H.

Experiment 6.

Temperatures of P.H. :—103.4°, 102.7°, 100.4°. Skin dry and burning for the first three hours, then moist with sweat.

Temperatures of S.H. :—98.8°-98.0°. Skin normal.

The lice were released at 2.15 P.M., having been last fed seven hours previously. An unusual activity was noticed amongst them, but about two-thirds commenced feeding. No scattering took place during ten minutes' observation before the men were covered up. In the third hour, when P.H. was examined, very great activity was noticed amongst the lice, which were running round and round with a rapidity which we had never previously noticed in the insects. The majority were still about P.H., but S.H. had been bitten within an hour of the release of the lice. In the fourth hour P.H. said he could feel them running all over him but they were not biting. S.H. was being bitten on the abdomen and legs. In the seventh hour P.H. said he had been bitten once or twice only since the last visit but he could still feel them running about much. S.H. was being much bitten and could feel them walking about over him. In the eighth hour after the commencement the lice were collected, with the following result :

179 = 89.5 per cent of the 200 lice were recovered. Of these,

93 = 51.9 per cent were on or about P.H. ;

86 = 48.0 per cent were on or about S.H. ;

52 = 29.0 per cent were inside the pyjamas of P.H. ;

26 = 14.5 per cent were inside the pyjamas of S.H.

In considering this last result it should be borne in mind that the duration of the experiment was only half that of the previous ones. In spite of this, about half the lice migrated to the neighbourhood of the second man, and the biting on him commenced within an hour. Had this experiment been as prolonged as were the two previous ones, the result would have been even more striking, while, as it was, the migration may have been retarded as the febrile man wore a woollen undervest under his pyjamas, and this was not removed as his fever was high and the afternoon rather chilly. It should also be noted that the fever in his case was higher than in the previous ones, and in correlation with this the lice showed the surprising activity referred to above, and, while they fed at first when very hungry, their first hunger appeased they ceased to do so. In each of the other cases the primary host was being bitten throughout the experiment.

TABLE SHOWING THAT THE MIGRATION OF BODY-LICE IS INCREASED BY FEVER

No. of Experiment.	Date.	Condition and Temperature of Primary Host.	Condition and Temperature of Secondary Host.	Duration of Experiment.	Number of the 200 Lice recovered.	Percentage on or about Primary Host.	Percentage on or about Secondary Host.	Percentage inside Primary Host.	Percentage inside Pyjamas of Secondary Host.	Time when Secondary Host was first bitten.
A 1.	Feb. 6-7	Normal 98.4°-97.8°	Normal 98.3°-98.4°	15½ hours	184	65.7	34.2	38.0	19.5	Unknown, but not in first 5 hours
A 2.	Feb. 12-13	Normal, sweated a little 97.1°-98.2°	Normal 98.4°-97.6°	16½ "	188	78.7	21.2	42.0	5.3	In 6th hour
A 3.	Feb. 14-15	Normal 99.0°-97.8°	Normal 98.4°-98.2°	15¼ "	159	80.5	19.5	40.9	8.2	In 6th hour
B 4.	Feb. 3-4	Febrile 100.2°-99.0°	Normal 98.2°-97.0°	15½ "	167	54.0	46.0	17.3	9.6	In 2nd hour
B 5.	Feb. 9-10	Febrile 101.4°-98.8°	Normal 98.4°-98.2°	14½ "	179	56.4	43.5	7.8	18.4	In 3rd hour
B 6.	Feb. 10	Febrile 103.4°-100.4°	Normal 98.8°-98.0°	7¼ "	179	51.9	48.0	29.0	14.5	In 1st hour

¹ Temporary rise.

CHART I.—ILLUSTRATING THE MIGRATION OF LICE FROM AN AFEBRILE MAN (P.H.) TO AN AFEBRILE BEDFELLOW (S.H.).

96 LICE AND THEIR MENACE TO MAN

CHART II.—ILLUSTRATING THE MIGRATION OF LICE FROM A FEBRILE MAN (P.H.) TO AN AFEBRILE BEDFELLOW (S.H.).

Summary.—The lice were placed on the primary host at the beginning of the experiment, being emptied into a heap on his skin, and had not settled down there as in the case of a man in a normal lousy condition. The results must not be taken to mean that under natural conditions the migration of lice from a man in bed would necessarily be as high as the experiments indicate. That some migration would occur under natural conditions in bed is, however, certain, since there is no obvious reason why these should have been averse to the quarters allotted them on the normal men. Incidentally also, the experiments emphasise the importance of treating the blankets of lousy men in any scheme of disinfection.

There was a very marked difference in the behaviour of the lice in the two series of experiments. This difference was marked by the increased migration from the primary host when he was febrile. This will be seen by reference to Chart III. In this chart the points on the curves represent the migrations of the lice to the same points as in Charts I. and II. The continuous line represents the wanderings of the 600 lice used in Experiments 1 to 3, while the broken line represents the wanderings of those in Experiments 4 to 6. From this it will be seen that when both men were afebrile, 62 per cent of the lice remained on or near the primary host, 35·5 per cent being inside his pyjamas, while

only 20 per cent passed on to or near the secondary host, 9·5 per cent of these being inside the pyjamas. When the primary host was febrile 44 per cent

CHART III.—ILLUSTRATING THE EFFECT OF FEVER ON THE MIGRATION OF LICE.

The continuous line represents the migration when both Primary Host (P.H.) and Secondary Host (S.H.) were afebrile.

The broken line represents the migration when the Primary Host (P.H.) was febrile and the Secondary Host (S.H.) afebrile.

Each curve represents the movements of 600 lice.

of the lice only remained on or near him, 15·5 per cent being inside his pyjamas, while 38·5 per cent passed on to or near the secondary host, 12·5 per cent being inside his pyjamas. The

febrile condition of the primary host nearly doubled the migration. Where the primary host was febrile the second man felt the biting of the lice very much earlier than in the other cases, so soon, in fact, that it is indicated that some of the lice migrated either before they had fed on the febrile man, or at any rate before they had obtained a full meal. Where the first man was normal the interval before the second was bitten was such as to have allowed them to be ready for a second meal after having fed to temporary repletion when first released.

Conclusion.—The temperatures attained in the sufferers from the three diseases carried by lice and characterised by a febrile condition are: typhus fever 103° - 104° , sometimes 105° ; relapsing fever 104° - 105° usually; trench fever commonly 103° and often 104° . It may therefore be taken as proven that the fevers of these maladies tend to increase greatly the shedding of the lice from the patients, quite apart from their deaths, and that this phenomenon is partly accountable for the rapidity with which louse-borne epidemics spread.

CHAPTER IX

RELAPSING FEVER

RELAPSING fever is the name given to a disease which is characterised by an intermittent fever and is caused by a parasite known as a spirochaete. To-day in Europe it is common in Poland, Russia, parts of Austria and the Balkans. In Western Europe it has become very rare in recent years though occasional cases still occur in Ireland. It is found over the greater part of Africa in one form or another, over all Asia except the most tropical parts, and in South America. In North America cases are occasionally recorded, but the disease has never established itself there. Australia has always been apparently free of it. It is a malady of the colder part of the year rather than of the hotter, and epidemics rage chiefly amongst people of the poorer classes. The epidemics have usually been associated with some period of special distress such as a famine, and the disease is sometimes known by the name of "hunger typhus." The characteristics of the sickness vary in the different areas, but to so

small an extent that most authorities are now agreed that they are variations of the same disease. There may be a number of relapses at quite definite intervals in the course of the sickness, and during the intervals the patient often feels well enough to go about. In the European form of the disease there is not usually more than one relapse after the initial attack.

About fifty years ago a German worker, Obermeyer, when examining the blood of a case of relapsing fever saw the minute organisms known as spirochaetes there for the first time. The word spirochaete means "spiral hair" and was given to these organisms on account of their shape. A considerable number of spirochaetes are now known, and a few of them have been proved to cause diseases in man. There has been much controversy as to whether they are members of the Bacteria, which are classed with the Vegetable Kingdom, or of the Protozoa, of the Animal Kingdom, or whether they belong to neither. Those best qualified to come to a decision are to be found speaking on either side and the question must be considered unsettled. Generally speaking, in structure they resemble the Bacteria, and in their life-history Protozoa, but as in some stages they are so minute that they escape the microscope altogether it must be admitted that some of the details of their life-history are based on assumption. The spirochaete is a ribbon-shaped thread-like organism

thrown into waves which are nearly in the same plane, like those of a swimming eel, so that it is not a true spiral. When stained in microscope preparations it is seen to have a core of material which takes a deeper coloration than the enveloping outer sheath. It has, however, no definite nucleus as most Protozoa have. It swims actively about backwards or forwards by means of a corkscrew movement or in waves. It multiplies by splitting either along its whole length or across the middle. At times at one end a small granular swelling is seen, or the whole organism appears to split up into granules. It is considered that these granules represent a stage in the life-history and that they grow again into typical spirochaetes, but the actual change has not been observed. The spirochaete which is the cause of relapsing fever is known as *Spirochaeta recurrentis*, this name being given to it as it cannot be found in the blood between the bouts of fever but recurs when the disease relapses. The parasite is found not only free in the blood but also in the cells of certain tissues, including the white cells of the blood and sometimes in the red cells.

Shortly after Obermeyer reported his discovery it was shown that if the blood of a relapsing fever patient was injected into a healthy man the latter developed the disease. Following on this it was found that the disease could be transmitted similarly to monkeys, rats, and several other animals, and that the parasite could be demon-

strated in their blood. This paved the way for further research, but no further discovery of importance was made until the present decade in regard to the European form of the disease.

Meanwhile in Tropical Africa two workers, Doctors Dutton and Todd, who had been sent out by the Liverpool School of Tropical Medicine, were studying the form of relapsing fever found there, and which Todd thinks is identical with that of the rest of the world. In Central Africa there exists a tick called *Ornithodoros moubata* which has habits similar to those of a bed-bug; that is, it lives in cracks in the walls and floors of the native huts and issues forth at night to suck blood. Full-grown it is about the size of a large pea; its skin is tough, grey, and wrinkled, and it is able to survive many months without taking food. Some of these ticks were fed on cases of relapsing fever and afterwards on susceptible animals, and these in time developed the disease. It was also found that the offspring of such infected ticks (to the third generation) could similarly transmit the malady, the spirochaete passing in some form from the parent to the egg and so to the young. Judging from the analogy of what was then known of the mode of transmission of diseases by insects, the investigators naturally thought that it was by means of the bite itself that the virus was injected into the blood. Some of the infected ticks were brought to the Liverpool School, and a great deal of work

104 LICE AND THEIR MENACE TO MAN

was done with this strain of the parasite. Attempts were made to transmit it by the bites of other vermin, fleas, lice, and bed-bugs. None of these were successful, with the exception of one experiment of Nuttall's, in which a bed-bug was allowed to partly feed on an infected animal and then to complete its meal on another animal while its proboscis was still wet with the blood of the first. The second animal developed the disease, but this did not suggest that this was a normal mode of conveyance of the disease in nature. It was therefore concluded that the *bites* of these vermin did not transmit relapsing fever. Todd now thinks that it is not the actual bite of the tick either which causes it. While the tick is feeding, an operation which occupies two or three hours, a quantity of fluid flows from two glands on the lower side of the body and forms a film between it and the skin. At the same time it discharges from the anus a small quantity of a whitish excrement which mixes with the fluid. Both the fluid and the excrement contain small spirochaetes, and these probably penetrate the wound caused by the bite, thus causing the disease.

Though the bites of lice did not cause relapsing fever it was still thought that the vermin had some connection with the disease, and this was finally proved to be the case by Dr. Sergent, working in Algeria, where it is almost constantly epidemic. He showed that if body-lice were fed

on a relapsing fever patient and were afterwards, under certain conditions, crushed and rubbed into a scratched surface of the skin of a healthy man or animal, the latter will develop the disease. The parasite is equally able to pass through the unbroken moist membranes of the body such as the eye and the inside of the nose. The dissection of the lice which had fed on the infected blood showed that the spirochaetes in the gut become rapidly immobile, appear to degenerate, and within twenty-four hours have all disappeared. For the next seven days no spirochaetes can be found in the louse. About the eighth day they reappear in the coelomic cavity, that is, the space between the gut and the body wall. This phenomenon takes place in about 20 per cent of the lice which have taken the infecting feed. The parasites are at first very small and thin, but they grow to that size which they develop in the blood of man. By the twentieth day from that on which they fed on the relapsing fever patient they have all again disappeared. Throughout this period a person may feed the infected lice on himself with impunity, as the bite of the insect is harmless. For the disease to be caused the louse must be crushed so as to release the parasites which are contained in the body of the insect and which do not appear to pass out unless its skin is broken. A man therefore inoculates himself with the disease by scratching the bites and at the same time crushing the louse. The

106 LICE AND THEIR MENACE TO MAN

lice are capable of transmitting the disease at two periods, firstly, just after they have imbibed the infected blood, and secondly, after the elapse of two or more days. They are most infective on the sixth day after the infection, just before the spirochaetes reappear in them, and from this time the infectivity becomes less until it ceases altogether. As in the case of the tick the offspring of the infected lice are capable of passing on the disease.

Isolated cases of relapsing fever are not of themselves serious things. An average healthy person would not as a rule die from it and it does not usually leave serious after-effects. The drug salvarsan nearly always aborts an attack in a few hours and cures the disease, subsequent relapses being rare. The danger of isolated cases occurring in a country is that in times of misery and distress, in war and in famine, vast epidemics are liable to break out. They are the sparks amongst the tinder, and wretched conditions of life are the wind that blows the sparks into flame. Then, when doctors and nursing staffs are overworked, and the sick, ever increasing, in their already enfeebled condition are unable to throw off the complaint or to receive careful attention, the mortality may be truly frightful. The great epidemics are usually associated with those of typhus, since the conditions favouring the spread of both diseases are the same, as are also, very largely, the areas where they occur. Chart IV.

shows such an association of the two diseases in the recent Roumanian epidemic. The relapsing fever commenced rather before the typhus, and

CHART IV.—CURVES OF THE INCIDENCE OF TYPHUS AND RELAPSING FEVER IN THE SECOND ROUMANIAN ARMY, SHOWING THE ASSOCIATION BETWEEN TWO LOUSE-BORNE DISEASES. (After Wells and Perkins.)

its spread was more rapid, so that it reached its maximum in April and was declining quickly in the following month when the typhus epidemic reached its climax.

CHAPTER X

TYPHUS FEVER

TYPHUS fever, or, to give it its full name, *Typhus exanthematicus*, is a disease which works terrible havoc when it becomes, as it is so liable to do, epidemic. It is characterised by a high fever which lasts for about a fortnight, and a rash, with all the usual manifestations of acute blood-poisoning. The mortality is rather high, as no treatment has yet been found which will prevent the disease from running its normal course. Careful nursing and plenty of fresh air are essential to its successful treatment.

It has been said that a full history of typhus fever since the Middle Ages would be a history of Europe, so closely have the vast epidemics been associated with wars and famines, and so hard on the heels of improvement in social conditions has followed the abatement of the disease. The peoples who lag behind in the improvement in housing and general sanitation reforms are those who still suffer from the ravaging epidemics. Thus in Great Britain and the Western part of Europe generally the disease has almost dis-

appeared, but in Ireland and in Brittany it still lingers endemic, that is, sporadic cases occur which are not due to the immigration of an infected person, but which show that all the essentials for the disease are constantly present. These essentials are, firstly, the presence of lice, and secondly, the actual causative agent of the disease, whatever that may be, lingering either in the lice or in the bodies of those who have once suffered from the malady. To develop an epidemic from these sporadic cases, conditions of unclean living and poor housing, together with a general infestation of lice among the population, are essential. The disease is one which is mainly confined to cold and temperate climates, and those parts of the Tropics where the heat is not intense. In a country such as Mexico the epidemics occur on the hills and not in the hot low-lying coast towns. Similarly in temperate countries the epidemics rage more fiercely in the winter than in the summer. With the exceptions mentioned, typhus has been recorded from the greater part of the world, though Australasia, with the exception of the Celebes Islands, appears to have been spared its ravages. Outbreaks of the disease have not always been recognised as such, probably because the characteristic rash is not obvious on dark skins, and also because diagnosis must rest on symptoms, since modern methods in medicine have failed to find a means of recognising the complaint

either by the microscope or by the reactions of the blood.¹ At the present day it is most common in Poland, Russia, Austria, and Eastern Europe generally, the cooler parts of Asia, Northern Africa, and Mexico. It is uncommon in Canada, the cases which are occasionally reported there being due to small foci of infection set up by infected immigrants, and the conditions in the country not being suitable to widespread epidemics. The same remark applies generally to the United States, though it is definitely established in New York, where it is known as Brill's disease.

That the causative agent of the disease is present in the blood was shown by Moczutovski, who inoculated himself with such blood, suffered from the sickness, and later unfortunately died from the results of the attack. It was later shown that monkeys and rabbits could be infected with the disease by inoculation.

In spite of much careful searching by many brilliant workers the actual agent which causes the disease, that is, the organism which must be present, and multiplying in the body of the patient to cause the intense blood-poisoning, has not yet been certainly discovered. It is improbable that this discovery will be long delayed. Various organisms which have been found in the blood or other tissues have at different times been described as the causative agents, but no proof has been forthcoming.

¹ The Weil-Felix reaction now appears to be an established test.

An investigation into the possible association of body-lice with typhus was made by three French doctors, Nicolle, Blaizot, and Conseil. Body-lice were fed on men and monkeys suffering from typhus, and after a period of a week, during which the virus was developing in them, they were found capable of infecting, by means of their bites, other monkeys on which they were then fed. It was also shown that if the gut contents of such infected lice were removed and spread over a scratched area of skin on a healthy monkey, it developed the disease. It was further proved that if the excreta of the infected lice were collected and inoculated by scratching, an attack of the disease followed. Head-lice equally with body-lice are able to transmit the malady. It would appear that the offspring of the infected lice are not, as in relapsing fever they are, themselves able to hand on the disease, though this is still disputed, one experiment having had a positive result and many negatives being required to discredit one positive.

As soon as this association between lice and typhus fever was proved, all that was known about the spread of the disease fell into line. The theory most popularly held had been that the virus was air-borne, but that a short passage through air sufficed to kill it, a close approximation of the healthy to the infected person being therefore necessary. It was now seen why in times past doctors and nurses were so liable to

contract the complaint, and why with more modern methods of cleansing the patients on admission to hospital this so rarely happened; why those who first handled a patient or his rejected clothing were so likely to develop it; why it was dangerous to sit on the bed of a typhus case; why cold rooms containing the patients were less dangerous to those entering than hot stuffy ones in which lice would be prone to wander; why sporadic cases were not uncommon among dealers in old clothing. The larger aspects of the epidemiology of the disease also became clear. In the great epidemics the people who had been most attacked were those who lived under congested conditions, and people of the tramp class. These are just the ones most liable to harbour lice. Those living in one house might be attacked and those in an adjoining house spared, if they were not on friendly terms and interchanging visits, that is, if there was no opportunity for the passage of lice between them. Epidemics were worse in winter than in summer, and this is the season when lice are most numerous, because clothing is changed less frequently and bathing is less freely indulged in; people keep more indoors; crouch close together over fires; sleep in close proximity, wearing all their clothing, in order to keep warm by night as well as by day. The typhus among the natives of Cape Colony was more prevalent also in the winter, when they slept in huts,

than in the summer, when they spent the night out of doors.

Why armies in the field should have suffered so terribly from louse-borne diseases is obvious, for always the facilities for cleanliness to which the civilian is accustomed are lacking, and under most conditions the troops are congested. Often too, one may say always before the present war, hospital accommodation has been inadequate, sick and wounded have been crowded together in the same waggons, have lain close together in the same tents, often clothed still in the garments in which they fought. Dying in these conditions, they were often not moved for hours, and by this time the lice of the dead would have spread themselves over the living. The great epidemics of typhus and relapsing fever in Europe, when whole communities have been decimated, have generally been the sequel or the accompaniment of either famine or war. Before our fuller knowledge of the mode of spread of these diseases this was thought to be due to the reduced vitality of the population, but this is only partly the case. It is due to an increase in lice. When the general commodities of life become scarce and their prices rise, the poorer part of the population have money for only one thing—food! Clothing gets worn out and cannot be replaced; one garment goes to patch another until the unfortunates are left with a single outfit of rags, filthy because soap cannot be obtained. Inevitably they be-

come lousy, and increasingly so, since some lice are always present to commence the general infestation. Once introduced among them a louse-borne epidemic spreads like wild-fire. We in this country, and our Allies in France and Italy, have mercifully not experienced this condition of things, and are unlikely to do so, for though the cost of things has been much enhanced, famine prices have not been touched, and we have still, most of us, two shirts, one on the back and one in the wash. Our enemies have been less fortunate. The disease was common in Europe to the east of Germany, and naturally occurrences of it were not uncommon in the Russian Army. Cases broke out among the prisoners taken by the Germans, and epidemics started in the prison camps, for these were much overcrowded, and there was little facility for cleanliness in them, while no encouragement to destroy vermin was afforded by the callous authorities. From these we know that the disease spread to the large German cities, including Berlin and Hamburg, but to what extent they prevailed there we do not know. The Germans have been forced to develop the factors necessary for epidemics of typhus and relapsing fever among their civil population owing to the scarcity of soap and of clothing.

The sad story of the Wittenberg Camp is well known. Typhus broke out among our prisoners there, owing to contact with Russian prisoners.

All the German Staff, both administrative and medical, fled at once. The authorities cut off all necessary sanitary supplies, and forbade any communication between the people outside and the unfortunate prisoners. Man after man went down before the disease, and the epidemic spread right through the camp as the calculating brutality of the enemy doubtless intended that it should. Of 800 prisoners who contracted the complaint, 300 died, a heavy mortality which could not have been approached had any facilities been afforded to alleviate the suffering. The Medical Officer in charge, Dr. Aschenbach, visited the camp only once during the six months that the epidemic raged, and then only in a most casual manner. When Major Fry asked him for some simple remedies he turned away with a muttered insult. Of the six British doctors who grappled heroically with the disease, almost with their bare hands, four contracted the fever, and three, Major W. B. Fry and Captains A. C. Sutcliffe and S. Field, died of the malady, while Major A. E. Priestley, C.M.G., and Captains A. C. Vidal and J. La Fayette Lauder survived the horrors and gave to a startled world unshakable testimony of this unspeakable atrocity. There cannot be the slightest excuse for this cynical proceeding. The Germans knew, as we knew, that typhus was spread by lice, and that the epidemic could have been cut short and stamped out a week after its commencement by the dis-

infestation of all the prisoners, and this they would themselves most willingly have performed had the necessary apparatus been provided.

Typhus also wrought sad havoc in Serbia among both soldiers and civilians. There the disease is endemic, a case occurring here and there, year after year. It needed, however, the strained conditions of war to bring it to epidemic proportions. Three attacks from the Austrians the brave armies of our Allies withstood, until in a zone behind the front stretched an area of a congested population of wounded soldiers and refugees with all the supporting organisation of the battle. All the large buildings were converted into hospitals and were filled with the wounded so that the medical services were already strained to the utmost. Then this dread enemy appeared amongst them, spreading throughout, and the Austrians, taking advantage of the advent of this most loathsome ally, were able to sweep through the country, overcoming for a time, but never breaking, the spirit of this proud little nation.

To Doctors H. G. Wells and R. G. Perkins of the American Red Cross Commission in Roumania we owe an excellent account of the rise and fall of one of the worst epidemics of louse-borne diseases which have ever raged, at any rate in recent years. This followed on the invasion of Roumania and the consequent retirement of the army, and the flight of the civil population

before the invading hordes. In Moldavia, a territory normally occupied by about two and a half million people, the population was temporarily doubled by the retreat and the presence of about a million Russian troops. Food was naturally scarce when so many extra mouths had to be filled, and as it was winter the absence of fuel was bitterly felt, while transport was inadequate. The numerous refugees, ill-clothed and badly nourished, were in a pitiable state, crowding together in their dirty rags, and without blankets to keep out the cold. Early in the winter relapsing fever made its appearance and spread rapidly, while in February the more terrible typhus also began to rage in a country where it was previously almost unknown, and consequently was not at first recognised. Both diseases continued to spread, and increase into April and May, when warmer weather and some return of organisation led to their control.

Wells and Perkins write:¹ "Now arose a situation that can only be compared to the descriptions in Defoe's *Journal of the Plague Year*. The stricken population fled hither and thither to escape infection, or to find food, warmth, and shelter, and so they spread the disease until it is probable that nearly a million were infected in a population, including the armies, of something less than 5,000,000. Stories are told of horrors piled on horrors—of trains

¹ *The Journal of the American Medical Association*, March 16, 1918.

stagnating on congested tracks, while in box cars the people were packed so closely together that those who died could not fall, and were removed only when at last the cars were emptied ; of morning searches of the railroad stations and freight yards for the bodies of persons who had crept into corners and expired ; of daily sights of people dying in the streets of Jassy, some from disease and some merely from starvation and exposure. Every hospital and improvised barrack was swarming with typhus cases, and as at first the rush of trouble was too great to permit of prophylaxis, infection spread throughout the buildings, taking not only wounded soldiers, but also doctors, nurses, orderlies, and all divisions of the hospital personnel. In all places the same story of horrors is told. In all, the shortage of beds was so great that usually two beds were placed together to hold three patients across them, while often two more patients were laid on the floor underneath. So short-handed were the hospitals that sometimes it was hardly possible to do more than to pick out the dead to find place for those who were still living. It is said that in the little city of Jassy as many as 500 died in a day. . . Especially disastrous were the first barracks erected for the retreating army. To gain warmth they dug into the ground with only the roof above the soil, and the men slept on a layer of straw covering the floor, lying close together for warmth. In these places

infected lice had an uninterrupted march from one end of the place to the other, and the men came down by scores. And so in the course of a month the disease had spread throughout the country, adding a supreme misery to already unbearable conditions." Owing to the impossibility at the first rapid spread of the epidemic of making any arrangements for the disinfection of the patients admitted to the hospitals a sad proportion of the medical and nursing staff became sufferers from the disease, and 200 of the 1200 medical officers in the country died from typhus. The authors above mentioned pay tribute to the devotion of those whose duties took them amongst the sick, while the Queen went in and out of the wards regardless of the grave risk. Though the warmer weather of early summer made life a little more bearable for the suffering people, and prevented the peasants from herding together so much, thus, together with active measures against the lice, reducing the violence of the plague, it did not entirely cause its disappearance. Sporadic cases continued to occur here and there throughout Moldavia, and it is probable that typhus for a time will be endemic in the country, since the Roumanians are an agricultural people with the habits of peasants and, though not averse to cleanliness, will probably have a difficulty in eradicating the large increase in lice which these terrible times produced.

CHAPTER XI

TRENCH FEVER

By Major W. BYAM, R.A.M.C.

IF not a new disease, at any rate a disease with a new name, has come into prominence during the Great War. As this disease was first recognised by us among men in or near the trenches in France, we gave it the name of Trench Fever. So striking was the localisation of the trouble that it was felt for a long time that the trenches, or conditions of trench life, were essential to the production of this illness. We now know better, for it has been proved beyond doubt that the lice that infest so many of our soldiers are responsible for the carrying of the disease from man to man. At the same time we see why the trenches came to play so important a rôle when the disease first made its appearance, for it requires but little imagination to realise that the man in the fighting line would be the first to become lousy. While face to face with the enemy and living the life of the trenches, clean clothes and hot baths are luxuries to be dreamt

of but in vain, and without them men become verminous no matter who they are if one arrives amongst them with a louse upon him. Another factor also played a part in causing the trenches to spread the malady, for in them men live and sleep in the closest contact, and so it is that lice find no difficulty in passing from man to man, from the diseased to the future victim. As time went on the number of men carrying the germ of trench fever in their blood gradually increased, men infected passed to other areas than the foremost lines, and lice in many quarters had an opportunity of feeding on them, such lice in their turn becoming disseminators of the fever. In this way the disease spread, and attacked men in the field hospitals, in billets, rest camps, and any place where the two essentials for its production were present—men with trench fever in their blood and lice to pass it on to others. Besides being erroneous the giving of this name “trench fever” may prove a serious mistake. To those unfamiliar with the disease the man who has never been in the trenches cannot be suffering from trench fever, and for this reason the spread of the disease to new districts, and among those unfamiliar with its symptoms, will go unrecognised. Should trench fever spread amongst us at home, think how unfortunate such a name might prove to be.

That trench fever might come amongst us is no idle supposition. Many lice are always

present in poorer districts and places where facilities for cleanliness are limited, and unless great care is taken our fighting men will bring home many more. Men still capable of infecting lice that feed on them are returning to their homes every day, and will continue to do so until the disease can be stamped out, or such a treatment for the sufferer discovered that his blood is truly freed from the infection. So far the trouble has been by no means confined to our armies alone. The enemy, who suffers from it too, named it "Volhynia fever," and sometimes "five day fever." The first shows us how widely spread the illness is, the second merely draws attention to a characteristic of the disease which is by no means constant. Neither name is very helpful, or likely to survive when once we know the nature of the germ which produces the illness.

As men have passed from front to front they have taken trench fever with them, till we can say with certainty that all the European theatres of war are involved and that the disease has appeared in Egypt and possibly in Mesopotamia also. There was a time when some amongst us might have thought that this mattered little, as an attack of trench fever was but a simple affair, short-lived and soon forgotten. Even had this been so, the temporary loss in man power to our armies must have been immense; but ask the men who have suffered from trench fever what they

think. Some will tell you that they had fever, very like "flue" or "their old rheumatism" for a few days, and then got back to work; others will say that though the illness was unpleasant while it lasted they recovered pretty well and now only get returns of the old pains on damp days; but here and there will come a sufferer who is quite sure that he "has never been the same man since." Such men as the last will complain of pain and tenderness in the shins, particularly in the evenings or after even a moderate walk; of rheumatic-like pains in the muscles of the limbs or back, and sometimes of similar pains in or around the joints; of being generally below par and underweight; of getting easily fatigued and short of breath on slight exertion; of having headaches; of feeling depressed and nervous, so that things that used to have no effect on them are now actually frightening; of difficulty in getting off to sleep at night, with the result that they cannot rouse themselves at the usual hour in the morning; of palpitation or pain over the heart, cold and sweaty hands and feet, and a general tendency to perspire that is quite unnatural to them. It is not usual for a man to tell you of all these things, and sometimes he will be content to say that he just feels "rotten," but in any case you will have no doubt in your own mind that the man feels far from well. This state of invalidism may have already lasted for months, and of the questions that the future

alone can answer are—how much longer may it last? what may it lead to? At any rate we know that in the bodies of such sufferers the germs of trench fever continue to exist, and that from time to time the disease flares up, giving rise to bouts of fever, with the old pains and depressing after-effects, which are apt to be mistaken for attacks of influenza or rheumatism.

But if this is trench fever in its latest and most obstinate form, how does it appear at the onset? Like the familiar “flue,” trench fever is often upon one most unexpectedly. It is no unusual thing for a man to start the day in his accustomed good health and to be in the midst of his work when he is suddenly stricken down with severe headache behind the eyes, giddiness, weakness in the legs, and pain all over. So sudden may be the onset that a man may fall out of the saddle, or while walking become so weak and giddy that he has difficulty in dragging himself home to bed. In other cases coming events cast their shadows before them, and the victim feels “out of sorts” and complains of headaches for a day or two before the fever has him down. When once in bed the patient finds that he is unable to lie still because he aches all over the small of his back and limbs, his temperature rapidly mounts and may reach 103° or 104° F. or even higher, his tongue is slightly furred, his eyes become pink, and he passes a most uncomfortable day, becoming worse towards evening, when his mind may wander,

and gets no restful sleep throughout the night. As the hours go by his skin begins to grow moist and the pains easier, so that during the following morning comparative comfort is once more regained. But the respite is usually short and once more the fever comes on as night approaches; this time the pain is often not so general but seems to settle in the forehead, small of the back, and legs. The shins in particular are the seat of trouble and often feel as if they were suffering from toothache. Again the night is one of wretchedness and all desire for food has passed away; sweating occurs at intervals and may be profuse, but with it usually comes relief and eventually comfort. On the third evening the fever reasserts itself once more, but rarely with the severity of the first two days, and after that recovery is usually rapid. It is not every one who suffers so severely, yet on the other hand some continue to have fever after the usual three days. A few are lucky and escape with this one bout, but most relapse towards the end of a week from the original onset of the trouble, and go through a somewhat similar experience to that just described. After three weeks most trench fever sufferers are sufficiently recovered to return to work, but others, as already described, pass gradually into a condition of chronic aches and pains, with bursts of fever from time to time. These late fever waves are generally quite short, lasting but a few hours in many cases; they some-

times recur at such regular intervals that the patient can foretell his day of trouble. Every fifth day the fever may return, and so we see the reason for one name the Germans give to the disease, but most often the periods vary and each successive interval tends to become longer than the last.

Now let us turn to the louse once more and see the part it plays in spreading this disease that has caused so much suffering. Experiments performed by McNee and others proved that the germ of trench fever was in the blood of the patient during his attacks of fever. The question was, How did this germ leave the sick man and enter the healthy? Our recent work, carried out for the War Office Trench Fever Research Committee, has done a good deal to clear this mystery up. Several very gallant men came forward to help us in our task, and it is not too much to say that without such help we would have found out nothing, since experimental animals, which are all apparently resistant to trench fever infection, could not be used. These men volunteered to let us try to give them trench fever in any way we thought the disease might spread naturally in the field. The first two men to come forward were W. H. Cole and H. H. Edgeler, and to them great credit is due, as the work for which they offered themselves might, for all they knew, be productive of most unpleasant consequences. Attempts were made to convey trench fever to

these two men by allowing lice taken from trench fever patients to feed on them. Nothing happened though the experiments were continued for many weeks, but as we anxiously watched the men from day to day we were struck by the fact that they never scratched their skin where the lice had bitten. Now the average soldier suffers considerably from the irritation of the lice upon him and scratches himself accordingly. It occurred to us, therefore, that herein might lie the explanation of what, at first, seemed a disappointing failure. Cole and Edgeler were old and tough; the man of military age had a skin that was far more irritable. The latter scratched himself; our volunteers did not. Was scratching an essential to infection? To test this possibility the skin of a new volunteer named D. Sullivan was on 5th February 1918 scratched by means of a needle, and the droppings of the lice feeding on Cole and Edgeler rubbed into it. A week later Sullivan developed trench fever, and as a result the usual method of transmission of the disease had been demonstrated, for we have repeated this and similar experiments many times since with unfailing success. Further work, however, has shown that men bitten by infected lice, but who do not scratch themselves, may in some instances contract trench fever. Such happenings are the exception and not the rule, and are probably the result of lice depositing their droppings on the openings made in the skin by their own bites.

128 LICE AND THEIR MENACE TO MAN

These droppings are partly fluid when passed by the lice, and may be supposed to enter the minute punctures in the skin as they do the lesions caused by scratching. The fact that men who do not scratch themselves when bitten by infective lice develop trench fever at widely varying intervals of time from the day when such lice begin to feed on them, is strong presumptive evidence that it is not the act of biting which conveys the disease. Such infections have been produced after periods varying from sixteen to thirty-five days, whereas when droppings are rubbed into the broken skin the interval which elapses before the fever manifests itself is remarkably constant and is usually eight days. Even when dry these droppings have by no means ceased to be a danger as the disease germ continues to exist in them, and only awaits a suitable opportunity to flourish in another man. Droppings in this state may remain in clothes or blankets for weeks or months and be eventually rubbed or shaken into wounds or scratches of one who has never known a louse. We have ourselves kept droppings of lice for four months and then produced trench fever by introducing them into the skin of a healthy man, which shows how truly infectious they are. And skin wounds are not the only portals for this poisonous dust, the delicate membrane of the eye being an equally open door. Only allow the fine particles to get blown upon the eyeball, and trench fever may be the consequence as we

have proved. In this we see how dangerous a proceeding may be the homely shaking of a blanket used by one who is lousy and a sufferer from the disease.

Adult lice, given two full meals a day and kept at the temperature which exists inside the clothing, each produce daily about eighty fragments of the granular dust into which the excreta ultimately breaks up (Fig. 9). The female louse produces rather more than the male. One thousand of these granules weigh three milligrams. During its life of about forty days the louse therefore produces about ten milligrams. Since it may be transmitting trench fever for the whole of its life, after the shorter or longer incubation period of the virus of the disease in its body, practically the whole of this dust may be of a most dangerous nature, and since we have shown that one-tenth of a milligram is enough to cause an attack of the disease a single louse may produce sufficient to infect almost a hundred men. A soldier who harbours in his clothing five hundred lice, a by no means exceptional number, and has the trench fever germ in his blood, is the indirect means of producing enough infected louse excreta daily to cause an attack of the disease in every man in his battalion, and while much of this is retained in his own clothing much of it is also spread abroad and falls on his comrades.

But still, without the lice there could be no droppings, so that all our energies should be

130 LICE AND THEIR MENACE TO MAN

directed to the destruction of the pest if we would save our armies from a disease which lays low so many of our men, and also protect our children from the evil that might descend even unto the third and fourth generation.

INDEX

- Abdomen of body-louse, 14
 - of crab-louse, 78
 - of head-louse, 69
- African relapsing fever, 103
- Alimentary canal, 15
- American Red Cross Commission, 116
- Anatomy of body-louse, Figs. 1 and 3, 12
 - of crab-louse, 77
 - of head-louse, 69
- Anoplura, 1, 2
- Antennae, 12
- Armies, disinfestation in, 45, 51, 64
 - ideas on lice in, 6, 11, 46
 - inspections in, 65
 - louse-borne disease in, 113, 116, 118, 120, 122
 - lousiness in, 41, 113
- Armpits. *See* Axillary hair
- Aschenbach, 115
- Axillary hair, crab-lice on, 79
 - lice on, 65
- Bacot on disinfestors, 58
 - on fecundity of body-louse, 32
 - on *Pediculus humanus*, 3, 69
 - on repellants, 60, 62
- Baking oven disinfestor, 50
- Barrel disinfestor, Fig. 10, 52, 54
- Baths, not eradicating lousiness, 5, 64
- Beard, crab-lice on, 79
- Bed-bug contrasted with lice as regards finding host, 36
 - infesting dwellings, 39
 - irritation of bite, 7
 - relapsing fever transmitted by, 104
- Beds, disinfestation of, 64, 97
 - lice spread by, 36, 39
 - lice in, movements of, 97
- Belts, impregnated, 60
 - lice biting near, 27
- Birch tar oil, 60
- Bites of lice, 6, 27, 41, 127
 - relapsing fever and, 104
 - trench fever and, 127
 - typhus and, 111
 - of tick, relapsing fever and, 103, 104
- Biting lice, 1
- Blaizot on typhus, 111
- Blankets, eggs of louse on, 40
 - importance of disinfesting, 64, 97
- Blood of louse, 18
 - relapsing fever conveyed by, 102
 - sucking lice, food of, 2
 - trench fever conveyed by, 126
 - typhus conveyed by, 110
- Blue patches, crab-lice causing, 83
- Body, inspection of, 64
- Body hair, characters of, 79
 - eggs of lice on, 21, 42, 64
 - crab-lice on, Fig. 7, 79, 81
 - lice infesting, 70, 75, 79
 - removal of, 64
 - shedding of, 81
- Body-louse, anatomy of, external, Fig. 1, 12
 - internal, Fig. 3, 15
 - breeding of, 31, 32
 - characters of, 11
 - diseases carried by. *See* Diseases
 - dissemination of, 34
 - eggs of. *See* Eggs
 - excreta of. *See* Excreta
 - feeding of, 27
 - geographical distribution of, 43
 - habits of, 21
 - host, finding, 36
 - ignorance about, 4
 - increase of, causes of, 6, 41, 113
 - rate of, 32
 - winter, in, 43, 112
- infestation, 41. *See also* Infestation
- interbreeding with head-louse, 69
- irritation caused by, 6

132 LICE AND THEIR MENACE TO MAN

- Body-louse (*contd.*)—
 life-history of, 24
 migration of, 36, 84
 prevalence of, 3, 35
 rearing of, 32
 relapsing fever transmitted by, 104
 trench fever transmitted by, 121, 127
 typhus transmitted by, 111
 Boiler disinfector, 50
 Boiling water destroying lice, 48
 Bot-flies, dissemination of, 35
 Brill's disease, 110
 British Medical Sanitary Mission, 52
 Bronzing of skin, Fig. 2, 7
 Brushes, disinfestation of, 62
 eggs of hog-louse on, 23
 Brushing, disinfestation by, 18, 45
 dislodging lice, 36
 Butter, rancid, 61
 Byam, Major W., 84
- Carbolie acid, 60, 61
 Cement of eggs of body-louse, 19, 21
 of crab-louse, 79
 Chambers, hot air, 58
 steam, 55
 Chitin, 11, 25
 Circulatory organs, 18
 Claw of body-louse, 14
 of crab-louse, Fig. 13, 77
 Cleansing stations, army, 51, 65
 municipal, 50
 Clothing. *See* Garments
 Coal tar products, 60
 Coelom, spirochaetes in, 105
 Coitus, crab-lice spread by, 80
 of lice, 20, 31
 Combing for head-lice, 73
 Combs alleviating itching, 72
 Conseil on typhus, 111
 Conveyances, lice in, 4, 38
 Copeman on naphthalene, 62
 Copulatory organs, 15, 31
 Corpses, lice leaving, 36, 113
 Crab-louse, Fig. 12, 3, 6, 70, 76
 characters of, 76
 disease and, 82
 disinfestation from, 63, 64, 82
 dissemination of, 80
 eggs of, Fig. 6, 79
 habits of, 79
 irritation caused by, 6
 rearing of, 78
 Crushing of louse and relapsing fever, 105
- Dead lice, appearance of, 50, 62
 Death of louse, causes of, 33
 Defaecation of body-louse, 30
 of head-louse, 80
 Development of body-louse, 24
 of crab-louse, 80
 of head-louse, 71
 Digestive system, 15, 29
 Dirt, relation of lice to, 4, 113
 Diseases, louse-borne, 9, 100, 108, 120
 prophylaxis against, 66, 129
 rapid spread of causes, 99, 106, 113, 121
 salivary juice conveying, 28
 Disinfection of louse excreta, 49
 Disinfectors, 50
 Disinfestation, 44, 97
 armies, in, 46, 51, 65
 blankets, of, 64, 97
 body, of, 47, 64
 chemicals for, 60
 civilian, 50, 65
 clothing, of, 44-65, 75, 82
 crab-lice, from, 63, 64, 82
 general remarks on, 64
 head-lice, from, 64, 73
 household, 50, 62
 sick, of, 112
 tests of, successful, 50, 58
 train, 52
 Disinfectors, hot air, 50, 58
 loading, 59
 steam, 50, 52
 Dissemination of body-louse, 35
 of crab-louse, 80
 of head-louse, 71
 of parasitic insects, 34
 of trench fever, 121
 Distribution. *See* Geog. dist.
 Droppings. *See* Excreta
 Dug-outs, infested, 39
 Dutton on relapsing fever, 103
 Dwellings, infested, 39
- Eczema, 9
 Eggs of body-louse, Fig. 5, 19, 21, 32
 blankets, on, 40
 clothing, on, 42
 empty shell of, 23
 hair of body, on, 42, 70
 hatching of, Fig. 7, 23
 incubation of, 23
 laundry not destroying, 40
 oviposition of, Fig. 4, 22
 seams, in, 45
 of crab-louse, Fig. 6, 79
 dissemination of, 81

- Eggs of head-louse, 71
 of hog-louse on brushes, 23
 Epidemics of louse-borne disease,
 9, 99, 113, 121
 of relapsing fever, 106
 of typhus, 108, 113, 114, 116
 Epidemiology of typhus, 111
 Eucalyptus, 60
 Excreta of body-louse, Fig. 10,
 30, 127
 amount extruded, 129
 garments, on, 49
 scratching inoculating, 111,
 127
 sweat dissolving, 31
 trench fever infected, 129
 disinfection of, 49
 typhus infected, 111
 weight of, 129
 of tick, 104
 Experiments with lice on fevered
 men, 84
 trench fever, 126
 Eye, body-louse, of, 14
 infection through, 105, 128
 Eyebrows, crab-lice on, 79
 Eyelashes, crab-lice on, 79, 82
- Famine, louse-borne disease and,
 100, 106, 113
 Fat body, 20
 Feathers, disinfection of, 62
 Fecundity of body-louse, 32
 of crab-louse, 80
 of head-louse, 71
 Feeding of body-louse, 24, 27
 of crab-louse, 80
 on fevered host, 99
 of horse-flies, 29
 of lice, 2
 of tick, 29
 Female louse, 14, 19, 31
 Fever, crab-lice causing, 83
 lice migrating in, 84
 relapsing, 100
 trench, 108
 typhus, 120
 Field, Capt. S., 115
 Five-day fever, 122
 Fleas, contrasted with lice as
 regards control, difficulty
 of, 67
 feeding habits, 2, 30
 finding host, 36
 infesting dwellings, 39
 irritation of bite, 7
 longevity, 33
 metamorphosis, 24
- Fore-gut, 15
 Fry, Major W. B., 115
- Garments, discarded, lice on,
 36, 38
 disinfestation of. *See* Disinfes-
 tation
 dissemination of lice by, 40,
 71, 81
 famines, scarcity in, 113
 excreta of lice on, 31, 49
 infested, 41
 Geographical distribution of lice,
 43
 relapsing fever, 100
 trench fever, 122
 typhus, 109
 Germany, prison camps of, 9,
 114
 Glands of tick, secretion of, 104
 Glandular troubles caused by lice,
 9
 Gonopods, 15, 21, 69
 Grant, Capt., 52
 Greases, 18, 63, 73
 "Ground lice," 6
- Habits of man, lice in relation to,
 4, 5, 35, 72
 of body-louse, 27, 31
 of crab-louse, 78
 of head-louse, 70
Haematopinus sui. *See* Hog-
 louse
 Haemocoele, 18
 Hair, cropping of, 72. *See also*
 Body hair
 Hamar, Dr., on lice in beds, 39
 Hats, eggs of lice in, 71, 75
 Haustellum, 12, 28
 Head, of body-louse, 12
 of crab-louse, 78
 crab-lice on, 79
 head-lice on, 70
 Head-lice, 3, 69
 characters of, 69
 disinfestation from, 73
 habits of, 70
 prevalence of, 3
 typhus transmitted by, 101
 Heart of insects, 19
 Heat, disinfestation by, 46, 50, 58.
 See also Temperature
 Hind gut, 16
 Hippoboscid flies, dissemination
 of, 35
 Hog-louse, eggs of, on brushes,
 23

134 LICE AND THEIR MENACE TO MAN

- Horse-flies contrasted with lice as regards pain of bite, 29
specialisation to host, 2
Hot air chambers, 58
Hunger typhus, 100
Hunter, Col. W., 52
- Incubation of egg of body-lice, 23
of crab-lice, 79
period in trench fever, 128
Infection of lice by relapsing fever, 104
trench fever, 121
typhus, 111
Infestation, body-lice, by, 41
crab-lice, by, 79
famines increasing, 113
head-lice, by, 3, 70
origin of, 5, 39
troops, of, 41
Influenza, trench fever resembling, 123, 124
Inspections for lice, 10, 42, 65
Iodoform, 63
Ironing, 45
Irritation caused by lice, 6, 27, 71, 81, 83, 127
Itching. *See* Irritation
- Kerosene, 62
Kit-bags, lice in, 40
- Larva of body-lice, 24
of crab-lice, 79
of flea, 24
Latrines, crab-lice spread by, 81
Lauder, Capt. J. La Fayette, 115
Laundry, lice surviving, 40
Leather, disinfection of, 50
Lefroy, Prof., 63
Legs of body-lice, 14
of crab-lice, 77
Lice, bites of. *See* Bites
body hair, on, 65, 70, 79
danger of, 9
dead, appearance of, 51, 62
diseases carried by, 9
ignorance in regard to, 4
migration of, in fever, 84
origin of, 5
species of, infesting man, 3
- Malaria, 66
Male body-lice, 14
Mallophaga, 1
Malpighian tubes, 16
Mashakalumbwe, lice on, 72
McNee on trench fever, 126
- Mercury ointment, 64, 82
Metamorphosis of body-lice, 25
of crab-lice, 25
of flea, 80
Migration of body-lice from corpses, 36, 113
clothing, 36, 40
in fever, 84
of crab-lice, 80
Mobile disinfestors, 53
Moezotovski, 110
Monkeys, human lice on, 2
lousing, 44
Mosquitoes contrasted with lice as regards difficulty of control, 66
feeding habits, 2, 30
skin maggots conveyed by, 35
Moulting of body-lice, 25
of crab-lice, 80
Moustache, crab-lice on, 79
Mouth of louse, 15
- N.C.I., 61, 63
Naphthalene, 60, 62, 75
Nervous system, 17
Neurasthenia caused by lice, 9
Nicolle on typhus, 111
Nits. *See* Eggs
Nose, infection through, 105
Nuttall on biology of crab-lice, 78, 81
on coitus of lice, 31
on dry-storage of clothing, 46
on hatching of egg, 23
on oviposition of louse, 21, 70
on *Pediculus humanus*, 3
on transmission of relapsing fever, 104
- Nymph, 26
- Obermeyer, 101
Oesophagus, 15
Offspring of infected lice, 83, 111
of ticks, 103
Oils, 18, 63, 73
Ointment naphthalene, 62, 75, 82
mercury, 64, 82
Operculum of egg of body-lice, 21
of crab-lice, 79
Ornithodoros moubata, feeding of, 29
habits of, 103
relapsing fever transmitted by, 103
Orr, Capt. H., 52
Ovaries, 19
Oven, 50
Oviposition, 21

- Paraffin, 62, 75
- Parasites, dissemination of, 35
 - of relapsing fever, 101
- Peacock on disinfestors, 52
 - on eggs on blankets, 40
 - on locomotion of lice, 38
 - on lousiness of troops, 41
 - on N.C.I., 63
 - on senses of lice, 37
- Pediculus capitis*, 3, 69
 - corporis*, 3, 11, 21, 34
 - humanus*, 3
 - vestimenti*, 3
- Penis, 20
- Peristalsis of gut, 16, 29
- Perkins on typhus, 116, 117
- Petrol, 62
- Pharynx, 15
- Phthirus pubis*, 3, 76
- Pigs, human lice on, 2
- Pit, Russian, 58
- Plague, 2, 66, 68
- Pomades, 73
- Prevalence of lice, 3, 43, 112
- Priestley, Major A. E., 115
- Prison camps in Germany, 9, 114
- Progression of body-louse, 37
 - of crab-louse, 78, 80
- Protozoa, 101
- Pubic hair, body-louse on, 70
 - crab-louse on, 79
 - head-louse on, 70
- Rat fleas, 2, 66
- Rearing of body-lice, 32
 - of crab-lice, 78
 - of head-lice, 70
- Rectum, 17
- Reinfestation, 64, 65, 75, 82
- Relapses of trench fever, 125
- Relapsing fever, 9, 83, 99, 100
- Repellants, 60
- Reproduction of body-louse, 32
 - of crab-louse, 79
- Reproductive organs, 16, 20
- Respiratory system, 17
- Rheumatism, trench fever resembling, 123, 124
- Roumania, relapsing fever in, 107
 - typhus in, 116
- Russian Army, typhus in, 114
- Russian pit, 58
- Salivary glands, 17
 - secretion of, 28
 - causing fever, 83
- Sanitary bins as disinfestors, 55
- Scratching louse-bites, 7, 9
 - loosening hair, 81
 - infection, causing, 9
 - by relapsing fever, 105
 - by trench fever, 127
 - by typhus, 111
- Scratching sticks, 4
- Serbia, typhus in, 52, 116
- Serbian barrel, 52
- Sergeant on relapsing fever, 104
- Sex of lice, distinctions, 14
- Shaving of body hair, 64, 82
- Shin pain in trench fever, 123, 125
- Sick, cleansing of, 112, 119
- Skin, effects of lice on, 7, 80, 83
 - of louse, 25
- Sleeping sickness, 66
- Sleeplessness caused by lice, 9
- Soap shortage and epidemics, 113
- Soft soap, 62
- Specialisation of lice, 2
- Species of lice infesting man, 3
- Spiracles, 18, 63
- Spirochaetes, 101, 104
- Spread. *See* Dissemination
- Stabber, 15, 28
- Stammers, Lt.-Col. G. F., 52
- Starvation of lice, 37
- Steam chambers, 55
- Storage, disinfestation by, 46
- Sucking lice, 2
- Sulphur, 63
- Superstitions concerning lice, 6, 57
- Sutcliffe, Capt. A. C., 115
- Sweat dissolving louse excreta, 31
 - dried, obscuring crab-lice, 78
- Tabanidae. *See* Horse-flies
- Temperature, disinfection of louse excreta, 49
 - disinfestation, in, 48, 49, 53, 57
 - recording, 58
 - effect on development of louse, 29
 - incubation of egg, 23
 - starvation of louse, 37
 - louse-borne diseases, in, 99, 124
 - lysol solution, of, 61
- Testes, 20
- Tick. *See* *Ornithodoros*
- Todd on relapsing fever, 103, 104
- Tracheae, 17
- Transmission of relapsing fever, 102
 - of trench fever, 127
 - of typhus, 111

136 LICE AND THEIR MENACE TO MAN

- Trench fever, 9, 82, 84, 85, 120
virus in louse excreta, 49, 64, 127
- Trenches associated with trench fever, 120
- Tropics, lice in, 43
- Tsetse-flies contrasted with lice as regards difficulty of control, 66
feeding habits, 2
- Typhus, 9, 28, 52, 54, 83, 106, 108
in Roumania, 116
in Serbia, 52, 54, 116
- Underclothing, disinfection of.
See Disinfection
lice reduced by changing, 4, 35
repellants on, 62
- Vagabond's disease, 8
- Vagina, 20
- Vermijelli, 63
- Vidal, Capt. A. C., 115
- Virus of relapsing fever, 101
of trench fever, 122, 124, 128
of typhus, 110
- Volhynia fever, 122
- Wars causing increase of lice, 6, 35
epidemics of louse-borne disease, 106, 113, 116
- Water, action on lice, 40, 48
- Wells on typhus, 116, 117
- Wet heat, damaging leather, 50
disinfection by, 49, 57
- Wind disseminating lice, 36
- Wittenberg Camp, 114
- Yellow fever, 67

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