BRITISH MUSEUM (NATURAL HISTORY)

ECONOMIC SERIES, NO. 1A

THE HOUSE-FLY

ITS LIFE-HISTORY IMPORTANCE AS A DISEASE CARRIER AND PRACTICAL MEASURES FOR ITS SUPPRESSION

BY

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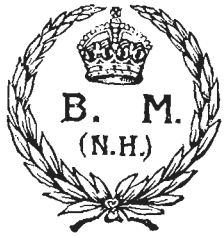

SECOND EDITION

LONDON
PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

SOLD AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W.7,
AND BY
B. QUARITCH, LTD.; DULAU & CO., LTD.; THE OXFORD UNIVERSITY PRESS; AND WHELDON & WESLEY, LTD., LONDON; ALSO BY OLIVER & BOYD, EDINBURGH

1926

PRINTED IN GREAT BRITAIN BY
WILLIAM CLOWES AND SONS, LIMITED,
LONDON AND BECCLES.

PREFACE TO SECOND EDITION

UNDER the slightly different title, "The House-Fly, its Life-History and Practical Measures for its Suppression," this pamphlet was originally published in 1920. The exhaustion of the first edition, and the demand for a second, have afforded the author an opportunity of revising and expanding the text, of which he has taken full advantage. Wherever necessary in the light of present knowledge, amendments have been effected, and, by the inclusion of a considerable amount of additional matter, an endeavour has been made to keep pace with research. Among other new material included in the second edition may be mentioned a short section dealing with insect enemies of the House-Fly; another relating to the insect's connection with animal diseases; and additional notes on bionomics and control.

It only remains to add that, for this edition, figures 5, 7 and 10 have been redrawn, and that an additional figure (12) of some historic interest has been included.

CHARLES J. GAHAN,
Keeper of Entomology.

BRITISH MUSEUM (NATURAL HISTORY).
March, 1926.

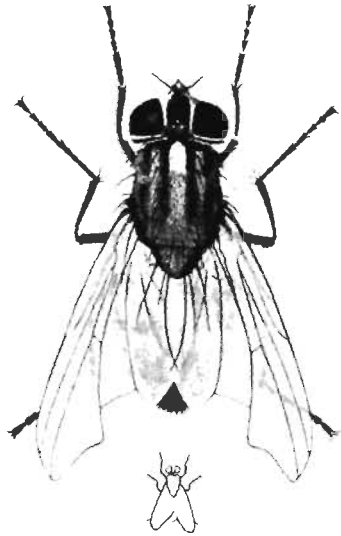

FIG. 1. THE HOUSE-FLY (female).

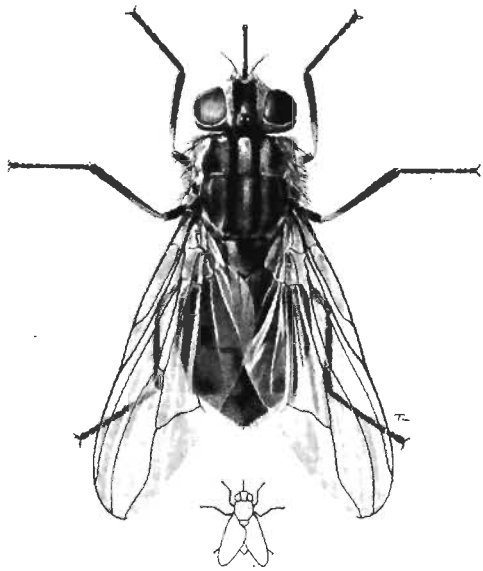

FIG. 4. THE STABLE-FLY (female).

All figures six times the natural size, which is indicated in

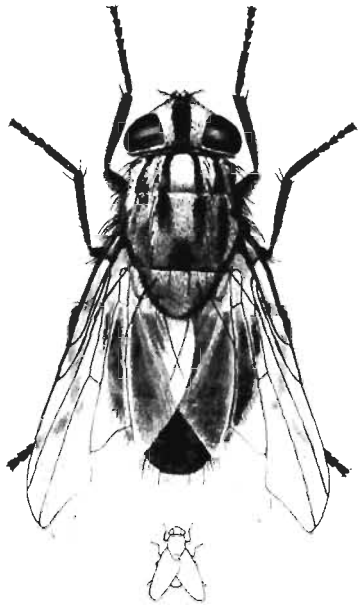

FIG. 3. MUSCA AUTUMNALIS (female).

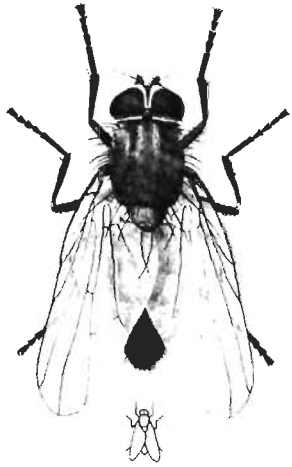

FIG. 2. THE LESSER HOUSE-FLY (male).

[1] the outline drawing below. See also Fig. 5, p. 13.

PREFACE TO FIRST EDITION

THIS number in the *Economic Series*, although similar in its objects to the pamphlet by the same author, entitled "The House-Fly as a Danger to Health" (*Economic Series*, No. 1), is of wider scope. In his treatment of the subject here, Major Austen has had other conditions in view besides those usually met with in the British Islands. His experience on three fronts during the course of the late war has enabled him to take into consideration the requirements of the Army as well as of the civil population, and in the practical measures recommended he has endeavoured to serve the purpose of both.

CHARLES J. GAHAN,
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THE HOUSE-FLY.*

(*Musca domestica*, L.)—Figs. 1 and 11.

The Common Fly or House-Fly, to which the great Swedish naturalist Linnæus gave the name *Musca domestica* in 1761, is probably the most familiar as it is certainly one of the most widely distributed of all insects. The pertinacity with which the creature returns again and again to the same spot, in spite of opposition and even attack, was perhaps the reason why in Ancient Egypt successful generals were rewarded with a golden collar bearing colossal silhouettes of House-Flies; and this characteristic must from infancy onwards repeatedly have drawn the attention of every one to the Common Fly. It is therefore not a little curious that, in the British Islands at any rate, very few people are capable of recognising a House-Fly infallibly at sight. The failure to do so, however, is doubtless due to the fact that, in Europe, several species of flies, in addition to the true House-Fly, to which they present a general and in some cases a fairly close superficial resemblance, are of common occurrence in houses, and are in consequence frequently mistaken for the subject of this pamphlet.

Before proceeding to give such brief descriptions of the House-Fly and some of the other species referred to as, with the accompanying illustrations, it is hoped will serve to remove misconceptions and facilitate identification, it may be useful to devote a

* In the Central Hall of the British Museum (Natural History) there are exhibited enlarged models (28 times natural size) of the House-Fly, and of its eggs, maggot or larva, and pupa (puparium) or chrysalis, as well as specimens of the actual insect and of certain other flies often found in houses in the British Isles, and liable to be mistaken for it; the foregoing are accompanied by representations of a portion of one of the House-Fly's breeding-places and of the manner in which the insect pollutes human food.

paragraph to a summary of present knowledge of the occurrence of the House-Fly beyond the limits of the British Islands.

Distribution of the House-Fly.

Musca domestica is found throughout Europe and the Mediterranean Sub-Region, while eastwards its range extends across Northern Asia and reaches Japan. In the Ethiopian Region, besides occurring all over Africa, from Khartoum to Cape Town and from Monrovia to Mombasa, the House-fly is also a pest in the outlying islands, such as Madagascar, Mauritius, the Seychelles and Sokotra. In the Oriental Region, *Musca domestica* is found in Northern India and elsewhere, as far east as Celebes; in India itself, however, where it is said not to occur in the south, although it is certainly found in Ceylon, it appears to be largely replaced by the closely allied and equally objectionable *Musca nebulo*, Patton and Cragg (Fabr.?), which has precisely similar breeding habits, and is especially fond of ovipositing in night soil. As regards the Australian Region the House-Fly is probably universally distributed, for the British Museum (Natural History) possesses specimens from a number of localities in the Northern Territories of Australia, North and South Queensland and Victoria, as also in New Zealand, while other examples from the Solomon, Samoa and Sandwich Islands indicate the occurrence of the species throughout Polynesia. Finally, as regards the American Continent, specimens in the National Collection show that the House-Fly is found at least from Nova Scotia to the Argentine, as well as in the West Indies, and there can be little doubt that it occurs in all centres of population south of the Arctic Circle.

While the House-Fly's close association with and dependence upon man, and the strong attraction exerted upon it by human habitations and human food, have naturally tended to facilitate its carriage about the world in ships and trains, and to extend its distribution, there would seem to be some reason for regarding the insect as a *native* of the warmer parts of the earth, and as an immigrant into temperate regions. Such, at any rate, is apparently the conclusion logically to be drawn from the comparative lateness of the season at which House-Flies usually become abundant in

the British Islands (*see* p. 31), where it would appear that only a small number of individuals succeed in surviving the winter, in whatever stage that season may ultimately prove to be passed.

Distinctive Characters of the House-Fly, and of certain other Flies Frequently Mistaken for It.

The House-Fly (Figs. 1 and 11), which is normally about a quarter of an inch in length, though undersized individuals are frequently met with, is mouse-grey in colour, with the thorax (middle part of the body) marked above with four narrow black stripes, and the sides of the abdomen (hinder part of the body) more or less buff in the male, and frequently in the female also. In the male House-Fly the space between the eyes, as seen from above, varies from between one-fourth and one-fifth (in British specimens) to about one-thirteenth (in certain specimens found in warmer latitudes) of the total width of the head; but in the female the corresponding space is broader, and occupies nearly one-third of the diameter of the head. As shown in Figs. 1 and 11, the black stripe occupying the centre of the space between the eyes in the female is relatively broad, and is separated from the eye on each side by a much narrower interval. The proboscis, or tube through which the insect sucks up its food, ends in a pair of fleshy lobes, and when not in use is folded away into a cavity on the under side of the head, so that it is invisible from above. Lastly, it may be noted that one of the long veins or supporting rods (the so-called *fourth longitudinal vein*) in each wing is, near the tip of the wing, abruptly elbowed in such a way that the end of this vein almost meets that of the vein in front of it (*see* Figs.).

As already stated, in the British Islands, and Europe generally, especially in country districts, in addition to the subject of this booklet, flies of certain other species more or less resembling it in general appearance often occur in the living-rooms of houses, and some of them are in consequence frequently mistaken for the true *Musca domestica*. The principal flies in question, not all of which possess English names, are the Lesser House-Fly (*Fannia canicularis*, L., Fig. 2); *Musca autumnalis*, De G. (Fig. 3—formerly called *Musca corvina*, Fabr.); the Stable-Fly (*Stomoxys calcitrans*,

L., Fig. 4); *Muscina stabulans*, Fln.; the Cluster-Fly (*Pollenia ri*
F., Fig. 5); * *Limnophora humilis*, Ztt.; and *Chloropisca notata*,

It will be seen, on referring to Figs. 1 and 2, that the Le
House-Fly (*Fannia canicularis*, L., Fig. 2), the preliminary sta
of which are passed in decaying organic matter, as compared w
the true House-Fly, is a smaller † and more slenderly built inse
with a silvery-white face in the male sex, and without a c
spicuously *elbowed* vein near the tip of each wing. In the restin
posture the wings are carried like those of the House-Fly, althoug
they are not quite so wide apart at the tips. Making its appearanc
(in the British Islands) earlier in the year than *Musca domestica*—
often so early as March—the Lesser House-Fly may not infrequently
still be seen in living-rooms so late as November, when, with the
exception of an occasional isolated straggler, the true House-Fly
has usually disappeared. Everyone must frequently have noticed
group of flies circling in the centre of a room, playing a sort
f aerial kiss-in-the-ring beneath the electrolier or gas-pendant;
he members of such groups are seldom if ever true House-Flies,
it whenever examined have proved to be specimens of *Fannia*
nicularis.

Musca autumnalis (Fig. 3), which breeds in cattle droppings
attered in the fields, though agreeing approximately with the
ouse-Fly in length, is a bulkier, more compactly built and

The Blow-Fly or Bluebottle (*Calliphora erythrocephala*, Mg.) is not
ed to here, since it is quite different from the House-Fly in appearance
ize, and its general characteristics are familiar to everyone.

Specimens of *Fannia canicularis*, and other small flies occasionally met
in houses, are often supposed by those who are not entomologists to be
ng" House-Flies. It may therefore be worth while to repeat that, as
equently been stated before, *House-Flies*, like other insects in the same
do not grow. Growth, after the insect leaves the egg, is confined to the
or maggot-stage, and the House-Fly, on passing from the chrysalis-
o that of the adult, emerges from its pupa-case fully grown. When
re small flies resembling House-Flies are seen in houses, they are
oung" House-Flies in the sense that they will in time grow bigger,
ner belong to a distinct and smaller species, or are undersized House-
nich will never become any larger, their diminutive dimensions being
unfavourable conditions (generally insufficiency of food or too great
of the food-material) during the maggot-stage.

thickset insect, and, although like the House-Fly itself subject to great individual variation in size, is often decidedly larger. In the male the upper surface of the abdomen has a black base, from which there is a backward prolongation in the shape of a longitudinal, median stripe, both base and stripe being sharply defined, and presenting a well marked contrast to the cinnamon-buff of the remaining ground-colour; in the female the upper surface of both thorax and abdomen is grey, with darker markings. In the case of both sexes, however, the surest criteria for distinguishing *Musca autumnalis* from *M. domestica* are those presented by the upper surface of the head. Whereas in the male of *Musca autumnalis* the eyes are so close together as to be almost or actually in contact at one spot, in the male House-Fly the space between the eyes is always much broader, and, as already indicated, may be nearly equal to one-fourth of the total width of the head. As regards the opposite sex, in the female of *Musca autumnalis* the black longitudinal area (frontal stripe) in the centre of the space between the eyes is approximately equal in width to the grey border on each side, separating it from the corresponding eye. In the female House-Fly, however, the frontal stripe is much broader, and its width greatly exceeds that of the border, yellowish-golden in front and below, blackish above, on each side of it. The resting position of the wings in *Musca autumnalis* is the same as in *M. domestica*. In the autumn, in country districts in the British Islands, *Musca autumnalis* frequently enters houses and public buildings, sometimes in large numbers, and subsequently hibernates in attics, roof-lofts, towers, in the folds of curtains in disused rooms, and in similar retreats.

The Stable-Fly (*Stomoxys calcitrans*, L., Fig. 4) deposits its eggs in fermenting vegetable matter, such as cut grass, as also in stable manure containing much straw. This insect is a blood-sucking fly, not infrequently responsible for causing a casual observer to think that he has been bitten by a House-Fly, although the proboscis of the latter is merely adapted for sucking, and is quite incapable of piercing the human skin. While of the same length as the House-Fly, the Stable-Fly is of a somewhat broader

and more thickset shape, and may readily be distinguished
Musca domestica by the character of its shining black prob
which is slender, rigid and non-retractile, and, instead of b
folded away out of sight beneath the head when not in actio
always visible, projecting like an awl horizontally in front of
head. In colour the Stable-Fly is darkish grey, and its abdon
which has no buff-coloured patches on the sides, is spotted w
lark brown; the fourth longitudinal vein in the wing of this
lthough somewhat bent up at the end, is not sharply elbowed
the House-Fly, and consequently its termination is distinc
eparated from that of the preceding vein. When at rest, t
table-Fly agrees with the House-Fly as regards the position
e wings, but characteristically sits with its head and the fro
rt of its body somewhat more raised.

Muscina stabulans, a fly which breeds in decaying organ
tter and excrement of various kinds, and sometimes hibernate
houses or outbuildings, is, as a rule, of larger dimensions tha
y of the insects already mentioned, and its length often con
erably exceeds a quarter of an inch. The general coloratio
the body is dark grey, and the abdomen is without definite
ts. The extreme tip of the middle part of the body and a
tion of each leg are more or less distinctly tinged with
amon colour; the proboscis, when not in use, is invisible
above; and in the wing the end of the fourth longitudinal
is not elbowed, and converges but slightly towards that of
ein before it. In the resting position the wings are carried
those of *Musca domestica*.

he Cluster-Fly (*Pollenia rudis*, Fabr., Fig. 5) may be dis-
ished, not only from the House-Fly but also from all the
flies enumerated above, by the fact that the wings when
use, instead of diverging at the tips, are closed one over
ther like the blades of a pair of scissors (*see* Fig. 5).
ring normally about one-third of an inch in length, although
erably smaller specimens are frequently seen, the Cluster-
as a rule, a much larger insect than the House-Fly, bulkier
ore heavily built, and correspondi

impulsive in its movements. The upper surface of the dark greyish-olive middle region of the body (thorax) is clothed with a thick coat of fine, silky, recumbent, yellowish or golden-yellow hair, easily visible to the naked eye, and, though readily rubbed

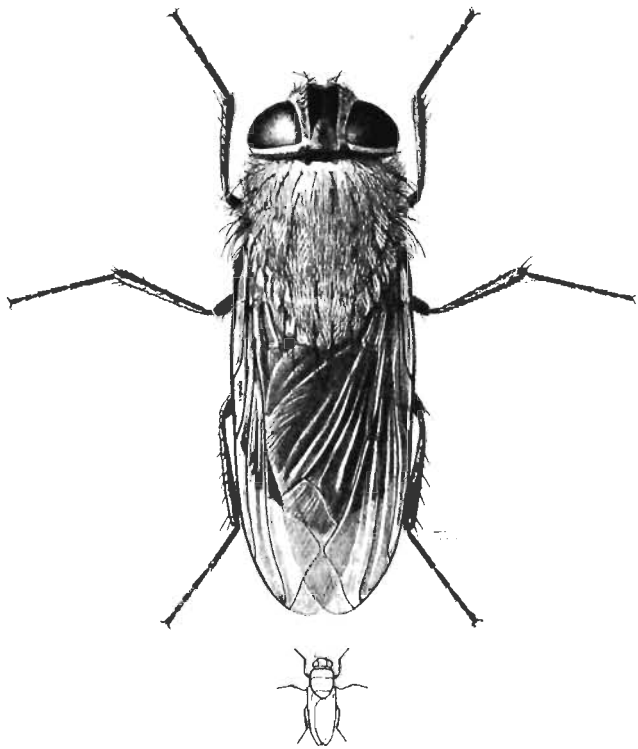

FIG. 5.
THE CLUSTER-FLY (female), six times the natural size.
The latter indicated by the outline drawing below.

off, still recognisable with the aid of a lens even in a much damaged specimen. The iron-grey upper surface of the posterior division of the body (abdomen) is mottled with shimmering metallic patches of lighter grey. In 1908 Dr. D. Keilin, working in Paris, made the extraordinary discovery that the maggot of

the Cluster-Fly is an internal parasite of a small eartl (*Allolobophora chlorotica*, Sav.), which, like the fly itself, is ingly common and widely distributed in Europe, North A and elsewhere.

The popular name of the insect figured on the previous due to the habit of this fly of clustering together, sometimes large numbers like a swarm of bees, when hibernating in or other buildings.* A favourite retreat of the Cluster-Fly purpose of hibernation is the interior of the sash-frames an pockets of windows of the older type, usually in rooms southern aspect, and either unoccupied or only in inter use; on warm, sunny days, during winter, or when fires lighted, the flies frequently emerge from their hiding-places a appear on the window panes in sluggish swarms.† Other sp often chosen as winter quarters are beneath loose wall-paper walls, behind shutters, in the chimneys and ventilators of disu rooms, beneath thatch, and under the slates or tiles of the ro in the latter case generally in close proximity to a chimney sta in use. It may be added that the Cluster-Fly's habit of hibernati inside dwelling-places, though of common occurrence in coun districts, both in Europe and North America, has not be observed in large cities such as London and Paris, even thou the fly may be found breeding there in suitable localities.

Limnophora humilis, Ztt., hitherto more usually, though wrong referred to as *Limnophora septemnotata*, Ztt., is a small dark gr or brownish-grey fly, about 4 mm. in length, with more or le distinct olive-brown blotches on the upper surface of the abdome The pattern of the wing-veins resembles that seen in the ca

* In England it frequently happens that swarms of Cluster-Flies, son mes accompanied by large numbers of *Musca autumnalis* (*see* p. 11), take eir abode for the winter in the roofs of *churches*; on days on which t tter are warmed during winter and spring, the flies cause great annoyan issuing from their retreats and falling to the floor in a semi-comato dition.

† Although in no way prejudicial to health, these swarms are often rce of annoyance; they are best got rid of by the aid of a domestic vacuu

of the Lesser House-Fly. In various parts of England, this species, which on one occasion was bred from stable manure, although its life-history is not yet definitely known, sometimes occurs in very large numbers, year after year from October to January, in particular rooms of certain houses in the country. The swarms, which are composed almost entirely if not exclusively of females, are often so numerous as to render the affected rooms well nigh uninhabitable.

In a similar manner, from September to May, the tiny yellow and black fly known as *Chloropisca notata*, Mg., which breeds in the stems of *Lolium perenne*, L., and other wild grasses, frequently causes annoyance by appearing in thousands on window panes and ceilings.

Such are the more conspicuous flies often found in houses in addition to the true House-Fly; the list, which is by no means complete, might be extended by the inclusion of several species, none of which boasts a popular name. Those that hibernate in houses, especially the Cluster-Fly, *Musca autumnalis*, and *Limnophora humilis*, besides being responsible in the British Islands for much popular misconception on the subject of the fate of the House-Fly in winter, often cause annoyance by their presence and numbers. Yet none of these flies are of any importance from a health point of view, since, unlike the House-Fly, they are not attracted by, and consequently do not contaminate, human food. Considerations of space render it impossible to deal further with this section of our subject, but it is hoped that enough has been said to enable the more common species to be differentiated, and to show that *the occurrence of a fly inside a house does not necessarily prove it to be a "House-Fly."*

Life-History of the House-Fly.

Breeding-Places.—The nature of a House-Fly breeding-place depends upon the needs of the insect in the larval or maggot stage, for the female fly deposits her eggs only in material that will provide food as well as a home for the future maggots. To satisfy the requirements of the latter, a food-material must be capable of being readily swallowed and digested, and must

also be *moist*;* it is likewise generally though not invariably *warm*.

Although in temperate climates, as a general rule and under normal conditions, accumulations of *fermenting* horse-manure form the chief breeding-places of the House-Fly, the insect frequently breeds freely in exposed human faeces, and in decaying and fermenting organic matter of various kinds,† such as is often present in ashpits and larger deposits of house-refuse. It is stated that in Denmark *pigsties* are the favourite breeding-places, oviposition taking place on the fresh excreta. Much House-Fly breeding in pigsties was also observed in Northern France, on several occasions in 1915; in these cases, the temperature of the mixture of litter and wet pig-droppings, in which fly-breeding was proceeding, was apparently low.

Although the House-Fly does not breed in cow-droppings scattered in fields, cow-dung mixed with straw may form a breeding-material.

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* The House-Fly cannot breed in *perfectly dry* material: should the food-substance dry up when the maggots have attained their final stage but not their full dimensions, the resultant flies will be undersized (*see* Note † on p. 10). The need of House-Fly larvae for moisture is well illustrated by a discovery made in 1916 in Cairo, during the hot weather (June to August). At this season, when the heat causes House-Flies in Egypt to disappear, and fly-breeding in the municipal refuse-dumps of Cairo is for the most part impossible owing to the surface of the heaps being dried up by the sun, the persistence of the insect is secured in consequence of the fondness of the inhabitants for water-melons. Owing to the enormous consumption of the fruit in question, the refuse-heaps of the city become littered with pieces of melon rind, each usually lying with the inner side downwards, and producing a moist patch which is effectually shielded from the sun. These moist and protected spots generally swarm with House-Fly maggots, although it often happens that none are to be found elsewhere.

† Certain substances not naturally suitable for House-Fly breeding may become so under special conditions. For example, although House-Flies cannot breed in camel-droppings scattered naturally, they will readily do so, even under the sun of Northern Sinai, in camel-dung piled into a heap, and in consequence permanently moist beneath the surface. As an instance of a somewhat unusual breeding-material, may be mentioned decaying lime-peel refuse (in British Guiana.—G. E. Bodkin). In Southern Italy during the Great War, House-Flies were found to breed in enormous numbers in the crust of septic tanks (E. Hargreaves).

In the case of horse-manure, the material is attractive to egg-laying House-Flies only so long as it is perfectly fresh, *i.e.* usually at most during the first twenty-four hours. As a rule, however, eggs are laid in a manure heap within the first eight hours, since, with the drying of the surface and the onset of fermentation, even fresh manure soon ceases to attract House-Flies. It follows that a manure-heap *to which no fresh additions are made*, but which consists of manure deposited all at the same time, can only produce a single crop of House-Flies, and that, once the flies resulting from eggs laid within a few hours of the dump being made have hatched out, no further House-Flies can be bred from it. The apprehensions of those inclined to regard old, and even grass-grown manure-heaps as potential House-Fly breeding-places are therefore devoid of foundation.*

After what has been mentioned as regards the nature of House-Fly breeding-places, the appearance of House-Flies in abnormal numbers among troops engaged in active operations in the field will readily be understood. The prevention of House-Fly breeding by means of the special treatment or abolition of breeding-places—by no means always a simple matter even among civilised communities in times of peace—becomes infinitely more difficult in war, when, as the result of the crowding together of vast numbers of men and animals under conditions not altogether unlike those of primitive man, excreta and waste organic matter of all kinds are produced in such quantities as to make their

* It is worth noting that, as was first shown by J. Robertson in 1917, House-Flies will not breed in horse-manure when *peat* is used as litter in place of straw; and that apparently sawdust and shavings, employed as litter, are partially effective in preventing fly-breeding. Robertson experimented with fresh straw, fresh sawdust and shavings, and fresh peat litter, in order to ascertain which of the three, when used as stable litter, is least attractive to flies and least facilitates their breeding. No flies bred out of the peat-manure; 18 emerged from the sawdust and shavings, and 244 from the straw-manure. The apparent total absence of House-Fly breeding, in stables in which peat moss was used as litter, was observed by Lt.-Col. G. E. F. Stammers, O.B.E., and the writer, in Kent, in July, 1921. To what such absence of breeding is to be ascribed is uncertain, since it has been found by experiment that an extract of peat moss is not repellent to House-Flies.

prompt destruction sometimes well-nigh impossible. For this reason armies in the field have in the past only too often been visited with a plague of House-Flies, such as that with which our troops in Gallipoli were afflicted in 1915.

Eggs and Egg-Laying.—The glistening white eggs of the House-Fly, which, if examined under a fairly strong hand-lens, in shape and general appearance look very much like tiny grains of polished rice, are about $\frac{1}{25}$th to $\frac{1}{20}$th of an inch in length, and

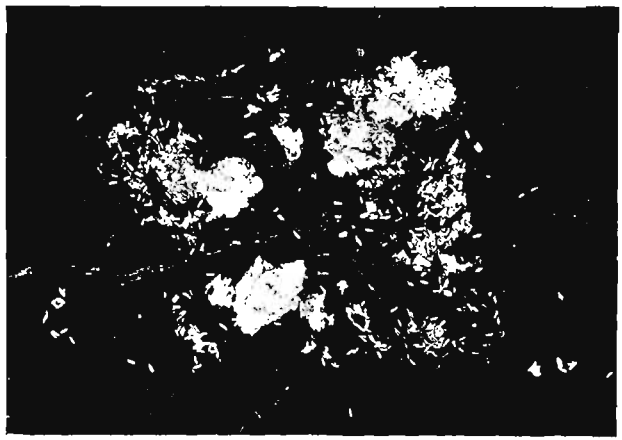

FIG. 6.

BATCHES OF HOUSE-FLY EGGS IN STABLE MANURE (natural size).

Total number of eggs about 1,500.

From a photograph by Professor Robert Newstead, F.R.S., kindly lent by the Health Committee of the City of Liverpool.

are usually laid by the insect one on the top of the other, so as to form small masses (*see* Fig. 6). The latter are generally concealed in crevices in the material that is to supply the maggots (or larvae) with food, in such a way that the eggs are protected from the direct rays of the sun, which, if at all powerful, are rapidly fatal to them. Apparently female House-Flies prefer to deposit their eggs in company, and, under suitable conditions, twenty to fifty females may be seen clustered together in a compact group in a hollow on the surface of a fresh manure heap, all busily ovi-

ıg. Provided that such a collection of flies has been at work
ufficient time, investigations on the spot with the blade of
ie, or other similar excavating instrument, will sometimes
se a mass of eggs nearly large enough to fill a small tea-cup.
gle female House-Fly lays from about 120 or fewer, to about
ggs at one time, and, according to the locality and climatic
ther conditions, may deposit from five or six to over twenty
batches during its life, at intervals varying from about
ty-four hours to three or four days. Thus each female may
uce from 600 or 900, to between 2,000 and 3,000 eggs.*
ler experimental conditions in Paris, using a large cage, it
found by Roubaud (1922) that an individual House-Fly may
tinue to deposit batches of eggs for two and a half months,
ough in nature reproduction evidently continues for a longer
iod. From the laying of the egg, the rate of subsequent
elopment varies greatly, depending upon several factors such
the temperature of the food-material and of the air, and the
ıracter of the food. Provided that heat be not great enough
dry up the food-material, development, which is much pro
cted should the weather after the eggs are laid becom
rsistently cold and wet, is accelerated when temperatures ar
gh. In the British Islands it has been found that in ver
ot weather the progeny of a House-Fly may be laying egg
out three weeks after the eggs from which they themselv
eveloped were deposited.

The Maggot, or Larva.—In from eight to twenty-four hou
fter deposition (when the weather and food-material are warı
hough a longer period, up to three days, may elapse if t
emperature be lower), the eggs hatch into tiny, white, footle
naggots. These burrow into and feed vigorously upon th
iood-material, grow rapidly, and in very hot weather attain th

* The largest number of eggs recorded as having been deposited b
single female House-Fly, in forty-two experiments at Panama, is 2
(twenty-one batches).—*Cf.* L. H. Dunn, "Observations on the Oviposi
of the House-Fly, *Musca domestica*, L., in Panama": *Bulletin of Ent*
——— *Research*, Vol. xiii, Part 3, pp. 301–305, and table (January, 1923).

full development and size, or a length slightly under half an inch (*see* Figs. 7, 8 and 9), in from about forty-two hours to four or five days. At lower temperatures the maggots require a much longer time, even as much as six to eight weeks, to reach maturity. It is worth noting that in an infested manure heap House-Fly maggots are not to be found all through the mass, but are confined to a superficial layer usually at most from four to five inches in depth, since, owing to the great heat produced by fermentation (*see* p. 41), it is impossible for them to exist at a

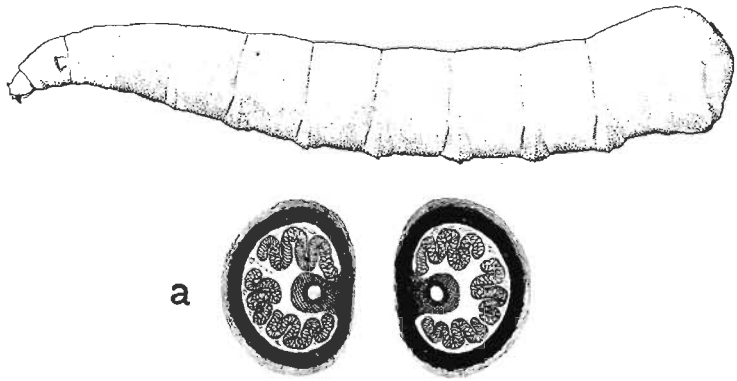

FIG. 7.

FULL-GROWN HOUSE-FLY MAGGOT, OR LARVA (about eight and a half times natural size).

a, the two plates on the hinder extremity of the maggot, showing the deeply folded air-clefts through which the creature breathes (greatly enlarged).

The anterior extremity of the maggot is to the left, the broader end being the posterior one. The maggot crawls, with its narrower end in front, by the aid of a hook (shown in the figure), which is protruded from the mouth, and a series of spiny pads on the under surface of the body. The mouth is situated on the under side, just behind the narrow end, and the maggot, like the parent fly, feeds upon matter in a fluid condition.

The larvae or maggots of a very large number of other flies are similar in appearance to those of the House-Fly, which, however, can be distinguished from most other larvae by the deeply folded shape of the three air clefts in the posterior breathing-plates (*a*).

deeper level. Even in the superficial layer they do not occur continuously, but are collected together, often in very large numbers, at certain spots; apparently larvae hatched from the same collection of eggs, whether the progeny of a single female or not, remain together so long as they continue to feed. Although at night the maggots appear on the surface and move about, they shun daylight, and under ordinary conditions remain

FIG. 8.

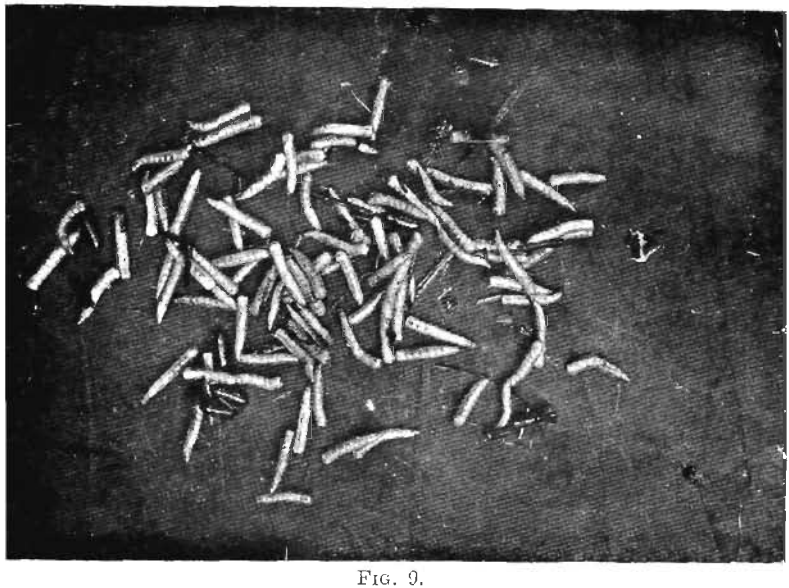

FIG. 9.

FIG. 8. A MASS OF HOUSE-FLY MAGGOTS IN STABLE MANURE (natural size).
FIG. 9. THE SAME MAGGOTS SEPARATED FROM THE MANURE.

From photographs by Professor Robert Newstead, F.R.S., kindly lent by the Health Committee of the City of Liverpool.

invisible; if exposed, owing to disturbance of the food-material, they rapidly burrow out of sight.

An infallible indication of the presence, actual or previous, of mature House-Fly maggots in large numbers in a manure heap is a characteristic *triturated* or comminuted appearance at certain spots, where, owing to the activities of the larvae, the surface has been reduced to the condition of finely chopped straw.* The fully-fed maggot, which is about to pass into the next (pupal or chrysalis) stage of development, is always recognisable owing to its ivory yellow, *waxy* appearance. Before assuming the pupal condition the maggot, which by this time has ceased to feed, leaves the spot at which it has hitherto existed, and, if in a manure heap, usually makes its way to the outside of the base of the heap, where conditions are drier and the heat due to fermentation is less. Here the maggot may remain under cover of the dry, overhanging straw and, sometimes after an interval of three or four days, undergo the change to the pupa; in other cases the maggot may crawl away from the heap to a distance varying from an inch or two to as much as one hundred and fifty feet, and subsequently burrow into the soil to various depths, not exceeding a couple of feet, before pupating. It occasionally happens that a certain number of the maggots actually burrow into the ground *beneath* the heap; in these cases the larvae in all probability make their way inwards from the outside of the base of the heap, since, even though the heat of fermentation may have diminished, it is unlikely that they pass downwards through the manure from above. As already explained, in a manure dump infested with House-Fly maggots, the majority of the latter occur in "nests" at certain

* Equally characteristic is the *flattening of the surface* at these spots, which has been well described by Patton (*Indian Journal of Medical Research*, Vol. 7, No. 4, p. 755. 1920). Writing of House-Fly breeding in horse-dung in Mesopotamia, this author says that, when the maggots "have eaten through a mass of horse-dung, it presents a characteristic appearance. The heap, which was probably irregular at the surface, is now flattened out and presents a worm-eaten appearance, due to the larvae having passed through it over and over again. This is a point of practical importance, for it enables the observer to detect a breeding ground with certainty, and when once noted it can be readily recognised again."

spots; similarly in most cases the majority of the subsequent pupae will be found scattered in little heaps under the straw round the outside of the base of the pile.

In cases where House-Fly breeding occurs in *trench latrines*, such as in the past have often been used by troops in the field, the maggots when full grown, whether the latrine has previously been filled in or not, leave the moist faecal layer in which they have been feeding, and, passing into the surrounding or superincumbent soil or sand, make their way upwards. Although the depth of sand or loam through which House-Fly maggots are capable of ascending in this way has not been finally determined, it is certainly considerable and is known to amount to several feet—in the case of sand to as much as six feet. Eventually, at depths below the surface of the ground varying from a foot to

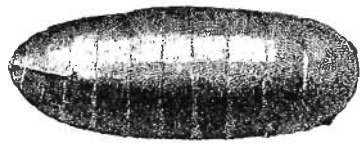

FIG. 10.

HOUSE-FLY PUPARIUM OR CHRYSALIS-CASE (about seven and a half times natural size).

As in all species of flies belonging to the same natural group as the House-Fly, the puparium is formed from the contracted and hardened skin of the full-grown larva, which serves as a case to contain the pupa or chrysalis. The fly when ready to emerge makes its escape by forcing off the upper and lower surfaces forming the anterior end (to the left in the figure) of the puparium.

little more than an inch, the maggots come to rest and the change to the pupal condition takes place.

The Pupa, or Chrysalis.—This stage, which succeeds that of the full-grown maggot, is motionless, and lasts according to the temperature for from three to four days to two to four weeks or more, is passed within a barrel-shaped puparium or shell (Fig. 10), normally about a quarter of an inch in length, which is at first yellow, and becomes successively red, brown, and finally, shortly before the fly is hatched, black.

The Adult Fly.—The newly-hatched House-Fly presents little

resemblance to the familiar insect known to everyone, since it is lacking in colour and has a wizened and shrunken appearance; while, although it is able to run with speed, its notched and shrivelled wings are quite incapable of flight. On the front of its head the insect is provided with a temporary dilatable sac or bladder (ptilinum), by means of the alternate expansion and contraction of which * the fly not only effects its escape from the puparium, but, in the case of buried pupae, forces its way to the surface of the soil; flies emerging from pupae buried in sand have been proved to be capable of ascending in this manner from a depth of at least two feet. Having served its purpose, the frontal sac is withdrawn into the interior of the head and is seen no more; soon afterwards, that is within about an hour after the emergence of the insect, the wings spread out and become capable of flight, the outer covering of the body and legs hardens, and the insect assumes its normal aspect.

It will have been seen, from what has been stated in the foregoing pages that, under very favourable circumstances, a batch of eggs may develop into House-Flies in about a week; † a further period of (in Western Europe) from six to eighteen days must, however, elapse before these flies are themselves capable of laying eggs. ‡

* The expansion of the ptilinum is caused by fluid being driven into it. *Cf.* C. W. Mally, "Note on the Eversion of the Ptilinum during the Emergence of the House-Fly, *Musca domestica*, L.": *South African Journal of Science*, Vol. 13, p. 599 (1917).

† On one occasion, at Rouen, in June, 1915, during very hot weather, House-Flies bred out in little more than six days from eggs laid in horse-manure, but it is probable that so short a period is highly exceptional. In an experiment at Kantara, on the Suez Canal, in May, 1916, the weather during the greater part of the time being excessively hot, the earliest House-Flies from a batch of eggs in fresh horse-dung made their appearance in about seven and a half days.

‡ In hot climates, such as that of Panama (L. H. Dunn, 1923), the pre-oviposition period is often very much shorter, and may be as brief as two and a quarter days.

Experiments carried out by Hutchison at Arlington, Va., and New Orleans, during 1913 and 1914, using laboratory-bred flies originating from larvae or pupae found in manure heaps, showed that in the United States the pre-oviposition period varies between two and a half and twenty-three days. The shortest records occurred in midsummer, and the longer ones during

Owing to the fecundity of the House-Fly and the rapidity of its development, truly colossal figures may be obtained by calculating the descendants of a pair of House-Flies during a single season. Some idea of these figures may be gained by estimating only a *small fraction* of the possible progeny of a single female egg-laying *Musca domestica* in the short period of seven weeks, *i.e.* three generations, taking the time of development from egg to fly as seven days, assuming that in each generation a fortnight elapses between the hatching of the flies and the laying of eggs, that in each case half the flies hatched are females, that each female lays only a single batch of eggs instead of the usual five, six or more batches (*see* p. 19), and that all eggs laid are fertile. It will be found that under the conditions stated, and taking the egg-batch as consisting in each case of 120 eggs, in seven weeks the progeny of the original female House-Fly will number 432,000; and that if each egg-batch consists of 150 eggs the descendants in the same period will amount to the enormous total of 843,750 flies. This, as already indicated, must be regarded as only a small fraction of the possible progeny of a female House-Fly during a single season, lasting, *say*, three months, since every female in the series might lay, not one batch, but five, six or even many more batches of eggs in the course of her life. It may be noticed, however, that in these calculations no account whatever is taken of mortality from various causes, which, in the course of the life-cycle of the House-Fly, is doubtless at least as great as during that of any other highly prolific species.

In temperate climates, large numbers of House-Flies are destroyed in late summer and autumn by a parasitic fungus (*Empusa muscæ*, Cohn), which is one of the most effective natural

autumn, showing that temperature has a marked influence on the length of the period. The latter is also dependent on humidity, quality of food of adults, and quality of the larval food, with the resulting effect on the size and physiological condition of the adult. The date of *pairing* varied from the first to the forty-seventh day after emergence, and pairing did not occur when the temperature was below 55° F.—*Cf.* R. H. Hutchison, "Notes on the Preoviposition Period of the House-Fly, *Musca domestica*, L.": *U.S. Dept. Agric.*, Washington, D.C., *Bull.* No. 345, pp. 1–14, 1 fig., 3 tables (Feb. 5, 1916).

enemies of *Musca domestica*; dead flies, killed in this way, with swollen, whitish, dark-banded abdomens, may often be seen adhering to window-panes, walls or shelves, attached to the supporting surface by outgrowths (rhizoids) from the fungus itself, and frequently surrounded by a sort of pale halo composed of fungal spores (conidiospores).*

Evidence adduced by Glaser (1924) indicates that in America a percentage of House-Flies succumbs to bacterial disease caused by *Staphylococcus muscae*, though there is little prospect of this discovery being turned to economic account.

How long a House-Fly lives is a question often asked but very difficult to answer.† Although in a few instances House-Flies have been kept in captivity (in Seoul, Korea, during the winter, by Dr. H. Kobayashi) for from over twenty-one to over twenty-three weeks (151 to 163 days—*see* p. 31), data obtained under such conditions do not necessarily form reliable indications as to what happens under ordinary circumstances. While it is quite likely that in hot weather, at the height of the breeding season, when the insect's activities are greatest, a House-Fly may not live more than eight or ten weeks, there can be little doubt that in late autumn and early winter, in warm indoor situations in the

* Although the employment of *Empusa muscae* on a wholesale scale in a campaign against the House-Fly has often been mooted, the idea of doing so has never been carried into effect, owing to the difficulty of obtaining an artificial culture of the fungus. Nevertheless, it is perhaps worth noting that, so long ago as 1913, it was stated that E. Hesse, on rearing House-Fly larvae in horse-manure inseminated with "artificially cultivated" *Empusa* "spores," found that, though the larvae pupated, the pupae failed to hatch into flies (see *British Medical Journal*, No. 2714, p. 42. January 4, 1913). On the other hand, it should also be remarked that, according to Roubaud (1922), infection of the adult does not prevent reproduction, and House-Flies infected with *Empusa* may continue to oviposit freely.

† Glaser, as the result of experiments carried on by him in the United States from May to November, 1922, came to the conclusion that a great deal depends upon the insect's food, and that sugar, or some form of starch that can be eaten and assimilated, is an important factor in its longevity. On the other hand, it has been shown by Roubaud that a certain amount of nitrogenous food is necessary for the production of eggs; and that, when fed upon pure sugar or sugary matter, House-Flies remain permanently sterile, though capable of relatively long life.

British Islands, the period of life in individual cases may be prolonged considerably beyond this limit. It is possible that, in the case of certain House-Flies, thus granted an extended lease of life, survival may be sufficiently long to enable them to become the parents of the earliest broods of the following year (*see* p. 31).

A point of greater practical importance than length of life, especially in connection with search for breeding-places, and, in particular instances, the possible carriage of disease by House-Flies, is the distance to which the species, either entirely unaided or with the help of the wind, is capable of flying. As has been pointed out in the United States by Dr. R. R. Parker, the House-Fly is "essentially a migratory insect," and "it is a false idea to assume that when flies breed out near 'food and shelter' they necessarily do not migrate far." Although, under the ordinary circumstances of modern civilised life, especially in towns, a tendency on the part of House-Flies to "pass along" may not be particularly noticeable, it is often recognisable enough under active service conditions. Thus, on a given day, doubtless as the result of simultaneous emergence from the pupal state either close at hand or at a distance, shelters in which House-Flies may not previously have been very numerous may almost suddenly prove to be "swarming" with the insects. Twenty-four hours or so later, however, without any change in meteorological conditions in the meantime, it may be found that the local fly-population has resumed its normal dimensions, the greater number of the winged invaders having proceeded elsewhere. In the course of experiments in the United States by F. C. Bishopp and E. W. Laake (1919; 1921), with marked specimens of the House-Fly and other allied species, the maximum distance of spread in open country from the point of release, observed in the case of *Musca domestica*, was 13 miles, 245 yards. The investigators in question, however, consider that, where great numbers of flies are constantly emerging, the distance traversed may be much greater than this. Marked flies of all the species employed dispersed in all directions from the point of liberation; and, of the stimuli inducing dispersion, the desire for

food and the necessity of reaching places for oviposition appear to be among the strongest. The fact, however, that many towns, farmhouses, and other favourable feeding and breeding grounds were passed by the flies released by Bishopp and Laake shows that the House-Fly, and certain other species, at least, are not satisfied with the mere finding of such places, but have definitely migratory habits. In the case of the House-Fly, there appears to be a tendency mainly to follow the direction of the wind, but the insect was also shown to travel against and at right angles to it, and it was concluded that, under natural conditions, the influence of moderate winds on dissemination is not of great importance. It was found that the House-Fly and other allied species spread rapidly for many miles, and the former was recovered over six miles from the point of release in less than twenty-four hours. In addition to the stimuli already mentioned, favourable conditions as regards weather and temperature assist dispersion, while adverse factors, such as low temperatures and rain, delay it and produce inactivity.

In towns, as was stated by Hindle in 1914, House-Flies do not travel so far as in the open country, probably owing to the abundance of food and shelter afforded by the houses. Hindle, as the result of experiments made by him in Cambridge, in 1912, considered that the usual maximum flight in localities in which houses are numerous is about a quarter of a mile. Dr. R. R. Parker, however, who, in 1915, experimented with nearly 400,000 marked flies, which were liberated by him in a town in Montana, U.S.A., recaptured some of these flies within the town limits at distances exceeding a mile (in one instance more than a mile and a quarter). It is obvious that results of this kind may sometimes be vitiated by accidental carriage of the insects, for the whole or part of the distance, in vehicles or upon human beings, horses, or cattle; and it does not necessarily follow that results obtained in a small town in the United States afford reliable criteria as to what may happen in large cities elsewhere.

Over water House-Flies may be carried by wind to spots relatively remote; thus there is evidence that these insects are

sometimes blown from the city of Cleveland, Ohio, U.S.A., to points five and six miles out in Lake Erie; and Wenyon (1921) mentions an instance, which occurred in the Persian Gulf, of House-Flies in large numbers being blown ten miles across the sea by an off-shore wind.

Apart from their potentialities as disease-carriers (dealt with on pp. 33–38), House-Flies as *disturbers of rest*, especially if in numbers and in a warm climate, are the cause of an incalculable amount of annoyance and even suffering. In this respect the greatest victims are often troops on active service, who, however exhausted, are frequently unable, owing to the "infinite torment of flies," to obtain any sleep by day, except under the protection of mosquito nets or other coverings. Fortunately the activities of House-Flies, though commencing with the sun, terminate betimes, and usually about or a little before sunset the insects take up their positions for the night. Subsequently, so long as darkness lasts, rarely moving and undisturbed by artificial light,* they sleep soundly upon the ceilings or walls of rooms, tent linings, hanging cords, overhead wires and similar favourite roosting-places. Under conditions of abnormal heat and drought, however, the usual nocturnal immobility of the House-Fly may be greatly modified. Thus at Deir el-Belah, in Southern Palestine, on May 19th, 1917, during the campaign against the Turks in the Great War, after a day of *khamsin*,† the behaviour of the House-Flies in tents at

* In the British Islands towards the close of the year the behaviour of surviving House-Flies undergoes a certain change, in consequence of which at this period, in warm rooms, the insects are sometimes active for hours by artificial light at night. This was particularly noticeable in the author's house at Northwood (Middlesex), in November, 1921. The summer of that year was abnormally hot and prolonged, and even well into October the mean daily temperature was remarkably high. Doubtless as a result of the favourable breeding conditions, House-Flies at Northwood were locally much more abundant than usual, and the belated flies remaining in or entering the house in November, after colder weather set in, were unwontedly numerous. During that month these domestic pests were often particularly aggressive and troublesome by night, repeatedly settling on the author's face and hands, and persistently returning after being driven away, up to 10 p.m., or even later.

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night was extraordinary. The insects, apparently maddened by thirst, displayed a restless and altogether abnormal activity, not only by artificial light but long after "Lights out," constantly and impulsively crawling—evidently in search of refreshment—over the faces of would-be sleepers until at least 11.0 p.m.*

What becomes of House-Flies in winter in the British Islands and North America is a matter of more than merely academic interest, since definite knowledge on the subject, should it prove possible to attack the insects when they are least numerous, might prevent a large amount of future House-Fly breeding. The problem has within the last fifteen or sixteen years been the subject of a certain amount of investigation, as well as of frequent correspondence and some controversy in the public Press and elsewhere; but results cannot yet be said to be entirely conclusive. While in climates such as that of Egypt, temperature never falls sufficiently low to prevent House-Fly breeding altogether, so that even during what corresponds to the winter months the insect can still be found in all its stages, in more northerly latitudes, such as those of the British Islands, House-Fly breeding in general may be said to cease in October. Not long afterwards, except for a few individuals, which continue to exist for a considerable time, *in an active condition*, in bake-houses, kitchens, restaurants and similar specially favourable retreats, House-Flies under ordinary conditions disappear altogether, and are no more seen until late spring or early summer of the following year. The riddle to be solved is therefore:—*Where and in what stage does the House-Fly, in temperate*

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days in March, April, and May, and fills the air with sand from the desert. On the occasion mentioned, shade temperatures during the day were: 9.30 a.m., 93° F.; noon, 104° F.; 6.30 p.m., 101° F. The air, as if from an oven, was intensely hot and dry.

* *Cf.* also D. C. Parman, "Observations on the Effect of Storm Phenomena on Insect Activity": *Journal of Economic Entomology*, Concord, N.H., Vol. xiii, pp. 339–343 (August, 1920).

Most of these observations were made upon Muscids and related Diptera, including *Musca domestica*, *Stomoxys calcitrans* and other species. With a rapidly falling barometer it was noticed that the flies became nervously active, and then passed into a state of coma, during which they are more subject to the action of destructive agencies.

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climates, contrive to survive the winter, so as to perpetuate the species from year to year? Until the year 1914, in answer to this conundrum, it was customary to assert that the race of House-Flies is continued by the survival of a certain number of females, which were supposed to retire into cracks in walls, the shelter afforded by loose pieces of wall-paper, and similar hiding-places inside houses and other buildings, and there hibernate.* Without going into details—here precluded by limitations of space—it may suffice to say that investigations already alluded to have afforded no support whatever for the hibernation theory in question. On the other hand, there is as yet no actual proof that the *active* House-Flies, which, as indicated above, may still be seen in certain places in late autumn and the earlier months of winter, survive until the following breeding-season. The evidence, such as it is, seems to disprove the survival of many House-Fly *pupæ*,† if any, through the winter months; and though perhaps, on *à priori* grounds, it would appear at least possible that the persistence of the species is secured by the survival, in the soil or elsewhere, of a certain number of adult *maggots*, nothing of the kind has yet been proved. In Seoul, Korea, House-Flies kept by Dr. Harujiro Kobayashi (1922) under laboratory conditions, in glass tubes, at temperatures between 41° F. and 59° F. (*i.e.* about the same as in an ordinary inhabited house in Seoul during the winter), and fed on moistened biscuit, survived in three cases, in each of which the insect was

* Preconceived ideas of this kind are often due to mistaken identification, as when Cluster-Flies (Fig. 5, p. 13), or specimens of *Musca autumnalis* (Fig. 3), are supposed to be House-Flies.

† From over 10,000 pupæ collected by Dr. H. Kobayashi at Seoul, Korea, during February and March, 1922, a number of flies of various species emerged, but *Musca domestica* was not among them. Kisliuk, at Columbus, Ohio, U.S.A., the latitude of which is about the same as that of Madrid, found, on February 26, 1917, "a very large mass of House-Fly puparia" in a pile of sheep manure. The majority of these pupæ had been destroyed by Hymenopterous parasites; in a small percentage of cases the flies appeared to have bred out naturally. From the mass of puparia, after being placed in a breeding-cage, there eventually emerged one male *Musca domestica* on March 10, 1917, another male on March 11, and two females on March 12. This may indicate that, under natural conditions in Europe and the United States, a House-Fly pupa here and there may survive the winter.

female, for 151, 153, and 163 days respectively, that is in th
igest case for over 23 weeks. One male lived under the sam
nditions for 161 days, from November 11, 1921, to April 2
922; other individual flies lived for shorter periods, which
veral cases exceeded four months, the longevity of the male bei
ten not less than that of the female. Kobayashi considers th
ese results clearly show that in nature *Musca domestica* can li
rough the winter, from late autumn until early spring. On t
hole it seems probable that, in temperate climates such as th
f the British Islands, the continuance of the House-Fly throu
he winter is ensured by slow breeding in exceptionally favoura
situations, such as warm stables; the actual females by wh
such winter breeding is initiated quite possibly dying before
advent of the normal breeding season in the following year.
addition, or alternatively, Kobayashi's results, to which refere
has just been made, indicate the possibility of the survival, in
active state, until the earliest commencement of the follo
breeding season, of a certain number of very late hatched individ
of both sexes, which may not breed at all during the actual wi

Towards the close of 1919 much interest was aroused b
announcement that Mons. E. Séguy, of the Muséum Nat
D'Histoire Naturelle, Paris, had discovered House-Fly larvae i
snails in winter. In one case, out of fifty snails collected i
middle of January, nine were found to be thus infested; the
were not the Garden Snail (*Helix aspersa*, Müll.), but belonge
smaller species, in all probability either *H. hortensis*, Mü
H. nemoralis, L. At the time of writing (February, 1926)
remarkable discovery has not been confirmed in England.

In whatever stage the winter be passed in latitudes su
those of the British Isles, the House-Flies upon which the t
perpetuating their species devolves in the following spri
relatively few in number, while as a rule the species do
become unpleasantly common until the year is much
advanced, which are perhaps reasons for regarding *Musca do*
in countries like our own as originally an immigrant from
[illegible] p. 8). In the British Islar

earliest broods of the season usually commence to make their appearance in June, though as a rule it is not until the following month that the numbers of House-Flies begin to show a marked increase. Generally speaking, in the absence of local conditions specially favourable to the breeding of the insects in abnormal numbers at an earlier period than usual (as at Postwick, near Norwich, in June and July, 1910), House-Flies in the British Islands are most numerous in the months of August and September, though they are often still common in October, and sometimes even in November. In Egypt there are two well-marked seasons of House-Fly prevalence, namely, May and September; in the intervening hot months the insects practically disappear, or at least undergo marked diminution in numbers, and breeding is reduced to a minimum (*see* p. 16, note *). The occasional local occurrence of House-Flies in such numbers as to constitute a veritable "plague" is generally traceable to one or more of the following causes: (1) Exceptional meteorological conditions favouring abnormally rapid development; (2) the local abundance of breeding-places and of food-supplies for the maggots or larvae; (3) the presence, in the immediate vicinity, of a manure-dump to which additions are constantly being made, or of a "tip" or dumping-ground for household refuse, on which, with the latter, are continually being deposited large numbers of larvae and pupae, which have developed from eggs originally laid in a number of different centres.

Insect Enemies of House-Flies.

It is unnecessary here to do much more than record the fact that a considerable number of insects of various orders prey upon the House-Fly in its different stages, since, generally speaking, the attacks of these enemies appear to have little effect in reducing the number of House-Flies in existence. Perhaps the greatest destruction of House-Flies is wrought by members of the order Hymenoptera. Wasps of various species have been observed to pounce upon and carry off the adult flies; minute Hymenoptera of several genera and species belonging to the families Chalcididae and Cynipidae parasitise House-Fly pupae or larvae; and con-

siderable destruction is effected by certain kinds of ants. For instance, in Hawaii, according to Bridwell, House-Fly breeding-places are very generally penetrated by the tiny ant known as *Pheidole megacephala*, F., which destroys a large part of the eggs, larvae, pupae, and newly emerged adults; and there is said to be little doubt that the same species of ant is responsible for the scarcity of House-Flies in Fiji.

In Europe, according to a distinguished Russian entomologist, the late J. A. Portchinsky, the larvae of the House-Fly, as also those of the Stable-Fly (*Stomoxys calcitrans*, L.), are destroyed in large numbers by the maggots of the common Muscoid fly known as *Hydrotaea dentipes*, F. The latter can readily be reared in captivity, is not troublesome to man, and never visits human dwellings; its larvae do not eat each other, but are otherwise omnivorous, and will thrive on all materials serving as breeding-places for *Musca domestica*.

House-Flies and Human Disease.*

The House-Fly is not merely a nuisance, but is also, or under certain conditions is capable of being, a carrier of disease and therefore a very serious *danger to health*. In order that this familiar insect may be regarded in its true light, it is important that everyone should realise the grounds on which the foregoing statement is based, which are briefly as follows:--

(1) Human faeces frequently contain the living germs of certain dangerous diseases, or, especially in warmer climates, the eggs of various parasitic worms.

(2) Human faeces, if exposed or otherwise accessible, have an irresistible attraction for House-Flies, which feed greedily upon this material, and in so doing swallow the disease-germs or eggs (if present) mentioned in (1) †.

* *See* also "British Museum (Natural History) Special Guide No. 7. Guide to the series of Disease-Carrying Insects and Arachnids in the Central Hall," pp. 28-31 (in preparation, March, 1926).

† N.B.- *Predominance of females among flies frequenting human faeces.*- - Dr. R. R. Parker, in investigations (conducted from July 20 to August 21, 1914, at Laurel, Montana, U.S.A.) to determine what species of flies frequent "privy vaults," in the course of which flies belonging to twenty-six different

(3) Human food—more especially sugar, milk, jam, bread, cheese (all of which, be it noted, are consumed uncooked), and sticky fruits, such as dates, etc.—is only less attractive to House-

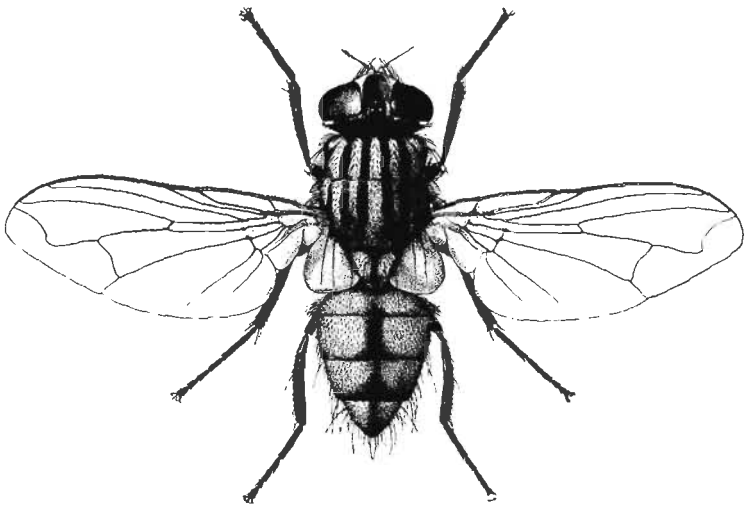

FIG. 11.

HOUSE-FLY (female) IN THE ATTITUDE OF FLIGHT (six times natural size).

Flies than are human faeces, and the insects may, and frequently do, pass *directly from faeces to food.*

(4) The disease-germs and eggs referred to in (1) pass through

species were captured, found "one fact that is common to all the species, namely, that the females greatly predominate . . . *Musca domestica* females were about three times as numerous as males, 564 to 197. The same relationship was found to hold good when flies were trapped out of doors with human excrement for bait, females being in that instance about four times as numerous as males." Dr. Parker continues: "I have no data to show the comparative abundance of the two sexes in houses, but it is apparent that as a seeker of filth the female House-Fly is potentially more dangerous to the human species than the male. For this reason any bait that will attract more females than males should be considered more efficient than one which will attract an equal number of both sexes. Several baits were tried with this in view, and a combination of beer and oatmeal was found the most effective."—*Cf.* R. R. Parker, "Data Concerning Flies that Frequent Privy Vaults in Montana": *Entomological News*, Philadelphia, Vol. xxix, pp. 143-144 (1918).

the House-Fly unaltered, at least within certain time limits *—in the case of the germs of bacillary dysentery up to at any rate four days after being swallowed by the insect. †

(5) The House-Fly's liquid excrement, which thus often contains the living causes of disease already alluded to, is voided at frequent intervals, *especially when the insect is feeding*. In this way virulent disease-germs may be deposited by House-Flies *directly upon human food* (such as is mentioned in (3)), or upon eating or drinking utensils in actual use. ‡

* Colonel C. M. Wenyon, C.M.G., C.B.E., late A.M.S., and Captain F. W. O'Connor, late R.A.M.C., working at Alexandria in 1916, obtained some remarkable results by examining the droppings of 200 House-Flies captured at random in different parts of the city. Among the organisms found in this way in the excreta deposited by the insects in glass tubes were : the resting-stages (cysts) of *Entamoeba histolytica* (the cause of amoebic dysentery), and of *Giardia* (*Lamblia*) *intestinalis* (another microscopic organism parasitic in the human intestine, and by some authorities regarded as one of the causes of diarrhoea); eggs of the hook-worm (*Ankylostoma duodenale*, the cause of miners' anaemia or hook-worm disease); the eggs of three other worms (*Taenia saginata*, *Trichuris trichiura*, and *Heterophyes heterophyes*), two of which at least cause disease, while all are parasitic in the intestine of man ; and eggs of the worm known as *Schistosoma mansoni*, the cause of a dangerous disease of the intestines and liver. Some or other of the organisms mentioned were found in the droppings of 15 (= 7½ per cent.) of the 200 flies examined, clearly showing that these fifteen insects at least had been feeding on human faeces before being captured.

† According to Wollman (1921), flies containing bacilli causing diseases such as anthrax, dysentery, tuberculosis, and typhoid fever may continue to be infective for from eight to ten days. With regard to amoebic dysentery, Dr. F. M. Root has shown that free forms of *Entamoeba histolytica*, the organism that is the cause of this disease, if swallowed by House-Flies, do not encyst, but, as previously asserted by Roubaud, are killed in an hour or even less ; on the other hand the *cysts* (resting stage) of *E. histolytica* may survive in the fly's intestine for more than two days (49 hours). Root also says, "if a fly containing cysts is drowned in water, milk, soup, or other liquid food, the cysts will live still longer, about a week, and there seems to be a possibility that human beings might be infected by swallowing such drowned flies."—*Cf.* F. M. Root, Ph.D., "Experiments on the Carriage of Intestinal Protozoa of Man by Flies": *American Journal of Hygiene*, Vol. i, pp. 131-152, 3 plates (1921).

‡ Certain disease germs may also be deposited in the insect's *vomit*, which the House-Fly uses to liquefy solid food, such as sugar: or they may be carried externally on the legs or other parts of its body. For various reasons, which need not here be specified, however, these modes of disease-carriage by House-Flies are on the whole far less important than that mentioned above.

The diseases that House-Flies carry or are capable of carrying, however, are by no means limited to dysentery and maladies caused by parasitic worms. To mention only some of the more important diseases—there can be no doubt that, under certain conditions, as past experience has proved, these insects act as carriers of cholera, typhoid fever, and serious affections of the

FIG. 12.

THE HOUSE-FLY MENACE IN THE MIDDLE AGES.

Facsimile of an illustration to a section on the House-Fly in *Hortus Sanitatis*, by Joannes de Cuba; printed at Mainz by Jacobus Meydenbach, 1491.

eye extremely prevalent in Egypt. As regards the spread of infantile or summer diarrhoea House-Flies are under grave suspicion; while it has been shown by experiment that a House-Fly infected with the organism of leprosy can convey that disease to a healthy individual, if the insect alights on a raw or wounded surface.

Although precise experimental evidence in support is lacking, it is considered by some writers that House-Flies have played an important part in certain outbreaks of smallpox. With reference to plague, Gosio has stated (1925) that, by rearing House-Flies from larvae fed upon material heavily infected with plague bacilli, it is possible to produce infected adult flies. The latter may prove to be short-lived and die within twenty-four hours, so that a heavy mortality among flies, which has sometimes been noted as occurring during a plague epidemic, is perhaps significant. According to Graham-Smith, in the case of House-Flies fed upon sputum rich in tubercle bacilli, the organism was recovered in the insects' faeces up to five days later; and it may be noted that the same writer also states that: "A fly which has access to abundant food produces between fifteen and thirty deposits (vomits and faeces) in twenty-four hours."

Concerning past experience of the House-Fly as a disease-carrier among troops on active service, when stationary or in standing camps, it is scarcely necessary to do more than refer to the classic illustration afforded by the typhoid epidemics in American concentration camps during the Spanish-American War of 1898, or to the outbreak of dysentery in the British forces in Gallipoli in 1915 (*cp.* p. 18).*

It will be evident from what has been stated above, under sub-headings (1) to (5), that the lower the state of general sanitation the greater are the possibilities of disease-carrying by House-Flies; and that therefore the House-Fly in some of the warmer and less highly civilised parts of the earth, or under conditions inseparable from active service in the field, is a still greater danger to health than in Europe or North America in the normal circumstances of peace. Nevertheless, the most superficial observation, coupled with a very little reflection, will suffice to show that even in the British Islands, especially in country districts and the poorer quarters and outskirts of large cities and towns, the House-Fly still finds many opportunities for evil, and there can be no doubt whatever that it is by far the most important of British

* *Cf.* also P. Simmons, "A House-Fly Plague in the American Expeditionary Force": *Journal of Economic Entomology*, Geneva, N.Y., Vol. xvi, pp. 357-363 (1923).

insects from the standpoint of public hygiene. Under modern conditions House-Flies, except as "danger-signals," serve no purpose useful to ourselves, while they may at any time develop into a menace to human life. It is therefore the bounden duty of everyone, by the employment of *all possible means*, to assist in protecting the community from the perils inseparable from the presence of these living vehicles of infection.

House-Flies and Diseases of Domestic Animals.

Experimentally at least, the House-Fly has been shown to be capable of conveying the spores of anthrax, while, in the United States, the insect has been regarded as, under certain conditions, a possible carrier of the virus of hog cholera; and a recent writer (J. W. Scott, 1924) thinks it probable that House-Flies play a part, though of subsidiary importance to that of *biting* flies, in the transmission of swamp fever (infectious anaemia) of horses. House-Flies, moreover, are intimately associated with the life-cycle, and consequently the transmission, of certain species of parasitic worms belonging to more than one group. *Musca domestica* and, in Australia at least, several allied Muscoid flies are the intermediate hosts of the worms known as *Habronema muscae*, Carter, and *H. megastoma*, Rudolphi, which are parasites of the horse. Infection of the flies occurs in the larval stage, by swallowing larvae of the worms present in horse droppings; an allied species, *H. microstoma*, Schneider, develops in and is conveyed by the Stable-Fly (*Stomoxys calcitrans*, L.). According to Roubaud and Descazeaux (1922), in the case of the species of *Habronema* carried by the House-Fly, infestation of the horse takes place through contact of the tip of the fly's proboscis with the mucous membrane of the lips, or with warm, moist wounds on the surface of the skin, such contact resulting in spontaneous emission of the larval worms from the proboscis.

The House-Fly is also stated to be the intermediate host of at least two species of tapeworms, which occur in poultry.*

* *Cf.* J. H. Woodger, "Notes on a Cestode occurring in the Haemocoele of House-Flies in Mesopotamia": *Annals of Applied Biology*, Vol. vii, pp. 245-251, figs. 1-3 (1921).

Preventive Measures and Remedies.

While the circumstances of the case must necessarily determine the precise measures to be adopted in order to deal with House-Flies, and, especially by reducing the numbers of the insects to a minimum, to lessen the risks due to their existence, the *two golden rules* which follow are of universal application and should never be lost sight of.

(I) **It is far better to prevent House-Flies from breeding, than to permit them to breed unchecked, and then endeavour to kill the resultant broods after they have invaded houses or other habitations.**

(II) **No system of sanitary control can be regarded as efficient which allows House-Flies to have access to material containing, or possibly containing, the germs of disease.**

Procedure against House-Flies resolves itself then into :—

(*a*) Measures against eggs, maggots, and pupae.

(*b*) Measures against the adult flies.

While operations under both headings, if properly chosen and conscientiously carried out, are effective, and while the House-Fly, like all other insect pests, if it is to be combated successfully, must be *attacked by every means at our disposal*, it follows from Rule (I) above that nothing must be allowed to stand in the way of—

MEASURES AGAINST EGGS, MAGGOTS, AND PUPAE.

Action under this heading, whether among civil communities or troops in the field, will depend primarily upon the nature of the breeding-place, which for practical purposes may be taken as consisting of either (i) horse-manure; (ii) household or kitchen refuse; or (iii) human faeces.

Before going into details, since, in spite of the lessons of the Great War, misconception on the point may still linger here and there, it seems advisable to state that, **for the prevention of House-Fly breeding** in any material whatever **chloride of lime is utterly useless.**

(i) *Prevention of breeding in horse-manure.*

To troops on active service, except on loose sand, in a hot and dry desert country (*see* below, under "Spreading," p. 42), horse-manure is simply a noxious waste product of no value; in the case of armies in the field, therefore, it is well if each day's output can be *completely* disposed of within twenty-four hours by *burning*. For various reasons this is seldom practicable. If, however, incineration be the method of disposal adopted, the type of incinerator employed must be efficient for its purpose, and there must be no accumulation of unburned manure, either in the form of a dump alongside the incinerator, or in or about the latter itself. In a hot country, or during the House-Fly season in temperate climates, breeding readily takes place in the corners of an incinerator, in small piles of unburned manure which has fallen from above.

After what has already been stated as to the upward-burrowing powers of adult maggots and newly hatched House-Flies (*see* pp. 22, 23), it is scarcely necessary to remark that, once eggs have been laid in horse-manure, simple *burial* of the material in ordinary soil or sand will not prevent House-Fly breeding.

Under conditions other than those of active service, the destruction of horse-manure by burning in order to prevent House-Fly breeding is of course not to be thought of, and, with this restriction, the possible courses of procedure may be classified and considered as follows: –

(A) Manipulation of the manure itself, in such a way as to kill the preliminary stages of the House-Fly, without the addition of special substances.

(B) Collecting egg-masses; trapping the adult and migrating maggots by means of special traps, or the use of water.

(C) Addition of substances which prevent the hatching out of adult flies.

(A) Manipulation of the Manure itself.

The methods to be considered under this head, while far cheaper, are preferable even on other grounds to those mentioned

below under (C), and, apart from incineration, are the only really practicable ones for troops in the field. The possible courses of action may be designated shortly as *close packing*; *turning over the surface*; and *spreading*.

Close Packing.—The essence of this as of the following method is the utilisation of the natural heat of fermenting manure, for the destruction of the eggs, maggots, and pupae (if present) of the House-Fly.

For *close packing* (a method introduced in 1915 by Colonel S. A. Monckton Copeman, M.D., F.R.S., T.D. (*late* Ministry of Health), an area of hard, level ground, at least three or four feet greater in extent each way than the ultimate size of the intended dump, must be selected or prepared * to receive the manure. On this, each day's manure is utilised in forming or adding to a compact rectangular block, which may be of any desired dimensions horizontally, but for convenience of treatment should not exceed five feet in height. Each load of manure on being added to the dump must be pressed down firmly with shovels, and if the weather be dry should be sprinkled slightly with water; finally the sides, which should be somewhat sloping, must be beaten and smoothed down with the shovel. While House-Fly maggots are speedily killed at temperatures above 114·8° F., it was found by Colonel Copeman that, four inches beneath the surface of a heap of fresh stable manure treated in this way, the heat produced by fermentation may be as much as 169° F. It should be noted that the fertilising value of *close packed* is greater than that of loosely stacked manure.†

* The area may either be cemented over, or receive a top-dressing of 1 part (by volume) of mineral-wood-preserving oil, mixed with 40 parts of fine soil, the mixture being spread on the ground and beaten down; 1 gallon of oil will suffice for 100 square feet.

† The liquid part of the manure being the most valuable, there will be less loss owing to drainage and evaporation. Thus, Sir A. D. Hall, M.A., F.R.S. ("Fertilisers and Manures," p. 190: London, John Murray, 1920), writing of the changes that take place "during the making and storage of farmyard manure," says that in the course of the "second change" (*i.e.* the change to "'short' or rotten manure," which "may continue slowly for years"), "if the mass is kept tightly pressed and moist enough to exclude

Although the success of close packing as a preventive of House-Fly breeding in horse-manure has been proved in England, the method has yet to be tested in warmer climates. In the event of failure from some unforeseen cause, the portion of the dump (both sides and top) in which maggots are seen should be covered over with a layer of sacking (old coal sacks, if without holes, answer well), soaked in heavy oil and secured by means of large stones; the sacking need only be allowed to remain for one week, after which if required it may be employed on another part of the dump.

Turning over the Surface.—The area on which the dump is placed should be similar to that described above under "*Close Packing*"; the dump itself should be kept compact and flat-topped, but need not have its surface beaten down; the slope of the sides should not exceed 30°. Each part of the dump, on the day after deposition and on the two following days, should be turned over with spades in such a manner as to bury the outer layer five or six inches deep, thus exposing the maggots, if present, to the almost instantly fatal effects of the heat and gases of fermentation at deeper levels. The method is somewhat laborious, but, to be effective, must be carried out conscientiously; if necessary, it may be supplemented by the use of oiled sacking, as already detailed.

Spreading.—This method is only suitable for use in hot, dry climates, or under very exceptional weather conditions in Western Europe; moreover, since manure after treatment in this way cannot well be employed for agricultural purposes, "spreading," though it may be practised with good effect by troops campaigning in desert countries, is not a practicable system among civil communities. *Spreading* horse-manure, in order to prevent House-Fly breeding, consists essentially in distributing within twenty-four hours each day's output in a thin layer, in such a way as to be desiccated rapidly by sun and wind; dry or drying manure does not attract egg-laying flies (*see* p. 17), and any

air, there will be no loss of fertilising constituents, only a gradual decline of weight as some of the carbon compounds are converted into gases."

maggots that may be therein, if not already adult, cease to develop and, under a hot sun, die before reaching maturity. While the best results are obtainable on hard ground, *spreading* may be employed with success even on loose desert sand, provided the surface be first raked over to ensure the absence of holes or "pockets." In any case, when in use, *spreading* should always be worked on the "three-day system," that is to say three areas, each just large enough to receive one day's output when spread to the requisite thickness, should be marked out, and each area used in turn for one day. On the fourth day the first area may be used again, the second area being employed on the fifth day, and so on. Just before using an area again the desiccated manure may, if desired, be swept or raked to one side, and burned in heaps or "wind-rows." It may be noted, however, that horse-line manure can be used to form good roads over desert sand, and, when so employed, will not be a source of fly-breeding provided that the directions as to spreading and drying about to be given are adhered to; the more such roads are used for horse and wheeled traffic, the less likely is fly-breeding to take place in them, in consequence of failure to adhere to the method laid down. On the appointed area, each day's manure must be spread to a depth not exceeding *one inch*, in a thin, uniform layer; furthermore, in order to break up the nodules of dung, into which the maggots are apt to retreat, the layer after being spread must be raked over thoroughly on the afternoon of the same day, and again on the two following days. Under no circumstances must a layer of manure be placed on the top of a previous one before the latter is thoroughly dry. As to the method of spreading, it should be noted that it is best to scatter the manure from a spade, with a horizontal, semicircular sweep; dumping manure in a heap, and then raking it out, is never satisfactory, least of all on roads.

(B) Collecting Egg-masses; Trapping the Adult Maggots.

The two simple methods to be described first under the above heading are suitable for use on manure heaps of the

ordinary, loose, farmyard type, to which additions are constantly being made, and where no other precautions are taken to prevent House-Fly breeding.

Collecting Egg-masses.—Fresh additions to manure heaps of the type just mentioned should be examined about 9.0 or 10.0 a.m. daily during the House-Fly season. Whenever a closely packed cluster of House-Flies, as described on p. 18, is seen ovipositing, the insects should not be disturbed, but the spot should be marked; some two or three hours later (not longer, lest the eggs should hatch), the egg-mass should be removed with care and burnt.

Trapping the Adult Maggots.—This method of checking House-Fly breeding is based upon the migratory instinct, which causes the fully-fed maggot to leave the surroundings among which it has been feeding, in order to seek a cooler and drier spot in which to pupate (*see* p. 21). Although within recent years it has been shown that House-Fly breeding in manure heaps can be checked, by means of arrangements which ensure that the migrating maggots fall into water and are drowned, it is unnecessary here to do more than make passing mention of the fact, since it is extremely unlikely that the system will ever secure general adoption.

Simpler and more practical in every way are the maggot traps devised in 1915 by Lieut.-Col. P. J. Marett, R.A.M.C. (ret.). The traps in question consist of large tin boxes, such as those in which army rations are packed. In all four sides of each tin a horizontal slit (terminating in a short vertical slit at each end) is cut, about two inches above the bottom and not quite reaching the angles; each slit is wedged open with a stone, and the tin is then filled with dry sand or chaff to a height of about four inches, and provided with a cover. When full-grown, *wary* maggots (*see* p. 21) are discovered in any part of a manure heap, the spot is surrounded with traps in such a way as to intercept the maggots on their journey to the outside of the base of the heap, each trap being sunk in the manure until the slits are just level with the surface. After being allowed to remain overnight, the traps

should be examined on the following morning, when the catch can be cremated. According to Colonel Marett, more than 5,000 maggots have been caught in one of these traps in a single night.

A more elaborate method of preventing House-Fly breeding in dumps of stable manure or other waste matter, which has been found very effective in South Africa, and likewise depends for its success upon the principle of trapping the migrating maggots, is known as the *Baber Larval Trap*. The essence of this contrivance is an impassable, brick-built trench, into which all adult maggots fall on leaving the dump, and from which they are prevented from escaping by means of an overhang (made from a strip of galvanised iron) on each side of the trench, forming a downwardly slanting sharp edge round which fly larvae are unable to crawl. The manure or other material to be dumped is stacked tightly inside an enclosure of iron hurdles covered with wire netting, placed upon a rectangular concrete or brick platform, the outer edge of which is bevelled to ensure that larvæ falling upon it from the manure will roll into the trench. In very dry climates manure treated in this manner should be wetted regularly. A sump for the reception of liquid flowing from the manure is provided in one angle of the trench, and in this the majority of the larvae from the dump will ultimately be found; it is necessary to remove maggots thus captured twice or thrice a week, and, with suitable precautions against escape, they can then either be thrown to fowls, or destroyed by boiling water or otherwise. It has been proved in South Africa that, on the Baber system, it is possible without nuisance of any kind to dispose of latrine bucket contents, by sandwiching them between layers of stable manure; and the adoption of similar methods for dealing with abattoir waste is said to have resulted in complete success.*

* For fuller details and illustrations, see—Captain E. Baber: "Fly Control by means of the Fly-Larval-Trap Manure Enclosure": *Journal of the Royal Army Medical Corps*, Vol. xlv, No. 6, pp. 443-452, 4 figures in text (December, 1925).

(C) Addition of Substances which prevent the Hatching Out of Adult Flies.

While it has been proved by experiment that various substances, if added in sufficient quantity to horse-manure in which House-Flies are breeding, are fatal to the maggots or eggs, for divers reasons such as cost, poisonous or possibly poisonous effects upon plants or animals, or the amount required, most of the materials referred to are practically useless. There are two substances, however—*borax* and powdered *hellebore*, which, while non-poisonous, are free from other of the objections mentioned, and both have been shown by American investigators to be effective for their purpose. The efficacy of borax as a preventive of House-Fly breeding in manure heaps was also experimentally confirmed in France during the Great War; but, although before the War borax as compared with hellebore was relatively cheap, neither material, if only on account of the large amounts required when dealing with manure in enormous quantities, can be considered suitable for use by troops in the field (*see* pp. 40–41).

Borax.—Powdered borax (half a pound dissolved in two to three gallons of water) is best employed in solution; the quantity mentioned is sufficient to treat nine cubic feet of manure, and should be applied by means of a sprayer or watering-can as soon as the manure is removed from the stable, the manure during application being turned over and over with a fork in order to bring the liquid into contact with every part of the mass. House-Fly eggs in borax-treated manure are killed without hatching; maggots, on the other hand, attain their full development without showing any apparent effects, but the resultant pupae in a large number of cases are malformed, and only a small percentage, if any, hatches into flies. Although horse-manure treated with borax at the rate mentioned can be applied to the soil in quantities up to fifteen tons to the acre without injury to crops, *if larger amounts of borax are used the results may subsequently be harmful to vegetation.* Caution is therefore necessary in applying borax to manure which is afterwards to be used for agricultural purposes.

Hellebore.—Powdered hellebore (*Veratrum album*, L., and *V. viride*, Ait.) root has been proved in the United States to be effective in preventing the emergence of House-Flies from horse-manure, killing on the average 95·5 per cent. of the maggots exposed to its action; its effect on the eggs and pupae is not known. For use, one half-pound of powder must be mixed with ten gallons of water, and this amount of the mixture, after being allowed to stand for several hours, applied, in the manner described above for borax, to every eight bushels (ten cubic feet) of manure on removal from the stable. Fowls scratching and pecking in hellebore-treated manure suffer no ill-effects, while, since powdered hellebore is completely decomposed in the course of fermentation of manure, it is impossible for injury to crops to result, even if the substance be employed in excess. Except in special cases, however, questions of expense and supply must be serious obstacles to its use.

The most practical methods of checking House-Fly breeding in horse-manure have now been dealt with, but, in view of the importance of this material as a breeding-place, before dismissing this part of our subject a few general remarks will perhaps not be out of place. House-Flies, as we have seen, never breed in old and fermented manure (*see* p. 17); in old-established manure heaps *fresh additions* are the only possible breeding-places, and here, during the breeding season, a sharp look-out should be kept for the significant *triturated* and *flattened* condition of the surface mentioned on p. 21. Barn-door fowls, if allowed to scratch and pick on manure heaps, by devouring a certain number of maggots and pupae, undoubtedly do something to keep down House-Flies, but at best are only a very partial check, and in farm-yard manure heaps in which there is much straw the maggots easily escape their attacks. If, therefore, a serious attempt is to be made to keep down House-Flies, *during the breeding season*, one or other of the methods of prevention described above should always be practised by those responsible for the storage of fresh manure.

(ii) *Prevention of breeding in household or kitchen refuse.*

Household or kitchen refuse, if containing organic matter to which the insects are able to gain access, is certain to be a breeding-place both of House-Flies and Bluebottle and Greenbottle Flies during the season, and should therefore before removal be kept in receptacles which are *really*, and not merely nominally, *fly proof*. In urban districts, where daily removal is not in vogue, such refuse should, during the House-Fly breeding season (in the British Islands *say* from June to October inclusive), be removed not less than twice a week. After removal, there is only one really satisfactory method of treating such refuse, both in order to prevent fly-breeding and on grounds of general hygiene, namely, to destroy it promptly and completely by

Burning.—In this connection it is unnecessary to say anything here on the subject of Municipal Destructors, except that care must be taken to prevent any accumulation of organic material in the vicinity of an installation of this kind. Should such an accumulation nevertheless occur, it should be treated two or three times a week with *borax*, applied at the rate and in the manner described above for horse-manure (*see* p. 46).

As regards incinerators for kitchen refuse in military camps, while in this case also due precautions must of course be taken to prevent accumulation, the *inadvisability* of permitting the digging *of ashpits* should be noted. Although intended solely for the reception of burnt material, holes in the ground of this kind are convenient receptacles for unburned refuse, and accordingly liable on occasion to be put to improper use, subsequently becoming a perhaps unsuspected source of fly-breeding; an *incinerator ash-heap*, on the other hand, is not subject to the objection indicated.

Under civil conditions, when in the absence of a destructor, *dumping* of household refuse has perforce to be resorted to, no municipal depôt, contractor's dumping ground or "tip," where the material is allowed permanently to remain, should, if any other arrangement be possible, be established or permitted to exist within at least a mile of the nearest habitations. It will be well

if, during the House-Fly season, *borax* can be used, in the manner prescribed above, on all such dumps, except where composed exclusively of ashes.

In the case of troops in the field, when, owing to military exigencies or tactical considerations, it is necessary to bury kitchen refuse instead of burning it, each addition of waste matter to a refuse pit must, in order to prevent egg-laying by flies, at once be covered over *completely* with soil or sand, in such a way as to prevent any upward soakage. Lastly, when such a pit is finally filled in, it should be *sealed with hessian or close-meshed sacking.* For this purpose sandbags, opened out and sewn together, may answer; when sacking is used, unless closely woven, a layer of stout paper, free from holes, should be placed underneath; in dry countries or seasons such a layer of paper will even serve alone, in default of hessian or sacking. The layer of fabric, which should be near the surface of the ground, must be covered over with four inches of soil or sand; it should extend all round to a distance of two and a half to three feet beyond the area occupied by the pit, and, after being placed in position, its outer six inches should be turned vertically downwards into the ground. This method will prevent the emergence of any flies, even though maggots should have been present in the contents of the pit, for maggots about to pupate and making their way upwards, as described on page 22 in the case of trench latrines, are stopped by the layer of fabric or paper and pupate beneath it; newly-hatched flies are likewise unable to pass through the obstruction, and die where they emerge from the pupa-cases. In proof of this statement, it may be mentioned that in Northern Sinai, during the campaign against the Turks in 1916, 300 newly-hatched House-Flies were found dead beneath two square feet of a layer of sacking used to seal the area surrounding a trench latrine.

(iii) *Prevention of breeding in human fæces.*

At the present day, the precautions with this end in view described below chiefly concern troops in the field, and what are

known as "native" races and white residents among them regards the former, experience in the Boer War of 1899–19 well as in the Great War of 1914–1918, showed that certain conditions human faeces may be not only the main s of House-Fly breeding among troops on active service responsible for the production of flies in intolerable nun and that, unless subjected to the most constant and scrupu supervision, open *trench latrines* are too often nothing mc than *carefully arranged fly breeding-places*.

Among native communities in warm climates, the disposal human faeces, in such a way as to prevent House-Fly cc tamination and fly-breeding, is a matter which in the past h frequently bristled with difficulty and cannot be dealt with detail here, although it may be said that, provided that su communities can, by education or otherwise, be induced to u them, much good results from the provision of suitable publ latrines. Wherever possible, the latter should be of the aut matic, "fly-proof bucket" type, and the method of faeces dispos should be properly controlled incineration, or by means of "fl trapped" excreta pits.*

As regards troops in the field, there can be no doubt that tl storing up of masses of human faeces in holes in the ground nc only conduces to fly-breeding, but is also open to other grav objections, and that therefore, wherever feasible, trench latrine

* For an illustrated description of these pits, with constructional detail Major A. L. Otway, R.A.M.C., "A Method of Excreta Disposal in th ics which Entirely Prevents Fly Dissemination": *Journal of the Roy y Medical Corps*, Vol. xlvi. No. 1, pp. 14–22, figs. 1–3 (January, 1926 following are the essential details of the form of excreta pit devised b r Otway, and stated by its author to have been introduced by him a ndee, Gold Coast, with entire success. The pit is protected from th ner, sealed over, and provided with a lidded, light-excluding filling orifice ess than six to ten feet from the latter, the covering of the pit is fitte a large-sized fly-trap, roofed with copper gauze. Since the only ligh ing the pit passes through the trap, all flies [illegible]

should be replaced by *fly-proof buckets*, the contents of which should be *incinerated* in such a way as to prevent flies from having access to the faecal material. The practical impossibility of excluding flies from trench latrines, even when provided with so-called "fly-proof" box-seat covers, was demonstrated repeatedly during the Great War; and although large numbers of flies may be destroyed by spraying the contents of such latrines with sodium arsenite solution (*see* p. 57), maggots present in the faecal material are unlikely to be killed, while the over-present risk of fly-contamination of food is certainly intensified by the use of latrines of this type. Unfortunately it frequently happens that troops reaching a fresh camping ground are compelled to use trench latrines pending the arrival of sanitary equipment. The latter may not be delivered until many hours or even days later, but in any case, mischief may be done in much shorter time, and often in the past the swarms of flies, that invaded a new camp a week or so after its occupation, have resulted from eggs laid in trench latrines within a few hours of the appearance on the scene of the earliest units or detachments of troops. The remedy is that each individual using such a latrine should *at once* cover up his excreta completely with earth or sand, in such a way that access by flies is prevented. Simple though this precaution is, it is a matter of extreme difficulty to ensure that it is observed in practice. Its observance, however, should be regarded by all ranks as a matter of good discipline, and should so be insisted upon by commanding officers, while regimental medical officers, by means of popular lectures on the life-history and disease-carrying potentialities of House-Flies, should impress its importance upon those under their charge.

So soon as buckets are available, temporary trench latrines should be filled in, and sealed with hessian or close-meshed sacking in the manner already described in the case of refuse pits (*see* p. 49). The buckets should have seats with self-closing lids, and, in order that they may be *really* and not merely apparently *fly-proof*, each seat should be surrounded with a sacking "apron," which, unless long enough to reach to and lie on the ground all

round, should be tied round the bucket with a cord. During incineration of bucket contents, due precautions must be taken to prevent any accumulation of faecal matter at the incinerator. If circumstances are such as to render incineration impossible, bucket contents must, of course, be buried as often as necessary; in this case pits must be filled, filled in and sealed precisely like those employed for refuse (*see* p. 49). Especial care must be taken, before the final filling-in, to ensure that there is never any upward soakage through the covering layer of soil or sand, since damp patches thus caused always attract flies and may lead to egg-laying.

Measures against the Adult Flies.

Having briefly outlined the simplest and most effective means of preventing House-Flies from coming into existence, this pamphlet may fittingly close with a short account of the best methods of dealing with flies which develop in spite of all precautions, or which negligence or ignorance have allowed to come into being.

House-Flies, as observed in 1916 by Miss Olive C. Lodge,* are characterised by "extreme curiosity," and this fact should be borne in mind when employing either traps or "tanglefoot" (see below) to catch the insects. Devices falling under either heading are likely to prove more attractive after a certain number of flies have been captured, and therefore it is always worth while at the outset to catch some of the insects and use them as decoys.

On the other hand, it was found by Miss Lodge, as previously by Hindle in 1913, that House-Flies display *no colour-preference*, so that the belief, occasionally expressed, that it is possible to exclude flies from rooms, or outbuildings such as cowsheds, by applying a particular colour to the walls is devoid of foundation.

* *Cf.* Olive C. Lodge, "An Examination of the Sense-Reactions of Flies": *Bulletin of Entomological Research*, Vol. ix, pp. 141–151, Plates viii–xi (September, 1918).

(i) *Methods of destroying House-Flies.*

These include the use of:—traps; the sticky composition known as "tanglefoot"; poisons; spraying fluids; flame; petrol fumes; and "fly-killers."

Traps.—The old-fashioned glass bell trap (baited with a mixture of oatmeal and beer) and the more modern "fly-balloon" of wire-gauze (baited with anything attracting flies at the time, or with a paste composed of equal amounts of sugar, cheese, banana and bread, moistened with beer or stout) are both efficient, and are too well-known to need description. To kill flies in a balloon trap, the latter should be placed for a minute or so in a hot oven.

House-Flies can also be caught in large numbers by means of the ingenious Japanese "clock-work" fly-trap, which, however, besides being expensive, somewhat complicated and liable to get out of order, is unobtainable in the British Islands. The trap consists essentially of a wooden drum, which can be smeared with some kind of bait, and is made to revolve very slowly by means of clock-work; a fly settling on the drum does not notice its slow movement, and, unless it take wing in time, is carried round into a part of the trap whence it makes its way into a cage from which there is no escape.

A simply constructed "box trap," for catching flies on a large scale, was designed during the Great War by Dr. Andrew Balfour, C.B., C.M.G., and often employed with conspicuous success in the vicinity of mess-huts, cook-houses, butchers' shops, and latrines, in standing camps in Macedonia, Egypt, and elsewhere. This trap, which is intended for use in hot sunshine in the open air, and is baited with any attractive material such as chicken entrails, tea leaves, a mixture of bread, sugar and vinegar, etc., is either oblong or cubical in shape, and may be of any desired dimensions; a cubical trap with sides 3 feet in diameter is, perhaps, as convenient as any. The frame should be of wood $1\frac{1}{4}$ or $1\frac{1}{2}$ inch square in cross section, and the uprights need not be connected by wood at their lower ends; the top of the trap and the lower half of the sides are covered with wire gauze, while the upper

half of the sides is formed by *tightly stretched* calico or canvas. At the bottom the trap is open and rests upon, but is *not attached* to, an alighting board of smooth planed wood, which should project from four to six inches beyond the trap all round. The uprights of the frame are alone in contact with the alighting board, the wire gauze sides being turned inwards one quarter of an inch above the latter, leaving a slit just high enough to admit a Bluebottle, and forming an inwardly and upwardly projecting flange two or three inches in breadth. As a proof of utility, it may be mentioned that 10,000 flies have been caught in a trap of this type in two hours. The imprisoned flies can be killed by means of one of the poisons or spraying fluids mentioned below.

A modified form of this trap, said to have proved effective in the United States, has the sides of wood; except at the corners, these are cut away at the lower edges sufficiently to allow flies to crawl underneath, and the bottom as well as the flat roof of the trap is of wire gauze. The bottom is indented upwards so as to form a roof-shaped ridge, beneath which the bait is placed, the ridge itself being about half the height of the trap, and pierced with holes a quarter of an inch in diameter to permit flies to enter the latter.

Tanglefoot.—Papers coated with this composition are, nowadays, procurable almost everywhere, either in the form of sheets, or narrow strips intended for suspension. For use during the day, the former are generally preferable, and are said to be most effective when *curved into the shape of an arch*. It is sometimes advantageous to make a supply of tanglefoot for oneself, since its manufacture is quite easy, and once made it can be kept indefinitely in a closed tin and used as required. The best ingredients are castor oil and powdered resin, which are converted into tanglefoot by weighing out five parts of the former and eight parts of the latter, and heating the two together until the resin is entirely dissolved. There is no advantage in allowing the mixture to boil; for use it should be applied as thinly as possible while hot, or after being heated, to the surfaces that it is intended to

coat. The latter may include *glazed* paper *; wires for suspension vertically in kitchens or latrines; horizontal wires stretched across the interiors of dining-huts above head level; and the woodwork of temporary shelters in which flies are numerous. Naturally, tanglefoot is effective only so long as it remains "tacky"; tanglefoot-coated surfaces which have become dry or are covered with dust are absolutely useless. Should coated, vertical wires have a tendency to drip, this may be prevented by affixing to the lower end of each a small square of stout paper, crumpled so as to form a rough cup. A wire which is covered with dead flies is readily cleansed by being passed through a fire, and can then be re-coated.

Poisons.—The most effective are *formalin*, *sodium arsenite*, and *pyrethrum powder*; sodium arsenite, however, being highly poisonous to man, is not suitable for general use, even were it obtainable by the public.

To kill flies by means of *formalin*, mix together two table-spoonfuls of commercial (40 per cent.) formalin, one heaped table-spoonful of sugar, half a pint of clear lime water, and water to make up one pint. It is advisable to use lime water, in the proportion indicated, since, as was discovered by Dr. Ll. Lloyd, in the Hygiene Department of the Royal Army Medical College, during the Great War, a solution of formalin in water otherwise soon becomes acid, and consequently unattractive to flies. For use, it is best to place the mixture in a closed vessel, so as to shield it from the action of the air and to ensure that flies do not fall into it, since exposure to the air and pollution by the bodies of flies neutralise the lime water, and cause the fluid to become acid. The mixture may be poured into a tin, which is then closed by a lid perforated with holes, through which are passed wicks so arranged that their lower ends dip into the fluid. But perhaps an even simpler mode of employment is that which is described by

* Or paper coated with a solution of one ounce of ordinary glue in three ounces of water, applied with a fine brush all over the surface, and allowed to dry before the coating of tanglefoot is given; *unglazed*, absorbent paper is useless.

Dr. Lloyd * as follows:—"The poison is placed in a bottle, and the mouth is closed by means of a platform of absorptive material, from the centre of which a stem of the same material passes down into the fluid. The top is wetted with the fluid at the commencement, and is kept wet by capillary attraction. Such an arrangement may easily be made from blotting paper. A circle of the paper two inches in diameter is cut out, and a small slit is made in the centre. Two strips of the paper of the same width as the slit are then passed through it, and the ends are doubled outwards and downwards. The strips are then drawn down till the doubled back portions rest on the platform, and the trap is ready for use. This form of trap may be used under cover or outside when it is not raining. The paper should be renewed every third or fourth day in any case." Indoors, formalin generally works best in the early morning, when, in kitchens, dining-rooms or offices, provided precautions be taken to ensure that *no other sources of refreshment are accessible* to House-Flies, the insects may often be found dead in large numbers round the vessel used as a container. In warm, dry weather, when there is no wind, formalin mixture can also be employed with good effect in the open air on the edge of manure heaps, near refuse bins, or in the vicinity of stables, kitchens and latrines. Since formalin is poisonous to human beings, the mixture must be used with caution, and care must be taken to prevent it from being interfered with by children.

Although a sweetened solution of *sodium arsenite*,† as a means of destroying House-Flies, is often extremely effective, this poison, owing to its deadly nature, is, as already explained, not to be recommended for general use. In the Army, on the other hand, under the control and supervision of medical or sanitary officers, the objection referred to is not insuperable, provided that the solution be not used in or about billets where there are children

* *Bulletin of Entomological Research*, Vol. xi, Part 1, pp. 61–62 (August, 1920).

† *Cf.* C. W. Mally, "Note on the Use of Poisoned Bait for Controlling the House-Fly, *Musca domestica*, L.": *South African Journal of Science*, June, 1915, pp. 1–8 (sep. imp.).

or other civilians, or in such a manner that it can contaminate water or food intended for human use. The poison can either be employed on a small scale indoors, or can be sprayed on to manure heaps and surfaces (such as leafy branches, straw made into bundles and suspended, etc.) in their vicinity or that of latrines, on which House-Flies congregate. Another method of employing the solution in the open, found very effective in Mesopotamia during the Great War, consists essentially in a double layer of sacking fixed in a vertical frame, and irrigated by means of a special contrivance. After being once thoroughly wetted, the material is kept permanently wet with the fluid, which automatically issues from a metal reservoir above. For indoor use 1 gramme (15½ grains) of sodium arsenite is dissolved, by aid of heat, in 3½ ounces of water, to which two heaped tea-spoonfuls of sugar should be added; the attractiveness of the solution to flies will be enhanced if beer be substituted for water. The mixture can either be exposed on pads of cotton wool in tin trays (in which case, once a pad is impregnated, it can be made to do duty for a week or more by moistening it as it becomes dry), or placed in closed tins provided with wicks.

For making sodium arsenite solution for spraying purposes the formula is:—

Arsenite of Soda (80 per cent.)	1 lb.
Crude sugar or treacle	10 lbs.
Water	10 gallons.

Since sodium arsenite is not readily soluble in cold water, it should be dissolved in a little boiling water and added to the sweet solution. In handling or storing the mixture, its highly poisonous nature in regard to human beings and animals must, of course, be borne in mind. For spraying manure heaps and other surfaces, a Vermorel's "Eclair" knapsack spraying pump, which delivers a fine, mist-like spray, has been found to answer well. When this method is adopted, while the weather is warm spraying should, for a time at least, be carried out daily, the afternoon between the hours of 4.0 and 6.0 being, in Europe, usually most suitable for the purpose.

Fresh *pyrethrum powder* ("Keating's Powder") distributed through the air—either by aid of a specially adapted pair of bellows, having a container near the nozzle, or by the rough-and-ready means of placing a few teaspoonfuls of the powder in the centre of a small square of muslin, screwing up the latter with the hand, and then vigorously shaking the bag thus formed—affords a simple and very effective method of killing House-Flies in *closed* rooms, huts or other shelters. If sufficient powder be used to produce a fogginess in the air, flies which cannot escape soon become paralysed in their hind legs and shortly afterwards die. The powder, although not harmful to human beings, is somewhat irritating to the nose and throat if inhaled, and also naturally settles upon everything in the room, so that the method is rather messy. In inhabited rooms, therefore, it is sometimes preferable to employ the fumes produced by bringing a candle flame into contact with the under side of the lid of a tin, upon which a small quantity of the powder is heaped. The effect of the fumes is to stupefy flies, which fall to the ground, and can then be swept up and destroyed.

Spraying Fluids.—Various spraying fluids for the destruction of House-Flies are on the market and obtainable from chemists and stores. They generally consist of an alcoholic extract of pyrethrum powder, to which in one case are added safrol, and sufficient soap to make the compound emulsify in water; the admixture of $\frac{1}{2}$ to 2 per cent. of castor oil is said to increase efficiency. For use, the fluid is diluted in varying degrees with water, and then atomised by means of a "Mackenzie" or other sprayer, producing a fine, mist-like spray; in order to kill flies the insects must be thoroughly wetted. While pyrethrum sprays are capable of being used with good effect under certain conditions, as in private houses at night when House-Flies are abundant, they are of little value in the open under field service conditions, at any rate, in warm climates.

Although not suitable for ordinary domestic purposes, an emulsion of paraffin oil, which is fatal to House-Flies if it actually comes into contact with them, is a satisfactory fly-spray

for use under certain conditions on active service. During the Great War the following formula was tried, in Macedonia, by Captain James Waterston, late R.A.M.C., and found to be thoroughly effective--

Soap	¼ lb.
Water...	½ gallon.
Paraffin	1 gallon.

When used pure, this emulsion was almost instantly fatal—"not a fly touched escaped"; a dilution at half strength was also satisfactory. Clogging of the sprayer with dried emulsion may be prevented by passing a small quantity of clean boiling water through he nozzle after use.

Flame.—In camps in which House-Flies are abundant, the insects may often be found at night sleeping in large numbers on overhead wires or hanging cords (*see* p. 28). Under such conditions, they can readily be killed by burning them off by means of a brown paper torch, or a lump of cotton wool saturated with methylated spirit.

Petrol Fumes.—If a soup plate, or similar shallow vessel, containing a small quantity of petrol be passed beneath House-Flies resting as described in the foregoing paragraph, the insects are stupefied by the fumes, fall into the liquid, and are killed.

"*Fly-Killers.*"—Racquets of flexible wire gauze mounted on wooden handles, or consisting of discs of soft leather provided with handles of wood or wire, are known as "fly-killers," and in capable hands amply justify their name. Of the two, the former pattern (in England generally obtainable from ironmongers) is preferable, particularly if the edges of the racquet be bound in such a way as not to fray. A general and energetic use of fly-killers in houses and other dwellings throughout the fly-season might reasonably be expected ere long to produce an appreciable effect upon the number of House-Flies in existence.

(ii) *General Precautions.*

The so-called "fly-proofing" of doors and windows of dining-huts, kitchens, and similar structures is useless, unless the only

entrance and exit is a porch (preferably not less than ten feet in length) with a *self-closing*, fly-proof door at each end.

House-Flies may, however, be excluded from sheds, marquees, and similar structures by protecting each door or other opening with a net (ordinary fishing net, with a mesh of about $\frac{3}{4}$ inch), which, provided it be without holes, the insects will not pass through. In the case of doorways, the net must of course reach to the ground, and care must be taken to see that it is nowhere caught up.

Larders, for the storage of cold cooked food and food intended to be consumed uncooked, *must* always be fly-proof, and eating and drinking utensils (including plates, glasses, cups, knives, forks and spoons) after being cleansed must be kept under similar cover.

When House-Flies are present at and before meal-times, especially under conditions such as those of active service, all food, including jugs of milk or other liquids, set out on tables should be protected by fly-proof covers. These may be either wire frames covered with wire-gauze or mosquito netting, or squares of muslin weighted along the edges. Under the conditions indicated, *plates and drinking vessels exposed on tables for use should invariably be turned upside down until required.*

House-Flies may be prevented from settling (and possibly defaecating) on the rims of tea-cups by smearing the edges of the latter with a little bacon-fat.

In hospital wards and similar places, House-Flies should not be allowed to settle upon persons suffering from infectious or contagious diseases. Rigorous precautions should, of course, be taken to prevent House-Flies from coming into contact with the sputa of consumptives, or with the evacuations from cases of cholera, typhoid fever, dysentery and summer diarrhoea.

The foregoing pages will have signally failed in their object if regarded merely as an academic treatise, or if they have not convinced the reader that the House-Fly is a creature of disgusting and dangerous habits, no more to be tolerated inside our dwellings

or upon our meal tables than a plague-stricken rat. In those already conversant with the facts recorded on pages 33 to 38 of this little work, the sight of a House-Fly browsing in a sugar-bowl, sipping at the edge of a tea-cup, or struggling in a milk-jug, excites a feeling of repulsion akin to nausea. Yet those who know are few indeed in comparison with the many to whom the subject of this booklet is nothing more than a nuisance, to be waved aside with a hasty exclamation or passing jest. On the other hand, to preach to the converted should be needless, were it not that even they do not always act in accordance with their convictions. If readers of this pamphlet will not only endeavour, so far as their opportunities permit, to translate its simple precepts into practice, but will also try to persuade others to do likewise, the results which are likely to follow may ultimately be productive of untold good.

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