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THE LOUSE PROBLEM

AT THE

WESTERN FRONT,

BY

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THE LOUSE PROBLEM AT THE WESTERN FRONT.

The insect dealt with in this paper is the clothes or body louse—*Pediculus humanus*, Linnaeus; order *Anoplura* or *Siphunculata*. The writer proposes to record observations on its natural history, its bionomics in relation to troops on active service, as well as to suggest measures for its prevention and destruction.

ENTOMOLOGICAL.

MORPHOLOGY.

Technique.—Microscopical preparations were made as follows:—the insects were chloroformed, fixed in formalin (10 per cent.) for a day, brought through the alcohols (50 per cent., 70 per cent., 90 per cent., absolute), cleared in xylol for a day or two, and mounted in Canada balsam. The drawings have been carefully drawn, and are as detailed and accurate as opportunity has permitted, but further work will, no doubt, reveal other features which may necessitate slight additions and modifications to them. The musculature and mouth-parts, for instance, are not fully worked out.

The nomenclature of the parts may possibly need correction. As the writer is not aware of any other detailed drawings of this insect, it is hoped that these will be of utility. For bench room and facilities to finish certain microscopical and recording work, the writer wishes to acknowledge the kindness of Captain MacNee, R.A.M.C.

External Characters.

Only the most significant features are dealt with. The female is the larger, being about four millimetres in length, while the male is about three millimetres. The proportion of the sexes is about equal. Soldiers speak of *black* and *grey* lice, and, with regard to the question whether these are different species, no distinctive features have been discovered which would necessitate separate classification. The black louse has a more dusky integument, the edges of the body are darkly pigmented, and the dorsal regions of the segments darkly patched. Murray gives the information that the different-coloured races of men have lice coloured to match. On the question whether the black variety exists peculiarly at the Front or more abundantly in proportion than in England there is no evidence available. One thousand eight hundred lice counted yielded 5.4 per cent. black. The bristles.

of which there are two kinds, long and short, are placed all over the body, are somewhat sparse in number, and roughly symmetrically arranged.

Head (see diagrams).—This bears the very simple sensory organs, the antennæ and the black eyes. The entrance to the alimentary

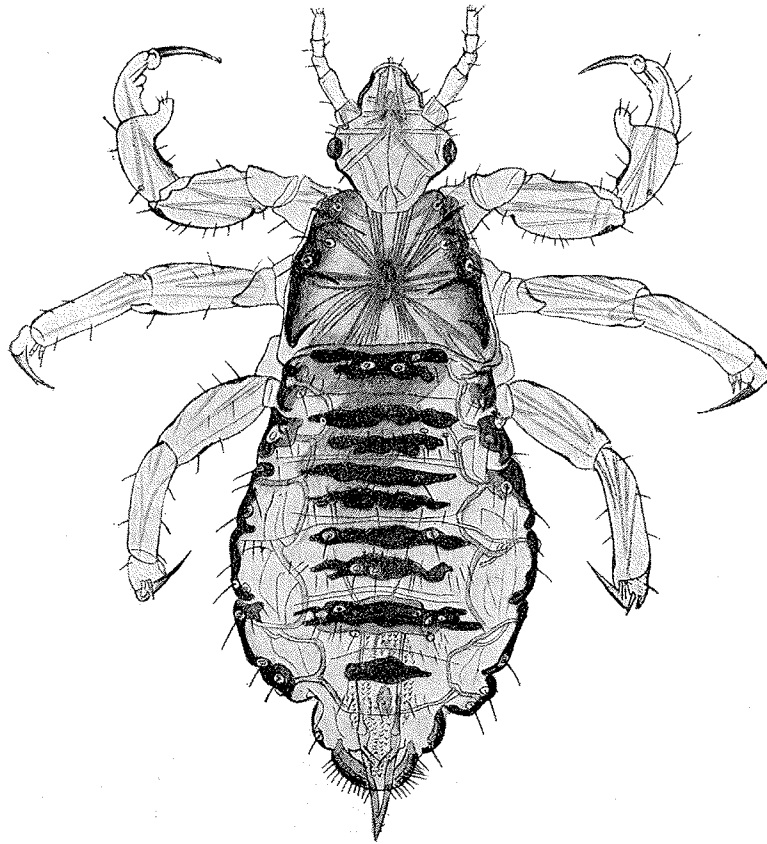


FIG. 1.—The clothes louse (*Pediculus humanus*, Linnaeus [synonym, *P. vestimenti*]). Male; black variety; enlarged about 60 times. Drawing made from cleared specimen, viewed dorsally, and seen by transmitted light.

canal is at the anterior end of the tubular chitinous mouth-part (5), which is nearly surrounded by a projecting sheath (1). This sheath arises from a thin chitinous diaphragm which forms the greater portion of the anterior part of the head. The dorsal margin overhangs

and forms a blunt rostrum (2). Ventrally are a pair of chitinous structures of unknown significance.

Thorax.—The three thoracic segments are fused and their boundaries are not sharply marked off. Mid-dorsally is an invagination. There are three pairs of strong legs which each end in sharp, powerful grappels and spines.

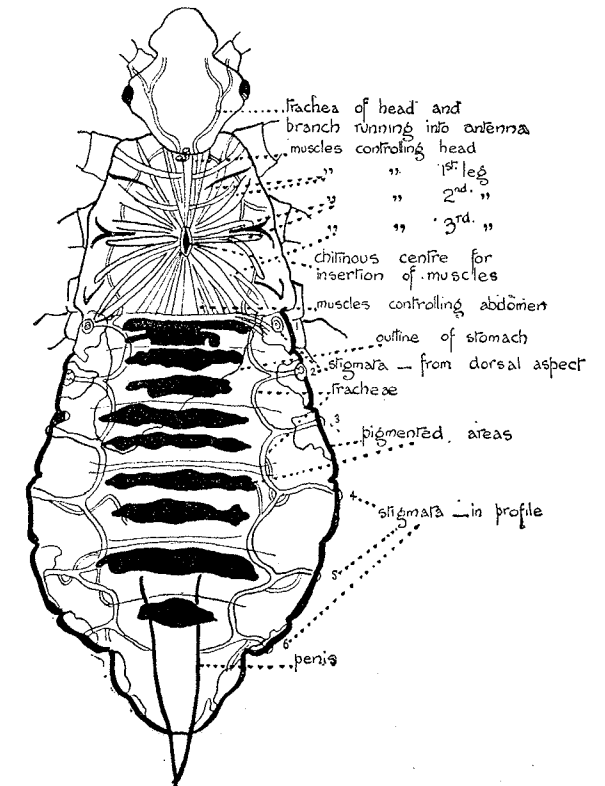


FIG. 2 (key to fig. 1).

Abdomen.—There are eight segments, the two posterior being fused. Each of the first six bears a breathing-hole, the stigma, on either side. The male is pointed at the posterior, and the sharp tip of the penis may often be seen extruded. The female's posterior is bi-lobed, and ventrally shows a pair of tooth-like appendages, the gonopods, which assist in copulation. In both sexes the anal region is fringed with numerous bristles.

Internal Characters.

Mouth-parts.—The interesting question of the homologies of the mouth-parts the writer desires to leave till a more appropriate season, and in the absence of knowledge on this point it would be best to use non-technical terms. The chitinous mouth-parts are—(1) an

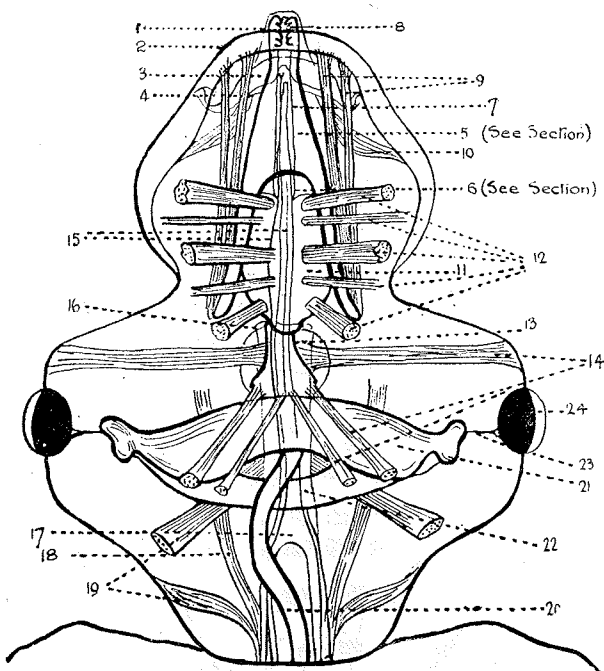


FIG. 3.—Diagram showing anatomy of head; dorsal aspect. Drawn from sections and cleared specimens; sections cut by Lieutenant J. Shaw Dunn, R.A.M.C. (1) Protective sheath—incomplete tube; (2) projecting anterior dorsal margin of head; (3) paired anterior ventral structure; (4) anterior ventral margin of head; (5) chitinous outer mouth-part, with (6) its tube running forward (7) and terminal teeth (8); (9) protractor muscles of outer mouth-part, and (10) retractor muscles (?); (11) first pharynx, and (12) muscles; (13) second pharynx, and (14) muscles; (15) the two structures of the inner mouth-parts, the dorsal being thin and broad, the ventral narrower and thicker, with three (?) terminal points; (16) ventral sac lodging the inner mouth-parts; (17) bifurcated posterior ends of inner mouth-parts; (18) protractor muscles (?) of sac; (19) retractor muscles (?) of sac; (20) oesophagus—dorsal; (21) supra-oesophageal brain, and (22) sub-oesophageal portion; (23) optic nerve; (24) eye.

outer structure adapted for sucking and for supporting the first pharynx; (2) two inner structures adapted for stabbing.

The strong outer apparatus is tubular for a certain length at the mouth end. When the insect is not feeding the entrance is lined with sharp chitinous teeth, seated in tissue and pointing inwards.

When feeding, the outer structure is thrust forward a little, so that the mouth region projects beyond the protective sheath. This action, in some way, appears to relax the tissue bearing the teeth, and these,

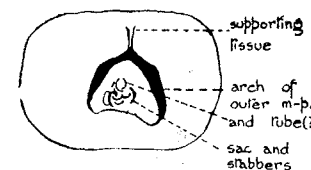


FIG. 4.—Transverse section through head at region 5 of fig. 3.

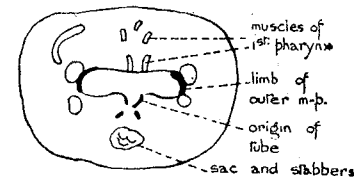


FIG. 5.—Transverse section through head at region 6 of fig. 3.

instead of lining the mouth, come to fringe it and point outwards. The first half of the outer structure dorsally is an arch which forms the roof of the beginning of the gullet. Backwards from the arch

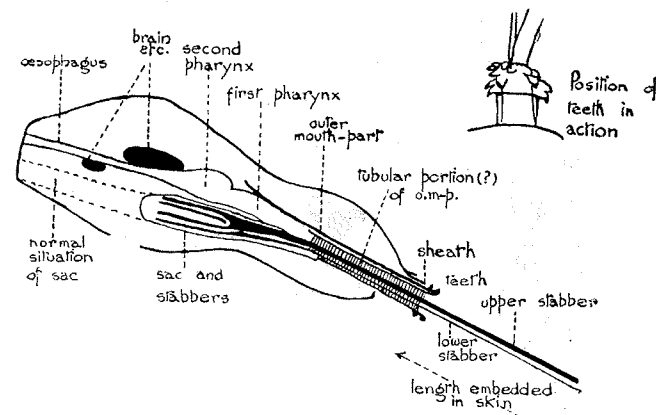


FIG. 6.—Diagram to illustrate mouth-parts in action.

run two limbs, to which are attached the protractor muscles which out-thrust the structure. They also support the sides of the first pharynx. In the arch run two curved walls, which appear to have

their origin just ventral to where the arch bifurcates and in the floor of the pharynx. Within these two curved walls lie the anterior portions of the two stabbing organs.

The inner mouth-parts, the two stabbing organs, are lodged in a tubular sac lying below the oesophagus, and extending from the back

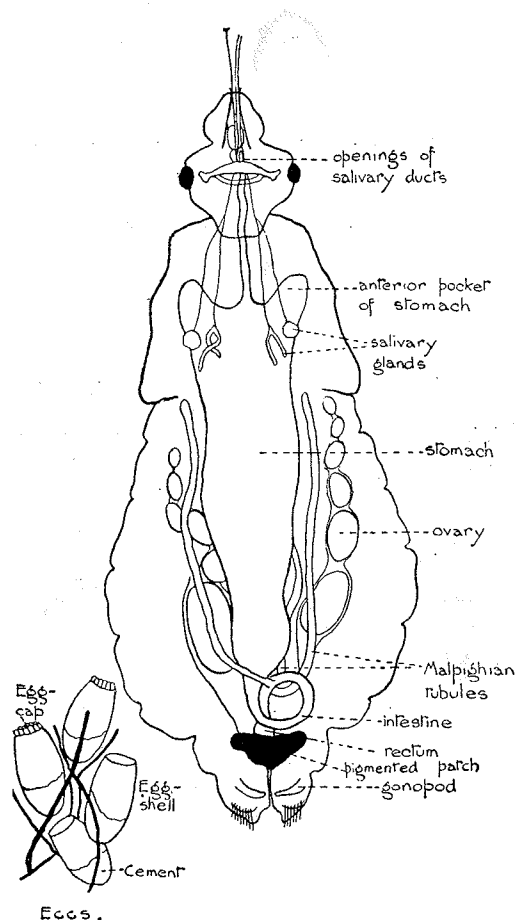


FIG. 7.—Diagram showing internal anatomy of female; ventral aspect. Drawn from dissections and cleared specimens.

of the head to the first pharynx. They are similar in so far as both are flexible, long—nearly the length of the head—enter the first pharynx together, and bifurcate posteriorly. They vary in detail.

The uppermost resembles a thin, broad chisel, double grooved along part (?) of its length. The lower is like a gouge bit, the tip being three-pointed. Protractor and retractor muscles bring the apparatus in and out of action.

Alimentary Canal.—The writer does not fully understand the relationships of the various structures composing the canal anterior to the first pharynx. It would seem, however, when human blood is being in-sucked, that a gutter or tube is formed, having for sides the curved structures of the outer mouth-parts, and, for a floor, the posterior length of the broad stabbing organ. It is possible, too, that the under stabbing organ becomes closely apposed to the upper, so forming a narrow tube leading to the wound.

Following this tube is the first pharynx, which has muscular walls and is lined with chitin. Its function as a pump is secured by the action of five pairs of muscles which diverge from it dorsally. The second and smaller pharynx resembles the first. It leads to a narrow gullet which opens into the stomach.

For information concerning the salivary glands the writer is indebted to Major Sydney Rowland, R.A.M.C. The glands are situated far back in the thorax, and consist of two on each side, one bifurcated and one globular. The duct from the bifurcated gland joins with that of the accessory gland to form a single duct, and this opens into the sac of the stabbing organs.

The stomach is of very large capacity. Anteriorly it has two pockets. A short, narrow, single-looped intestine follows and leads to a slight swelling, the beginning of the rectum. Into the intestine open eight excretory Malpighian tubules. A short rectum ends at the anus.

Circulatory System.—This is probably typical, a long tubular heart lying in a pericardial space dorsal to the gut, with few vessels and large blood sinuses.

Respiratory System.—The lateral stigmata lead to the tracheæ, which branch to smaller vessels to ramify in the tissues.

Nervous System.—The brain lies behind the second pharynx, above the gullet, and is connected by lateral commissures to a suboesophageal portion. Backward from the suboesophageal ganglia runs the ventral nerve cord. An optic nerve runs from the brain to the eye. The antennæ are sensory. Apart from these there is a marked absence of any structures denoting special sense.

Reproductive System.—With the exception of the penis the reproductive organs of the male have not been noted. Of the female only the eight (?) ovaries have been noticed. They are long tubes containing ova at various stages of development.

Insects, &c., Resembling Lice.

Many insects, &c., found in dug-outs at first and casual glance may be easily mistaken for lice. The *wood-louse* or *slater*, a crustacean related to the crabs and lobsters, is regarded as an ancestral or originative type of louse.

Springtails, primitive insects which move by leaping, resemble lice when at rest. Certain small beetles may be taken for adult lice, and

small mites, relatives of the spiders, look like young lice. These mites are very common in food which has been trodden into empty sand-bags and the floors of dug-outs.

HABITS.

Habitat.—For shelter the louse depends upon the clothing, particularly the garments worn next the body, and prefers the comfort of the seams. Soldiers express a habit of the insect graphically when they say "it digs itself in," and for this purpose the beautiful musculature and the strong claws and spines of the legs are admirably adapted. The shirt is preferred, but in many cases most eggs are found at the fork of the trousers. This is because the trousers are worn consecutively for a much longer period than the shirt. In order of importance the areas most favoured for egg-laying are the fork of the trousers and the armpits, and the triangles at the tail of the shirt. Next are the trousers, the shirt seams and then the neck, but under present conditions there is general distribution also. Eggs have even been found in the beads of rosaries. It will be noticed that the insect accumulates where there is plenty of warmth, plenty of humidity and plenty of shelter.

The possibilities of infestation are instanced in a case examined at a hospital. Apart from extreme lousiness of underclothing, the man actually had lice and eggs at the back of the neck of the tunic, the pocket seams inside the tunic, and the flap seams of the pockets. A walking distributing agent!

Alimentation.—The insect feeds by sucking human blood, and adult lice may suck for twenty minutes at one time. They feed voraciously and wastefully, their excreta often consisting of what appears to be undigested human blood. The peristalsis is violent, and the whole alimentary canal may move backwards and forwards while feeding is in progress. Young lice feed immediately on hatching. In consonance with Warburton's experiments, it was found that the young may be reared by feeding twice a day on the arm. They suck for any length of time between nine and twenty-two minutes averaging twelve. If allowed to feed three times a day they do not suck so long at one time.

The process seems to be: The stabbing organs are out-thrust, pierce deeply, and the sucking tube is anchored by the circum-oral teeth to the skin; by means of muscular action on each pharynx the blood is drawn in; leakage into the sac of the stabbing organs is prevented by the upper stabber; the saliva pours into the sac, and possibly via a tube formed by the upper and lower stabbers reaches the wound and prevents the coagulation of blood; the blood is digested in the stomach and intestine; the waste products from the gut and Malpighian tubules pass through the rectum and anus.

Life-history.—Concerning this it has not been possible to conduct many experiments.

In copulation the male lies below the female. The penis is extruded, up-curved, and is retained in position by the gonopods of the female. The eggs are about 0.8 millimetre long and 0.3 millimetre in diameter, and, according to Warburton, one female lays

five at one sitting and may produce a total of 125. They are clear and glistening when new, but towards the time of hatching appear a yellowish brown, due to the colour of the developing insect inside. The experimental method of incubation was as follows: Small pieces of shirt-seam bearing undisturbed eggs were placed in calico bags. These were tightly fastened with string to prevent the escape of any newly hatched young. The bags were slung next the body under the armpits and examined twice a day, morning and evening. The conditions, therefore, were almost natural.

One exact result of importance: A fortunate chance gave six newly laid eggs. One young hatched out in six days, three in about seven days, one in seven days and a half, and one in eight days.

A total of 291 eggs, of unknown age, taken in situ on eight pieces of shirt which had been discarded for about one day, yielded after two days' incubation the following:—

(1) A constant succession of hatchings each day of 9, 28, 33, 24, 10, 11, 20, 7, 72, 5.

(2) Total percentage hatched, eighty-two per cent.

(3) The greatest number took at least ten days to hatch. (Perhaps the one day's separation of the shirt from the body inhibited development.)

(4) Incubation may often take at least twelve days.

The attempts to rear the young in calico bags carried at the armpits and by freeing to feed twice a day were not very successful. The results differ, in certain respects, from those of Warburton. The first moult took place at various periods—*e.g.*, about two days in one case, after three days in one case, five days in one case, and seven days in one case. One specimen lived fifteen days and moulted twice, the first time on the fifth day and the second time on the seventh. It looked only half-grown at the end of the time which Warburton suggests to be the limit of growth. The conditions of the experiments were almost natural, and the heavy mortality of the young is rather baffling and disappointing. It may be that the young are especially susceptible to even the slightest confinement.

Vitality.—The duration of life on the body is not known. Warburton kept a mature female alive for thirty days. This would make the total length of life about seven to eight weeks. The duration is said to be dependent upon three factors: abundance of food, the normal body temperature, and body emanations. Kept at 37° C. dry heat in a bacteriological incubator, lice die in about three days. Specimens were fed twice a day and kept on a piece of clean shirt in a cardboard cylinder. This was carried under the armpit, so ensuring body temperature without body moisture. The insects died in about five days. Body moisture, therefore, seems necessary to the insects, but what is the more essential, the humidity only or the chemical quality, is not known to the writer. To these factors it is proposed to add freedom. Even under the very slight restraints imposed during experiments, the adult insects died quickly, that is, in two or three days. *As a result of many experiments it was found that the longest period during which lice survived separation from the human body was nearly nine days.*

The following results were noted :—

On an infested shirt, newly discarded and exposed to the open, during which the temperature varied between 40° F. and 45° F., two days being raw and wet, lice lived as long as five days.

On infested shirts, taken singly and stored in large Army biscuit tins or in brown paper parcels, they may live about seven days; on shirts stored in bulk, eight days.

Placed upon freshly won soil, they live seven days. On a piece of shirt which was placed upon soil in a large biscuit tin they lived eight days. Dry soil to the depth of two inches was placed on the bottom of a box 2 feet by 1½ feet by 1½ feet, and covering the soil were laid pieces of wood, so imitating in miniature the conditions of a dug-out. A lousy shirt was placed in the box. The lice congregated upon the uppermost part of the shirt and remained there alive for eight days.

A constant feature is the moribund condition into which the insects sink after two days' separation from the body. This condition lasts till death. On taking a moribund louse and placing it on the arm, there is evinced a quick response. The insect begins to take a distinct interest in life and shows it by perambulation and feeding. In connexion with this "warmth test" it is important to note that it may need to last quite five minutes at times.

With regard to vitality when subjected to various insecticides, these results were noted (*see* Section "Methods of Prevention and Destruction") :—

Infested shirts dusted with a white mercury powder, advertised as a vermicide, still held live lice at the end of four days. A similar test, using a powder of heavy oil residue (sulphonated), talc and aloes, gave the result that the lice lived nearly nine days. The insects crawled regardlessly through both powders. Placed upon a small piece of shirt in a pill-box, the bottom of which was smeared with vermijelli, they died in two hours, not having sense enough to keep away from the insecticide. They were killed by suffocation, their bodies becoming sticky with the preparation and the stigmata choked. Similarly placed above N.C.I. powder, they died in half an hour. A single infested shirt dusted with N.C.I. did not hold a live louse in ten hours. Shirts, each dusted with N.C.I. and stored in bundles of ten, each bundle being dusted above and below, did not contain live lice after three days. An infested shirt was immersed for half an hour in an emulsion of soapy water and crude paraffin oil (0.75 per cent. of emulsion being oil). The lice revived and lived in pill-boxes for seven days.

The maximum time during which eggs away from the body may remain dormant has been found by Warburton to be about forty days. This was under laboratory conditions in England, and the temperature fell at times below freezing point. Similar experiments were carried out here, shirts holding eggs being exposed to weather conditions. Samples taken from one shirt which had been exposed for eight days hatched after four or five days' incubation on the body. During the time of exposure the temperature fell twice to freezing point, and two days were raw and wet. Samples taken from a shirt

exposed thirteen days did not hatch after twenty-eight days' incubation.

In applying this knowledge the important fact is that eggs on the clothing, particularly the outer garments, if not treated regularly by ironing or disinfection, are a possible source of infestation for as long as a month after laying. Also, the removal of the clothing from the body for a few days in order to kill the eggs and lice by exposure is not a practicable scheme.

The existing scanty information on the parasite's powers of endurance indicates them to be small. The examples cited, however, show that these powers are by no means inconsiderable.

The louse, therefore, is a parasite which is utterly dependent upon man's blood for sustenance and man's body and clothing for prolonged prosperous longevity and reproduction.

INSTINCTS.

Migration.—To discover the capabilities of the louse with regard to its powers of locomotion and distribution, the following simple experiments were made: On four occasions, for a period of at least one hour, the tracks of four lice were charted. The diagrams illustrate two typical results.

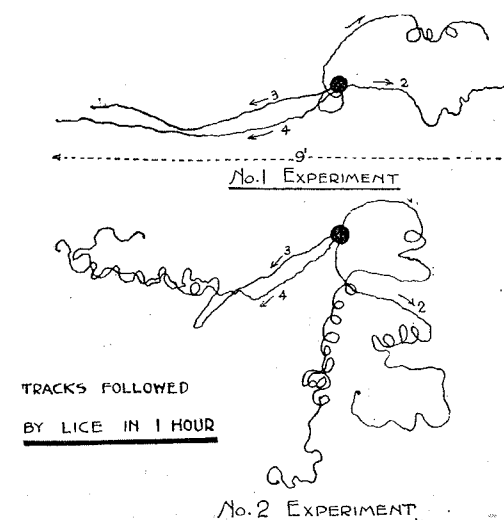


FIG. 8.—Tracks of lice. The breadth of the diagram represents nine feet.

The distance between the two lice farthest apart, was nine feet, two covering a distance, measured in a straight line, of five feet. The routes pursued were decidedly devious and exploratory. There was no desire evinced to make for a recently discarded shirt which

was laid as bait six and twelve inches from the insects. These experiments demonstrate how, under certain conditions, the louse may go far afield to find a local habitation and a means of livelihood.

It has been observed that the insects may climb the wall of a room to a height of three feet.

A box was made into a miniature dug-out; twenty lice were placed in it and watched with very short breaks for eight hours. The insects scattered quickly, roamed round, and twelve in all left the box within half an hour. The remainder were lost. In another case, in which straw was placed in the box, only two migrated after two hours. After twenty-four hours two were found on the straw and six on the boards. The remaining ten were lost.

Such migratory powers are most probably only fully exerted in times of stress. This is borne out by their curious habits of "congregating." Whenever lice upon discarded clothing were the subject of experiment, most of them invariably made for the uppermost portion of the material and showed no desire to forsake it. There is, therefore, a decided preference for warm material. On a shirt in a condition generally termed "walking" were computed ten thousand live lice. This would indicate gregarious habit and comfortable inertia, and that competition is no incentive to migration.

Lice certainly do wander from the host. Although no experiments have been performed with the definite aim of ascertaining the stimulus of wandering, five months' experience with the insects suggests that if the surroundings of the host be warm and comfortable, lice are tempted to wander about. Such conditions exist in a warm bed, or when soldiers are packed closely together. The insect, though moving about, is in its native air all the time, and there is not the adventure of changing an environment. In such a manner a bed may be infested through the louse not being fortunate enough to return to the host before he leaves the bed, and also other men, clean or otherwise, may become infected.

Selection and Preference.—Lice soon find the body if the host sleeps on any infested bedding. The discovery of the host may be due to three causes: (1) The warming of the bed giving the incentive to wandering; (2) contact of the lice and the body; (3) the insect "scenting" the host. Which is the most important factor is not known. A deliberate effort to reach the human body or recently discarded and sweat-impregnated clothing has never been observed. The instincts of detecting and pursuing the host seem, therefore, to be very feeble, if not absent.

These instincts being at best so feeble, it seems still more improbable that the parasite has any instinct of preference, *i.e.*, as popularly expressed, "choosing one person rather than another." Three types suffer most from lice—the person badly infested, the person with a very sensitive skin, and the person who has never been verminous before. The first type may be an unfortunate soldier, physically unclean, through campaigner's luck, or may be a man of unclean habits, in both cases the parasites having every opportunity for success. In the other two types it is a matter of susceptibility to the touch and stab of the insects.

MEDICAL AND MILITARY SIGNIFICANCE.

Scratching such as louse irritation induces renders the skin prone to sepsis. "Louse-rash," if it may be termed so, has been found distressingly common and has frequently been mistaken for scabies.

Lousiness is felt mostly at night. This in spite of the fact that practically the same number of lice is present on the body during the day. Probably the distractions of the day keep the mind away from the pest, but at night, when everything is conducive to the desire for rest and comfort, the mind is most sensitive to the slightest irritation. Then the crawling of the insects, their sharp stabs, the itchiness of each tiny wound and the fierce desire to scratch become intolerable. As one man said, "You feel as if you could rive yourself to pieces." Sleep, at best, is broken and uneasy, but is usually impossible. Consequent upon loss of sleep, impaired vitality and mental weariness become very real miseries to the soldier, the value of whom depends upon a high pitch of bodily well-being. These are the soldier's most acute troubles primarily due to lice at this Front, but it must never be lost sight of that the menace of typhus, possibly more imminent at the Eastern Fronts, is still present at the Western.

"LOUSINESS."

It is rather important to obtain definite information as to the condition known as "lousiness" for the following reasons:—

(1) At the time of writing the writer is unaware of any exact statements on what really constitutes lousiness of the soldier; and
(2) The necessity, therefore, of establishing a standard by which to judge the condition of men or a unit.

(3) To ascertain what general improvement is manifest in a unit after the operation of methods of instruction and combating.

The method of estimating the verminous condition of men was as follows:—The shirt was examined in areas—right arm, left arm, right body-seam, left body-seam and remainder of shirt. The numbers of lice on these areas were totalled. The areas taken on the trousers were—fork-seam, running from front to back of waist, right leg and left leg. Eggs were estimated—few (f), abundant (a), and very abundant (v.a.). Particulars were entered thus:—

Unit, date, case.	When last bathed.	When shirt last changed.	Number of lice.	Eggs.	Trousers when new or last treated.	Number of lice.	Eggs.	Total.
A 9.10.15 No. 1.	Fourteen days.	Fourteen days.	24	va	Six weeks.	46	a	70

As it was not always possible, especially at the commencement of the inquiry, to obtain full particulars of men fresh from the trenches,

the condition of the shirts was examined on arrival at the divisional baths. The graph illustrates the result of this. Later, more opportunity was afforded for examination of the condition of men straight

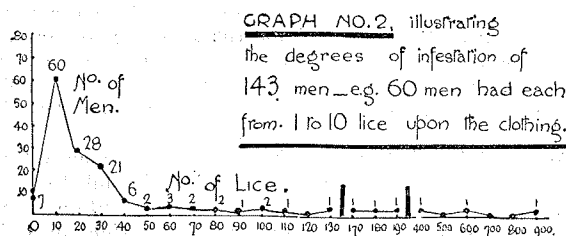
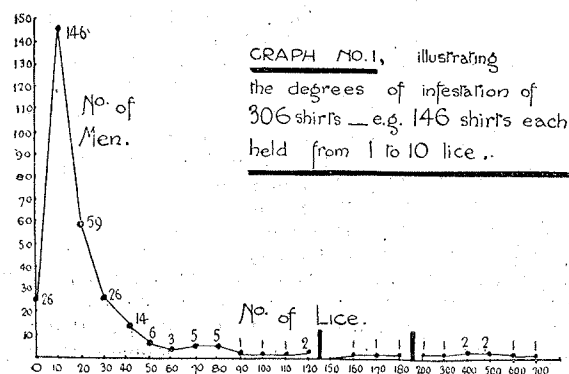


FIG. 9.—Graphs 1 and 2: number of lice.

from the trenches, and the particulars were obtained at the baths and billets. The result is shown graphically.

From the graph is derived:—

Without any lice	...	...	4.9 per cent.
With 1 and less than 10 lice	...	...	41.9 "
" 10 " " 20 "	...	...	19.6 "
" 20 " " 30 "	...	...	14.7 "
" 30 " " 130 "	...	...	11.2 "
" 130 " " 350 "	...	...	4.9 "
" more than 350 "	...	...	2.8 "

From the examinations it was found that the trousers (there were no linings in most cases) contained about two-fifths of the number of lice contained on the shirt. The number found on the socks is negligible. The average lousiness per man of a unit is approximated thus: from the average lousiness of the shirts, the average

lousiness of the trousers was estimated and the sum of these gave the estimated total lousiness. For example: average number of lice per shirt, 10.5; estimated average number per trousers, 4.2—estimated total, 14.7.

Average Lousiness of Units of a Division.

Particulars of all the units examined are not given in full, but the following table dealing with infantry is given for illustration:—

Unit.	Number of men examined.	Time since previous bath (mostly spent in trenches).	Average lousiness.	Remarks.
A	19	7 days	10.5	—
B	8	16 "	11.9	—
C	17	10 to 14 "	14.4	—
D	29	21 to 28 "	15.2	—
E	10	18 "	16.4	Shirts renewed 11 days before leaving trenches.
F	50	14 "	18.2	—
G	45	18 "	19.1	Shirts renewed 10 days before leaving trenches.
H	33	14 to 21 "	22.7	—
K	51	28 "	27.8	—
L	12	14 "	31.4	—
Total ...	274	—	19.9 (variation 10.5 to 31.4).	

These general remarks may be made:—

(1) Experimental error is not due to the fewness of examples, because most of the units, where most men were examined, show the highest degree of lousiness.

(2) *Ninety-five per cent. of the men examined were infested.*

(3) The condition of 274 infantrymen of the division shows, in round figures, a lousiness of *twenty lice per man*, the variation being between ten and thirty. The division had then seen six months of hard work at different parts of the line.

(4) Cases of lousiness above 100 have not been included.

(5) Where clean shirts have been issued in the trenches, even for the short space of two days, the shirt at the end of that time attained the usual degree of lousiness. Young lice hatching from eggs on the trousers and also adult lice both evidently migrate to the shirt.

(6) Clean underclothing, after men have bathed, becomes re-infected from the outer garments within half an hour.

(7) Eighty-nine cases taken from infantrymen newly out from England since a fortnight showed a lousiness of six.

(8) Infantry transport sections of the division examined—of which forty cases were taken—showed an average lousiness of ten, half that of the men in the line.

These men were in bivouac, and changed and bathed regularly

once a week; but because of the leather, the riding breeches were never treated with steam to kill the eggs.

(9) The cyclists (thirty-three cases), living in billets, changed and bathed once a fortnight, showed an average of eleven.

(10) Twenty men of the Royal Field Artillery, living in billets, changed and bathed once a week, showed the very low average of 3.5.

(11) As a contrast to this last example, fifty-one cases of the Royal Field Artillery newly out from England since a fortnight, and not changed or bathed in that time, showed the higher average of 7.9.

(12) A most interesting case is that of certain railway engineers. These men lived together in a large room, changed and bathed every week, and had been at the Front for three months. Not a single louse was found upon them. It is suggested, by nature of the work among oil, that to this factor is partly attributed the freedom from the pest.

(13) By reference to graph 2 it will be seen that there is a break after 130. This produces the result that nearly five per cent. of men are what may be termed "maximum cases." These "horrible examples" showed the number of lice upon each man to be 168, 180, 190, 376, 400, 552, and 895. Another shirt held 1,355 lice and 4,260 eggs, while another showed 10,428 lice approximately, and 10,253 eggs approximately. Reference has been made already to another extreme case.

"Lousing" in the Trenches.

The object of this inquiry was to ascertain, from the observations of the men themselves, what were the results of their self-searching for the pest. A certain division had served at two parts of the line, and the men from eleven different units were interrogated. Their average spell in the trenches had been about twelve days. The inquiry shows: (1) the average daily catch of the soldier was eight at one sector and nine at another; (2) the catch varied between nine and sixty; (3) that, from some source or sources, the man in the trenches is liable to a persistent daily visitation which insists on daily attention. The bag, as a general rule, is mixed, young and adults being obtained. Without encroaching on the section "Dissemination," it may be remarked that the main source of the young lice is undoubtedly the eggs on the clothing of the man himself. This accounts, in part, for the daily persistency of infestation. The difficulties of self-searching are great and may be responsible for the overlooking of some of the large adults; but the constant recurrence seems to indicate that other sources, external, supply the large specimens.

It would be expected that soldiers living in the bare trench, where no dug-outs exist, would be more free from lice than soldiers living in dug-outs. The contrast is afforded in the example of the division under inquiry. At one time of the year the men were in bare trenches at one part of the line and six months after they occupied dug-outs at another part. Men, however, were lousy to practically the same degree at each point. At the first place it was impossible

to change clothing, and at the second they lived in close contact in dug-outs.

Lice and Dug-outs.—One of the most prevalent terms is "lousy dug-outs." Before conducting examinations in the first line of trenches, the impression obtained from conversation with soldiers—and others, too, of a more critical turn of mind—was that dug-outs were swarming with lice. The most comfortable form of dug-out is that which is completely boarded. More primitive types exist in which less wood is present and the floor is of earth. Five dug-outs of the boarded type were carefully searched. Included was a large one occupied by six machine gunners. Skilful assistance in this search was given by a stretcher-bearer, an ex-schoolmaster. The search in each dug-out usually lasted an hour, and was conducted in daylight, with as much extra light as was possible to obtain from candles. In two cases the boards composing the floor were removed and carefully scrutinised, as were cracks and corners, with the fluff lurking there. Kits, great-coats and sandbags were subject to a like search. *In no case was a single live louse discovered.* Eight dug-outs with earth floors at another part of the line yielded a like result.

By reason of the military situation, a most interesting experiment was terminated before culmination. The stretcher-bearer and the writer took measures to secure freedom from the pest. They slept with less clothing than worn by men in the line, but using two blankets, for two successive nights, in a boarded dug-out newly vacated by three lousy soldiers. The conditions, therefore, were most favourable for picking up any lice present. After the first night an examination of the clothing and blankets gave a negative result. The night of that day the clothing and blankets were examined as carefully as candle-light permitted, and seemed clean, but the following morning the assistant's lining showed one louse and one flea. From one point of view, if this typical dug-out had been really a "lousy dug-out" it is reasonable to conclude that more lice would have been found on the clothing. It is quite possible, too, that the one louse found may have been obtained during the daily duties among the men, and overlooked at the night examination owing to the bad light.

It is not denied that lice may be present in dug-outs, but these play a minor part in the harbouring and disseminating of the parasite.

Lousiness of Material: Blankets.—In this connexion only two typical cases out of ten examinations are cited. The blankets of twenty-four infantrymen were searched. Their regiment had an average lousiness per man of 31.4 and had spent twelve days of the early autumn in the trenches. The blankets had been used for five days. Many were found free from lice. The highest number found on a single blanket was six alive, and the total number of lice found was only twenty alive, the average, therefore, being 0.8 per blanket. In the second example twenty-five blankets were examined in the winter, after being away from the men for about four days. Ten were free from lice; the highest number alive on a single blanket was two and the highest number dead was four. The total numbers were five alive and twenty-one dead, the average, therefore, being

about one dead or alive. The degree of infestation of the unit is not known, but is certainly no less than at any other time of the year.

In sporadic cases blankets have been found exceedingly verminous, holding twenty, sixty, and more lice. This condition was always correlated with the fact that the men using them were very unclean.

Blankets, therefore, are of minor importance as harbours and centres of dissemination.

Straw.—Straw sufficient for three men was placed in a corner of a room infested with 535 lice, and left for nearly four and a half days. At the end of this time three clean men slept for three successive nights upon it. After the first night the total number of lice from all the men was eighteen, the second night four, and the third night seven. The experiment shows that infested straw may be sufficiently lousy at the end of seven days to infest men using it. A similar experiment, using 1,000 lice and leaving the straw five and a half days, showed two after one night's use, two after the second night's, and none after the third night's.

Straw was placed as above, and infested with 500 lice. After three hours, to allow the insects to scatter and accommodate themselves, N.C.I. powder was dusted on the straw. After eight hours three clean men slept upon it. Next morning the total number of lice from all three men was seven alive and six dead. The straw was re-treated, and after the second night, with two men using it, no lice were picked up. The experiment demonstrates the efficiency of N.C.I. as a swift preventive of infestation from straw.

Palliasses.—Three palliasses, infested with 325, 500 and 500 lice respectively, were examined after eight days, and live lice were still found.

From the characteristic disinclination of the louse to leave clothing, it does not seem likely that straw will ever become very much infested.

DISSEMINATION OF THE PEST.

Three sources of infestation may be conveniently named: (1) Living-places—dug-outs, billets, bivouacs; (2) material—blankets, straw, beds; (3) the soldier, with his clothing and kit.

Living Places: Dug-outs.—Only the dug-out is discussed in this section, but the same remarks apply to billets and bivouacs.

The main problem presents itself thus. Men state confidently that they go into the trenches clean, and in a few days find themselves infested. The general statement goes: "The dug-outs are lousy." It will be well to examine this critically.

If it may be assumed that a "lousy dug-out" was one which harboured twenty live lice, it is very unlikely that careful trained observation would not discover a single live specimen in thirteen dug-outs.

A man may have lice upon him all the time and not yet feel any discomfort. Such men, it has been found, always believe themselves to be clean, and generally declare it aggressively. Another unobtrusive but most important source of danger is the presence of

eggs upon the clothing. There is the probability also of an unclean comrade.

The dug-outs with most unenviable reputation are those which are large and accommodate most men. Certain dug-outs—those of officers and senior N.C.Os.—are frequently occupied by only one individual, and in these cases lousiness is not common. These living conditions, giving greater opportunities for change of clothing, for physical cleanliness, cleaner companionship, and often comparative isolation, are the converse of those of the men.

An important observation is the preference of the insect for remaining on warm material. This renders the probability of infestation from the soil very small, though, as has been pointed out, lice may endure surface soil conditions for seven days. In so doing, it is quite possible for infestation to come from the ground. The chance of this, however, is very remote.

When a dug-out has been emptied of all kit, sandbags, &c., such usually being the case when one unit makes way for its relief, most of the lice are removed also with that unit.

The weight of the evidence, therefore, goes to show that the dug-out itself is not an important factor in the harbouring and dissemination of the pest.

Material.—Previously mentioned facts show that in exceptional cases infested blankets may be centres of dissemination, but that, as a general rule, they are a minor source of dissemination.

From the preference of the louse for clothing worn next the skin, or such clothing discarded, and the absence of lice upon blankets and empty sand-bags used as bedding, it seems fair to deduce that straw and palliasses, which are colder habitats for the insect, will not be tempting places of sojourn for them.

The Infested Soldier.—Infestation from dug-outs and blankets being very slight, there remains the soldier himself. Concerning the conditions of the soldier, it will be well to recall to mind that 95 per cent. of soldiers who had seen six months' service were found lousy, that the average number of lice per man was 20, that 5 per cent. (or 50 to a battalion of 1,000) were dangerous carriers, each bearing between 100 to 300 lice. Also to take the condition of a unit ready for the trenches after its few days' rest. During this time men are supposed to bathe and obtain a change of underclothing. Certain men have not bathed or changed owing to duty or through shirking, and most have not had the outer clothing ironed. That is, practically every man is still a carrier, while a certain few are likely to be in a worse condition.

Dissemination may possibly occur by three methods: accident, contact, and instinct on the part of the insect. In the first instance the ordinary actions of everyday life, dressing or undressing, may dislodge the insects from the inner clothing to the outer, or from the outer directly to the clothing of a comrade, or indirectly via blankets or kit. In the case of contact, transference may be effected during close proximity for a short time, as in the case of doctor and patient, teacher and scholar. More favour and, to the mind of the writer, the principal conditions of transference are the long periods of

proximity, engendering warmth and consequent movement of the lice, as when men are compelled to sleep closely together. The instincts of detecting and selecting the host seem at best too feeble to account for much dissemination.

The natural question is often asked, How did the parasite first gain a footing in the Army at the Front? In answer to this, the writer recalls the first day of mobilization, the pouring in of reservists to the barracks, among them many from the verminous slums; the mingling of mufti and khaki in the crowded rooms, and soon, with scant opportunity for obtaining anew the smartness and cleanliness of Army life, the hurried despatch to the seat of war. Once the louse was brought to the Expeditionary Force, the absence of facilities for washing and changing clothing, and the crowding together of troops, gave the parasite every condition favourable to lodging, feeding, multiplying, and spreading.

METHODS OF PREVENTION AND DESTRUCTION.

Treatment of Cases Naturally Infested.—The condition of men was noted by the method already explained. The effects of various preparations were taken after one day, in most cases, and in a few cases for longer periods.

Treatment of Cases Artificially Infested.—Artificial infestation was carried on by taking a known number of lice from a newly discarded shirt, and placing them on different parts of the body—*i.e.*, down the legs of the trousers and inside the back and front of the shirt. After two to six hours, time sufficient for the insects to scatter, feed, and accommodate themselves to the new environment, the clothing and body were treated with preparations.

A large number of experiments with various insecticides was performed. The results, however, of the experiments were unsatisfactory from the point of view of obtaining consistent and comparative figures. More experiments, impossible at present, are required. It may be that such exact figures cannot be obtained by the very nature of the experiments. It is quite possible that the preparations act with greatly varying results upon different men. When opportunity is afforded, other experiments will be conducted upon more cases and for longer periods. Till the incorporation of such results, the figures available at present are withheld.

Insecticides act in two ways—(1) the effect upon the pest present, and (2) the deterrent effect on any of the insects present externally.

The insecticides used when the parasites were present produced either or both the following effects: they killed or caused to evacuate. Resort is made to certain convenient terms.

Killing efficiency is measured by the percentage of insects killed in a certain time by the insecticide.

General efficiency is measured by the sum of the percentage of insects killed, evacuated, and unaccounted for in a certain time.

Deterrent efficiency is measured by the percentage of insects which the insecticide deters from reaching the body.

It is still possible, however, to give the following notes on certain insecticides:—

N.C.I. (naphthalene 96 per cent., creosote 2 per cent., iodoform 2 per cent.).—This preparation is a speedy killing agent, and is the best all-round insecticide tested. The investigator himself prefers it to any other preparation.

The following exacting test of its deterrent efficiency was made: Seven hundred lice were allowed to scatter in a sleeping bag improvised from a blanket. The writer used the preparation on the shirt, back and front, and on the riding breeches at the fork and as far down as the knees. The conditions were rendered as favourable as possible for the lice. Socks instead of puttees were worn, the shirt neck was opened, and the sleeves rolled up as far as the elbows. Almost immediately after settling in the sleeping bag, lice were felt crawling in great numbers in the socks, on the arms, and a few at the neck—in fact, at those parts of the clothing and body not treated with the powder.

Next morning, examination of the clothing and body gave the following results:—

One hundred and fifty-five dead lice were shaken from the socks; thirty dead lice were found below the breeches' knees; one dead louse was found at the thigh. No lice were found on the shirt.

The point of importance is that the powder was a complete deterrent. The duration of the deterrent efficiency of *N.C.I.* is illustrated in the instance where thirty men of a machine-gun section of infantry were supplied with the powder. The men since using have not been troubled. Most are of the opinion that the effect of one thorough application lasts five days. A few dusted the clothing every few days as a preventive measure.

Caution.—It is most important to remember that a too free use of *N.C.I.*, particularly at the fork, causes severe smarting. For this reason it is recommended that an ointment insecticide be used in this region. However, used with ordinary care, *N.C.I.* has undoubtedly proved the best insecticide for general use on the clothing material and in living places.

Vermijelli.—This ointment is very effective. It is found that the best way to use it is to anoint the body from neck to knees. Local application seems only to cause the lice to migrate to those parts of the body not treated.

Crude Oil Ointment.—The materials at hand permitted only a somewhat crude preparation. Two pounds of soft paraffin was melted, and four ounces of crude tar oil added. The mixture set like an ointment. Used like *vermijelli*, it showed a very much higher killing efficiency than that preparation, and a slightly higher general efficiency. As a deterrent it was subjected to the same test mentioned under *N.C.I.* and gave a result of 97.7 per cent. efficiency.

N.C.I. and Vermijelli.—The ointment was smeared at the fork of the trousers and the seams, the *N.C.I.* being dusted down the shirt and trousers. The killing efficiency of *N.C.I.* was increased slightly, but the general efficiency was increased highly.

The report received from the medical officer of one infantry unit which used the preparation in the trenches is convincing. The preparations were efficient from three to seven days. After about the

third day it was found that young lice appeared, obviously from eggs on the clothing. Periodic treatment is therefore necessary. There was a great demand for more.

N.C.I. and Crude Ointment.—Used as above, the results were very similar.

Mercury Ointment (variously termed blue unction, blue ointment, and navy's butter).—To prevent undue absorption of mercury into the skin, equal quantities of the ointment and soft paraffin were mixed. The killing and general efficiencies were both high when the ointment was used like vermijelli. It is feared, however, that the nature of the preparation precludes that consistent use which present conditions demand.

To verify its effect as a deterrent, a similar test as in N.C.I., but employing only 300 lice, was carried on in accordance with a well-known treatment. Strands of tape, well smeared with the ointment, were fastened round the ankles, knees, waist, arms, and neck. The precautions proved utterly useless. The lice simply swarmed over the body. After a somewhat unhappy two hours, and to secure rest, the body was smeared all over. Yet next morning thirty-five live lice were found on the body and clothing.

White Mercury Powder.—This preparation had very low killing and general efficiencies.

Sulphur.—Three experiments, one personal, were performed. In one case an ointment, half flowers of sulphur and half soft paraffin, and in two cases a generous amount of flowers of sulphur were used. They proved such complete failures that it is not proposed to pursue further experiments with these substances.

Treatment of Infested Underclothing.—The following notes are the result of many experiments carried on under the everyday working conditions at the divisional baths, treating clothing in quantity in large cauldrons, tubs and disinfectors.

Thresh Disinfectors.—For the horse-drawn "Thresh" it was found best that not more than 100 garments should be steamed at 215° F. for three-quarters of an hour. For the Foden lorry "Thresh" 100 garments per chamber should be steamed at 220° F. and five pounds pressure for half an hour.

Boiling Water.—When shirts have been boiled five minutes in water, lice are killed, and the eggs become white and opaque owing to the coagulation of the protoplasm. As a check, eggs at different parts of the shirts were incubated on the body for fourteen days. None hatched. Since writing the above it has been ascertained that Mr. Bacot, Entomologist to the Lister Institute, working on a small scale with small numbers of eggs and test tubes, found that boiling for one and a half minutes was sufficient to kill the eggs.

Cresol Solution, 1½ per cent., Cold.—This solution is bactericidal strength. It was found after thoroughly soaking infested shirts for one hour that the lice were killed. Patches holding eggs were rinsed in cold water to get rid of the cresol and incubated on the body. After thirteen days no eggs hatched.

Chloride of Lime, 7 per cent., Cold Solution, used for twenty-

four hours, is effective, but *alum, ten per cent., cold solution*, used for forty-eight hours, was a total failure.

The Role of Divisional Baths.—Apart from laundry work, the main object of the baths is to turn large numbers of infested men into clean men as quickly as possible. The three processes are the bathing, the issue of clean underclothing, and the disinfection of the outer garments. The first two are easily carried out, but the last presents many difficulties. Without it, the results of bathing and changing are of little value. Treatment by steam or gas disinfection takes too long, as it is usually necessary for men to pass through the baths in a quarter of an hour. Ironing with a hot iron is the most practicable scheme. This is a slow process, but one of cardinal importance, because it *determines the rate of bathing*. A bathing party being dealt with in a quarter of an hour, the time taken to iron the tunic, trousers, and cardigan jacket of each man being ten to twelve minutes, the number of ironers must equal the number of bathers per quarter hour. For example:—

Strength of Division	... ..	19,200
Rate of bathing	... ..	1 in fifteen days.
Number of men passed through per day	1,280	
" " " " " hour	160	
" " (eight hours' bathing per day) per quarter hour	40	
" " of ironers required	40	

Other considerations that may arise are—this bathing procedure, carried on regularly, will in time reduce the degree of infestation, so that less ironing will be necessary; as local conditions at certain times cause the baths to lie idle, it will be necessary to have other activities to hand, such as laundry or mending work, for the ironers.

RECOMMENDATIONS.

The main object of this section is to suggest an outline for a plan of campaign against the pest.

Research Centre.—The scope of this subject and virulence of the pest make it necessary that a centre of research be established under a specialist in each army. The apparatus required is really very simple and small in amount. Assistants are necessary for laboratory and outside work. *Advisory work* could also be carried on as each unit is frequently a special case. Facilities for transport should also be afforded.

Instructional Work.—At these centres instruction could be pursued by three methods:—

(1) *Classes* similar to those carried on for other military affairs could be initiated for such non-commissioned officers and men (Pioneers, Sanitary and Royal Army Medical Corps) as units may specially set apart for dealing with lice.

(2) *Lectures and demonstrations to military units* could be arranged, each unit being represented by officers, medical officers, non-commissioned officers, sanitary men, stretcher-bearers, and men

in such numbers as may be convenient. A suitable time is when regiments are resting for a period longer than a week. The aims are the presentation of the true facts with regard to the pest, recommendations for dealing with it, and, most important, to foster the idea that it is not by any means impossible to bring the parasite under.

(3) *Issue of Leaflet.*—A short leaflet embodying the following could be printed and distributed to all ranks:—

‘It is not correct to think that lousiness cannot be reduced to a minimum. Experiments, in detail and on a large scale, carried on among soldiers in billets and trenches go to prove—(1) that the soldier himself is the main source of infestation; (2) that the measures suggested below are of great benefit:—

(i) ‘Whenever possible, and as regularly as possible, search the clothing thoroughly for both lice and the ‘nits,’ or eggs. If you have discovered that the removal of the white patch which binds the seams at the fork of the trousers does not interfere with comfort, it is well to remove the patch. Special care during searching for the lice and eggs should be paid to this region.

(ii) ‘The great source of danger is the presence of eggs. These hatch in about a week. It is necessary, therefore, that the trousers should be ironed and brushed at least once a week. While in the trenches it is often quite possible, without undressing, to use a piece of hot metal or a tinder lighter. This removes the source of danger upon yourself.

(iii) ‘Against the lice themselves, whenever you find it necessary, use the remedies recommended. Powders, as a rule, should not be used at the fork but down the shirt and trousers. Care should be taken to see that any powder which falls from the shirt to the fork should be small in amount, as too much is liable to cause smarting. If your stock of ointment and powder is exhausted, apply to the man in your unit who is responsible for the distribution of these preparations.

(iv) ‘Just previous to going to the trenches be careful to treat the clothing and body as directed.

(v) ‘Use the preparations about every four days. Experiments in the trenches have shown this to give the best results.

(vi) ‘See that any material, blankets, empty sandbags, &c., which may be present to increase the comfort of the dug-out or billet are treated with the powder preparation.

(vii) ‘Take advantage of all the facilities offered at the baths.’

Divisional Baths.

(1) Each Division should be provided with two baths, each capable of dealing with eighty bathers per hour, and two Foden lorry Thresh disinfectors.

(2) Baths should be built and not improvised (except in specially favourable circumstances) from permanent buildings. The design of the buildings should be such that contamination is impossible.

(3) *Procedure for Bathing.*—Man strips in undressing room, outer clothing handed in or collected for ironing; then enters bathroom and baths; enters dressing-room, given clean change of underclothing, uses insecticide, receives ironed clothing, and dresses.

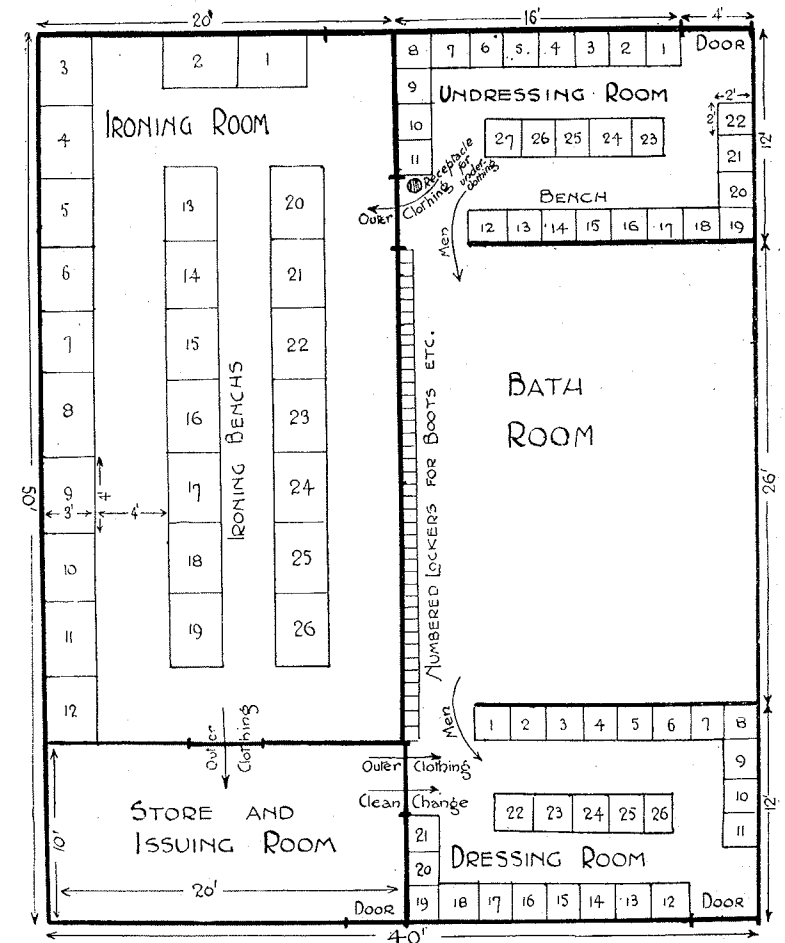


FIG. 10.—Suggested plan for a divisional bath (based upon one now working at the Front). Certain building questions—e.g., lighting—are not discussed.

(4) *Treatment of Underclothing.*—Laundry work may possibly be carried on with advantage at one centre and not at each bath.

(a) *Garments Disinfected in Thresh Apparatus.*—Three-quarters of an hour at 215° F. in horse-drawn type; half an hour at

220° F. and five pounds pressure in the Foden lorry type; washed, dried, folded, stored.

- (b) *Cresol Solution.—Auxiliary Method, suitable for Detached Units.*—Steep garments thoroughly for one hour or more in solution (one pint of cresol to eight gallons of cold water); rinse to rid of surplus cresol; wash, &c., in usual way.
- (c) *Boiling Water.—Auxiliary Method for Detached Units.*—Allow garments to soak thoroughly and remain in boiling soapy water for five minutes; remove and wash, &c., in the usual way.

(5) *Treatment of Outer Clothing.*—Clothing collected (tunics, trousers, and cardigans) ironed with hot iron, particularly at seams and forks of trousers, brushed with a hard brush, distributed to men in dressing room.

For the Trenches.—While a unit occupies a trench it should be the duty of a man set apart for the work to see that an adequate supply of insecticides is available for distribution to the men and for general use in the dug-outs. Company officers should see that their men take the necessary precautions against the pest.

For Billets.—This applies particularly to infantry in the rest areas and to isolated units, such as ammunition columns and infantry transport:—

(1) Men should be afforded set times for the express purpose of inspecting their clothes.

(2) A general inspection by the company officer or medical officer is recommended at least once a week, but men of known unclean habits require special attention, if only for the sake of their comrades.

(3) A keen look-out for cases acting as bad lice-carriers should be maintained and the men dealt with speedily.

(4) In addition to existing methods for maintaining clean billets, all old clothing should be removed. Floors and skirting boards should be washed with soapy water to which has been added crude oil and cresol.

(5) If bathing and changing facilities do not exist, the ironing of garments should still be attempted.

For Hospitals.—These remarks apply particularly to hospitals and rest stations carried on by field ambulances, where conditions are frequently difficult.

Even if patients are retained for one night, some measures should be employed. When possible a patient should bath, have a change of underclothing, and have the outer garments ironed.

None of these recommendations are difficult in themselves. The real difficulties are in the regular and persistent use of the methods during exceptional and trying circumstances. For troops living in billets and hospitals the work is feasible, but for infantrymen matters are more difficult. It is necessary, however, to emphasise that the most effective measures may be carried on while men are out of the trenches. In the trenches the work necessary is reduced to the regular distribution and use of insecticides.

To conclude, the matters of cardinal importance are, firstly, that a definite plan of campaign be formulated, and, secondly, that the plan

be followed up vigorously by the work of proficient men. It is not so much a problem of pure science as one of common-sense management.

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