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THE STABLE FLY.

BY

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UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., April 15, 1913.

SIR: I transmit herewith a manuscript entitled "The Stable Fly," by F. C. Bishopp, of this bureau. This insect is a pronounced enemy of domestic animals, frequently, as in the season of 1912, causing much loss among cattle and horses. It also becomes of great importance on account of its proved carriage of the disease known as "infantile paralysis" among human beings, and of its suspected carriage of pellagra. It is important that stockmen and medical men should know at an early date everything possible about this pest and the accompanying manuscript has been prepared for this purpose. I recommend that it be published as a Farmers' Bulletin, in order to enable its wide distribution.

Respectfully,

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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THE STABLE FLY.

INTRODUCTORY.

The wide distribution of the stable fly (*Stomoxys calcitrans* L.), its intimate association with man, and its close resemblance to the so-called house fly or typhoid fly (*Musca domestica* L.) have led many to consider it identical with that species. Not until the stable fly becomes so numerous as greatly to harass live stock, or until the acute pain which accompanies the insertion of its proboscis is felt by the farmer himself, is man usually brought to a realization of the presence of a fly different from that distributor of typhoid germs, the common house fly. Severe outbreaks of the stable fly have led many to observe the flies more closely and to note their identity. Thus many individuals in certain sections speak of the stable fly as the "wild fly," "straw fly," or "biting house fly," to differentiate it from the ordinary house fly. The common name "stable fly" is applied to it because of its continual presence around stables, except during cold weather, and its comparative scarcity about the dwellings of man. Until very recently the stable fly received little attention at the hands of the entomologist or others. The recent demonstration by Drs. Rosenau and Brues of the possibility of the transmission of a distressing disease of man, known as infantile paralysis, through the agency of this fly, greatly stimulated interest in the study of the insect. A similar effect was also produced by the possible connection of this pest with the transmission of pellagra in man, as pointed out by Messrs. Jennings and King of the Bureau of Entomology. The investigations of authorities in this and other countries indicate that an important relation exists between certain diseases of domestic animals and this fly. Aside from the rôle played by the insect in disease transmission, it is an all-too-common and persistent pest to domestic animals. It will thus be seen that the stable fly may be of importance in three ways, namely, as a tormentor of live stock, as a carrier of diseases of domestic animals, and as a transmitter of diseases in man.

DISTRIBUTION AND ABUNDANCE.

The stable fly is one of the most widely distributed of insects. It appears to occur commonly in all parts of the world inhabited by man and the larger domestic animals. In those parts of the tropical, sub-

tropical, and temperate regions in which domestic animals are reared, especially where those animals are kept in considerable numbers, the fly is a pest of importance. The absence of severe cold in the winters and the moist warm conditions prevailing in many of the countries bordering on the Tropics allow almost continual breeding; hence in these regions the fly is of importance throughout the entire year.

The stable fly has been in the United States for many years. Although it is probable that it was introduced from Europe with live stock brought here by the earliest colonists, we have no definite knowledge regarding its first occurrence in this country. The strong flight of the fly and its close association with domestic animals has permitted it to spread to all parts of the country.

The abundance of the species appears to be dependent largely upon local and seasonal conditions. In the southern part of the United States the insect is a pest of more or less importance throughout the year, but is usually most abundant in the latter part of the summer and during the fall. In the North and West it seldom becomes sufficiently numerous to cause annoyance to stock until the latter part of the summer and the early fall, the injury diminishing rapidly after heavy frosts. It appears that the fly is of much more importance as a pest in the grain belt than elsewhere. This point will be discussed more fully in another part of the paper.

From time to time climatic and other conditions have been favorable for the production of flies in great numbers, but little definite information is at hand regarding severe outbreaks which occurred prior to 1912. Old residents in the north-central part of Texas state that exceedingly large numbers of flies were present during the summer of 1867. Another outbreak occurred in parts of Texas in 1894 or 1895, and in 1905 the flies were again numerous enough to cause serious loss.

Notes have been published from time to time, in early entomological papers, on the injuriousness of this insect. In September, 1888, we find in Insect Life a reference to it as a pest to horses in Oregon. The correspondent in this case stated that the fly made its appearance at Salem, Oreg., two or three years before, though this information can scarcely be considered as reliable. This same issue of Insect Life also includes the statement that in the spring of 1888 the fly was reported to have caused considerable annoyance to cattle in Maryland and New Jersey.

In Kansas and Nebraska it has been determined that it is a pest of some importance every year throughout the grain belt of those States, but occasionally it appears in much greater numbers than normal. Statements made by farmers in other sections of the country where grain is grown extensively, notably in the Dakotas

and Minnesota, indicate that the fly is sufficiently numerous nearly every year to cause considerable trouble. In the Southwestern States it sometimes becomes very abundant, although records of serious outbreaks have not been made. In central and southern Louisiana it is often very annoying to all live stock. This is especially true in the region where rice is grown extensively. It appears from investigations conducted in the central part of Florida that the stable fly is seldom present in sufficient numbers to attract attention. Prof. C. P. Gillette, of the Colorado Agricultural College, says in a recent letter, "Possibly the common stable fly is really the worst pest [of live stock in Colorado] on account of its being so abundant and ever present." In northern Colorado and southern Wyoming, at altitudes of from 5,000 to 7,500 feet, the writer has observed the insect to annoy horses and cattle greatly during the latter part of summer. From a statement made by Prof. J. M. Aldrich we learn that it is troublesome to cattle in Idaho, and Prof. R. W. Doane states that it is one of the worst fly pests to live stock in California.

THE SEVERE OUTBREAK OF THE STABLE FLY IN 1912.

During the late summer and early fall of 1912 an unprecedented outbreak of this pest occurred in northern Texas. The area of greatest abundance was practically coextensive with regions where grain was extensively produced that season. The most severe injury was experienced in Grayson, Cook, Collin, and Denton Counties, in northern Texas. The fly was also abundant as far south as Hill County and as far west as Wichita County, and in parts of southern Oklahoma it also caused much alarm. In certain parts of Kansas and Nebraska it was also said to be more abundant than normal.

In Texas the flies appear to have become seriously numerous about August 12 and the outbreak to have continued in its severe form until the end of August. Flies were, however, very numerous throughout September and the greater part of October, but rapidly diminished after cold weather began. Under a number of the succeeding topics reference is made to conditions which prevailed during this outbreak. Some of these illustrate the severity of the pest during such an occurrence.

A study of the conditions existing in northern Texas during 1912 showed that the flies were breeding to a great extent in straw stacks. Unusually heavy rains occurred in the early part of August, and as most of the straw was freshly threshed and had not become settled, the rain deeply penetrated the stacks. The straw became heated immediately and formed very attractive breeding places for flies. The grain crop of 1912 was one of the largest ever produced in Texas, and as the straw was also heavy a great number of straw stacks

were present to furnish their quota of the pest. In fact, the flies were so numerous around these stacks that many men in plowing their fields avoided, so far as possible, the portions adjacent to them. Although the stacks dried out rapidly on the surface, the straw beneath continued moist for several months, and flies continued to emerge from these stacks where the straw was not destroyed or where breeding was not otherwise prevented.

Dr. L. O. Howard published a note a few years ago calling attention to a report by Prof. Iches on an invasion by this fly of a large estate in the Province of Santa Fe, Argentina. This occurrence appears to have been very similar to the recent outbreak in Texas. The flies were found by Prof. Iches to be breeding in wheat and flax straw after threshing.

HOSTS.

Practically all warm-blooded animals are attacked by this insect. Some of our domestic species, however, are much freer from injury than are others, owing to protection afforded the host by its hair or by some habit. Mules in general seem to be more annoyed by the flies than any of the other domestic live stock. Horses and cattle are, however, heavily attacked and often suffer severe injury. Those animals which are not easily disturbed and irritated act as hosts for a greater number of flies, but the result is probably not so serious as with more nervous individuals, which are consequently more easily worried. Sheep and goats are attacked on parts of the body not protected by wool, particularly the legs. Hogs are often attacked, especially when they are free in pastures. The flies are not attracted to the hog pens as are house flies, and where the animals have access to mud they are seldom bitten to any great extent except when flies are extremely abundant. Dogs and cats have also been seen with flies feeding upon them. Dogs with thin hair are exceedingly susceptible to injury and are greatly worried by the attacks. In some cases the flies become sufficiently numerous, especially on the ears, where they are inclined to feed most commonly, to cause the blood to trickle from the bites. In a few instances chickens have been seen with flies feeding upon their combs; however, healthy poultry are so active, as well as so largely protected, that they are seldom annoyed. Man is also frequently attacked by this pest, although the attack is usually quickly discovered on account of the pain caused by the insertion of the beak. During severe outbreaks men engaged in field work are often greatly annoyed by the flies, which not only attack exposed portions of the body but are able to bite through shirts or other comparatively thin garments as well. The flies also frequently attack the ankles of people, especially when low shoes are worn.

CHARACTER OF INJURY AND LOSSES.

As has been indicated, this fly is of importance in a number of ways. There is little doubt that it is a potent factor in disease transmission, although it has been definitely proven to carry only a few diseases. Among live stock there is no doubt that the tropical disease of camels, horses, and cattle known as surra is transmitted by this insect. This disease fortunately does not occur in this country, but unless great care is exercised in importing stock it may be introduced at any time. Another related disease of cattle, horses, and sheep, known as souma, and still another malady of hogs and cats are carried, at least in part, by this same insect. In this country anthrax in domestic animals and man is also probably disseminated to some extent by this fly. Some investigators also consider it to be an agent in transmission of septicemia in man and glanders in horses and other animals, and the disease known as infectious ænemia or swamp fever of horses is thought by some to be carried by this pest. A number of years ago it was found to act as an intermediate host for a species of roundworm which infests cattle. Thus it will be seen that the transmission of a formidable array of diseases is chargeable to this one species of biting fly.

Aside from its importance as a disease conveyor this insect is of much importance on account of the worry produced by its bites. During severe outbreaks this is probably the most important factor in bringing about losses. During periods of great abundance all live stock are compelled to keep up a constant fight against flies from early morning until dark. At such times the flies are not only present around barns but in towns and cities and open fields. Animals which are being worked in the streets or kept in stables suffer alike. During the severe outbreak which occurred in 1912 many horses and cattle became so weak that they gave up the fight against the pest and the flies swarmed over them in countless numbers. In a few of these cases, where the animals were not promptly protected from attack, they succumbed in a short time. The loss of blood during severe outbreaks is a very important consideration. When fully engorged the abdomen of the fly is greatly distended, and it has been found that the blood extracted at one feeding is soon digested and the fly is ready for another meal. Thus animals continually exposed must serve to engorge thousands of individuals each day, each of the flies ingesting several drops of blood during a meal.

In the portion of the United States where Texas fever occurs, in addition to the live stock actually killed by worriment and loss of blood, a considerable number of cattle are lost from Texas fever. In most of these animals, although the disease organisms are latent in the blood, no apparent injury would result under conditions favorable to live stock. Under the strain of continually fighting the flies and

with the weakened condition brought about by the loss of blood, however, an acute form of Texas fever is induced. When animals begin to suffer from the fever they are less energetic in fighting the flies and consequently become the more ready victims. During the outbreak in 1912 acute Texas fever was certainly produced as a result of fly attack. Owing to the continual biting of the insect the fever could not be reduced in many cases and the animals speedily died.

During severe outbreaks the loss brought about by the reduction of the milk supply in fly-infested zones is an important item. In the 1912 outbreak many dairymen found that their output of milk was reduced from 40 to 60 per cent, and that in some cases cows were completely dried up. For several months after the pest had abated, the effects of the outbreak were apparent in the reduced milk production. Even in cows which freshened several months after the pest had abated, the effect on milk yield was said to be still apparent.

During 1912 all animals in the fly zone were greatly reduced in flesh. Cattle which were fat enough for market in many cases were so much reduced that they could not be sold. Horses and mules in many cases lost from 10 to 15 per cent in weight during the outbreak. Some dairy herds which were usually shown at the State fair suffered such marked injury that they were not fit for exhibit.

In many cases the joints of both horses and cattle became so swollen and stiff, from standing in water where they sought protection from flies, that they could scarcely walk. The incessant stamping of the animals also had the effect of injuring the feet and joints. A number of liverymen found it necessary to discontinue making drives into the country, and some of their animals were completely disabled for regular work.

Another source of loss to farmers was their inability to proceed with their usual farm plowing and other operations at the proper time. In many sections the flies were so bad on the horses that they could not stand both the work and flies. Some men resorted to night work as a means of escaping the attack, but this was too severe for the teams, as the flies allowed them no rest during the day. Numerous instances of horses becoming frantic from irritation were recorded; these often resulted in runaways and consequent destruction. Animals which were not being worked sometimes received injuries from running into barbed wire fences in endeavoring to escape the flies.

The total loss due to the outbreak in 1912 is difficult to estimate. It is believed that in northern Texas over 300 head of cattle, mules, and horses were killed directly or indirectly as the result of the fly attack. This actual death loss may be conservatively placed at $15,000. The loss due to the reduction in milk supply may reasonably be placed at $10,000, and other losses far surpass these two items. Moreover, these were the losses experienced only in the few

counties in northern Texas where the fly was most abundant and does not include the more or less serious injury sustained in practically all parts of the United States.

ACTION OF ANIMALS ATTACKED.

All animals are usually greatly annoyed by the attack of this fly. Less nervous individuals sometimes permit the flies to feed without particular effort to drive them away, while others of more nervous temperament are driven almost frantic by the attack. In general, mules seem to be worried rather more than horses, and most cattle are less irritated than either mules or horses. Sheep and goats are much annoyed by the presence of the insect, but because they are largely protected by the wool they are able to keep the flies off their legs by frequently moving them. A great difference in the degree of annoyance produced among dogs has been noticed. Some individuals are greatly irritated by the presence of a single fly and frequently change their positions, going from one place to another to seek protection. Horses and mules that are being driven sometimes pay little attention to flies, while in other cases they may lie down and roll or even run away in their frantic efforts to escape. During times of unusual fly abundance animals, when free in pastures, frequently bunch up on knolls where they are exposed to the wind and apparently secure some protection by contact and concerted fighting. When streams or pools of water are accessible both horses and cattle, particularly the latter, take to them for protection. Cows often lie down in the water so as to be almost completely covered, and the coating of mud obtained in such situations offers some protection from fly attack. Stock often temporarily rid themselves of most of their annoyers by running through trees and brush. If permitted to reach stables or barns, the animals usually crowd within and remain inside throughout the day. During the severe outbreak in 1912 it was almost impossible to get some animals to leave the stables and go into pastures, even after nightfall, on account of their fear of the flies. Although the bunching of the horses in the stable affords some protection, yet this by no means exempts them from fly injury, as the pest is often as bad within such places as without. Sheep and hogs exhibit similar habits in endeavoring to secure protection; they often lie in close groups in shady places and keep their heads and legs protected by placing them against or beneath one another. When mudholes are accessible, hogs largely escape the flies by lying in the water and becoming covered with mud.

It is possible to determine, even at considerable distances, by watching the actions of the animals, whether the stable fly or horn fly is bothering cattle. When the stable fly is present the continual

stamping of the feet and striking at the legs with the head and tail indicate the point of attack, while when the horn fly is present the animals pay particular attention to the back and sides. The bite of the stable fly is evidently much more severe than that of the horn fly, as it causes very great annoyance even when the flies are present in much fewer numbers.

SUMMARY OF LIFE HISTORY.

Like all other flies, this species has four stages in its life history, namely, the egg, larva, pupa, and adult.

The egg.—The eggs of this fly are elongate ovoid and of a creamy white color. They are about one twenty-fifth of an inch in length and under a magnifying glass show a distinct furrow along one side. When placed on any moist substance they hatch in from one to three days after being deposited. In hatching a small slit is made around one end of the groove, and the minute maggot crawls out. Figure 1 shows four eggs on a piece of straw; the two at the right have hatched.

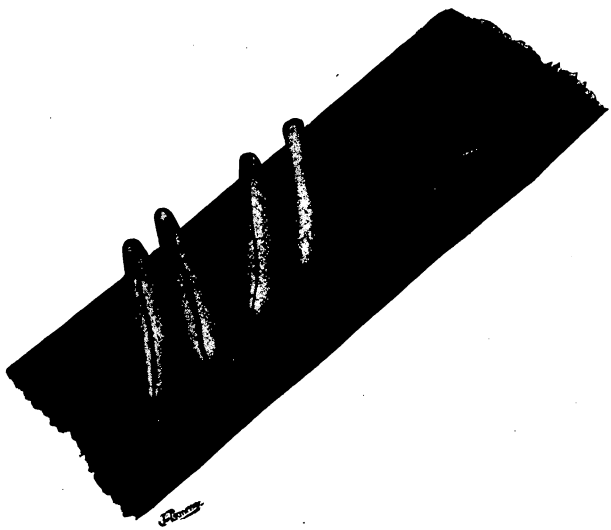

FIG. 1.—Eggs of the stable fly (*Stomoxys calcitrans*) attached to a straw. Greatly enlarged. (Original).

The larva, or maggot.—When first hatched the larvæ, or maggots, are about one-twelfth of an inch in length and, being translucent, are not easily seen with the naked eye. Development takes place fairly rapidly when the proper food conditions are available, and the growth is completed within eleven to thirty or more days. When full grown the larvæ (fig. 2) are pale yellow or nearly white and about four-fifths of an inch in length. They have the typical shape and action of most maggots of this group of flies. The hind end is large and the body tapers to the head. The larva moves quite rapidly by means of minute projections on the edge of each segment along its underside. When exposed to the light it quickly disappears again in the straw or other matter in which it is breeding.

The pupa.—When the larvæ are full grown they shorten and become thicker, and the skin contracts and hardens to form the case in which the transformation to the adult is to take place. This puparium, or pupal case, is rather soft and yellowish at first but soon becomes harder and changes to a reddish brown color. It is elongate oval, slightly thicker toward the head end, and from one-sixth to one-fourth of an inch in length (fig. 3). During this stage the insect is completely dormant, the transformation from maggot to adult fly going on within the puparium. This resting stage requires from six to twenty days, or in cool weather considerably longer.

FIG. 2.—The stable fly: Larva or maggot. Greatly enlarged. (Original.)

The adult.—When the fly has completed its development within the puparium it pushes its head against the end until the shell splits open. It then crawls out as an adult fly but so different from the fly ordinarily seen that one would scarcely recognize it. The color is pale and the head considerably produced in front between the eyes. At this time the wings are only small, wrinkled sacs. In a few minutes air is forced into the wings, and they slowly unfold, the fly becomes gradually darker in color, and its body becomes harder. Up to this time the beak is not visible, as it is bent downward between the legs. It soon becomes almost black and is brought forward in its natural position so that the tip may be seen from above. When completely dried out the adults show four rather distinct, dark, longitudinal markings on the thorax, as well as several dark spots on the abdomen. The male is usually slightly smaller than the female, the body of which measures from one-fourth to five-sixteenths of an inch in length. The adult, as seen from above, is shown in figure 4, and a side view of a female specimen engorged with blood is shown in figure 5.

FIG. 3.—The stable fly: Pupa. Greatly enlarged. (Original.)

This insect is closely related to the house fly, as can be readily seen by its close resemblance to that insect. It may be distinguished from the house fly, however, by the long, sharp, biting mouth parts,

a portion of which may be seen projecting forward from beneath the head. The proboscis of the house fly is short and broad and not capable of piercing. The stable fly is usually slightly stouter than the house fly, and the spots on the abdomen also aid in distinguishing it from that species.

The horn fly is also related to this species but is of much smaller size, and the color is considerably different. When on a host these

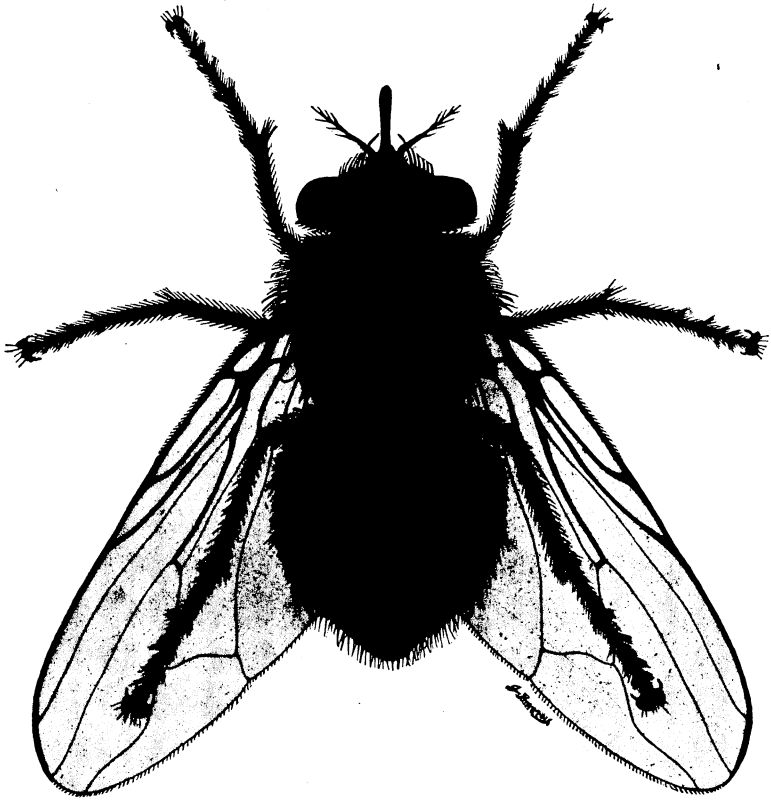

FIG. 4.—The stable fly: Adult female as seen from above. Greatly enlarged. (Original.)

flies may be readily differentiated by the attitudes they assume. The stable fly usually attacks the lower portions of the legs of its host and nearly always sits with the head up. The horn fly is more inclined to feed on the back and sides of the animal and always feeds with the head downward, while the house fly may be seen sitting in any position but never with its head pressed into the hair as though feeding.

DEVELOPMENT AND HABITS.

BREEDING PLACES.

Horse manure has long been considered the normal breeding medium for this pest. Investigations made during the outbreak in 1912 showed clearly, however, that the vast majority of the flies bred out in straw stacks, and investigations made around stables and barns indicate that while the fly breeds in pure horse manure it favors a mixture of this substance with straw. The fly was found to be breeding in much greater abundance in oat straw than in wheat straw. This appeared to be due to the softer stems and the greater amount of leaves in the oat straw, which furnished better food and allowed the stacks to become more compact. Rice straw was also found to furnish suitable breeding conditions, and there is little doubt that barley and rye also often serve as food for the immature stages.

FIG. 5.—The stable fly: Adult female, side view, engorged with blood. Greatly enlarged. (Original.)

As has been stated, it was found by Prof. Iches to breed in great numbers in the débris left after thrashing flax. A careful examination of portions of alfalfa stacks which were moist and readily accessible to numbers of flies showed that they were not infested. This was also found to be true of accumulations of weeds and bunches of grass in open fields. It is probable, however, that the insect may occasionally breed in broken-up masses of hay or dead grass, especially when they are permeated with liquids from manure. The manure piles commonly found by stables where horses are kept furnish suitable breeding conditions. This is especially true in the early spring, when the warmth of the manure appears to be very attractive to the flies for egg laying. Cow-lot manure which has become broken up, especially when mixed with waste feed, is also utilized as a breeding place for the insect. This has also been found to be true

of ensilage, particularly when mixed with straw, as is often the case when the bottom of a silo is cleaned out. Experimentally, a few specimens have been reared from pure cow manure, but this substance seems to be unattractive to the adult and not favorable for the breeding of the larvæ on account of its very compact texture. A Russian investigator, Prof. Portchinski, has made the statement that the larvæ have been found in the leaves of growing plants. This, however, must be a very rare occurrence. This species has never been found breeding in human excrement and does not frequent malodorous places, which are so attractive to the house fly. Hence it is much less likely to carry typhoid and other germs which may be found in such places.

The development of this insect is somewhat slower than that of the house fly, and it is therefore more essential, in order that it may breed out successfully, that the eggs be deposited in rather large accumulations of material. The larvæ are very sensitive to drought and soon succumb if the material in which they are breeding is not kept rather moist.

HABITS OF THE ADULT.

Both the male and female of this species feed on the blood of animals. They appear to discover their host mainly by sight and usually, especially on cattle, pass quickly to the lower portion of the legs (fig. 6), particularly on the outside, where the hair is somewhat shorter than on other parts of the animal and where they are less likely to be struck by the tail of the host. When the flies are very abundant their attack is by no means confined to the legs, as both cattle and horses have been seen practically covered with flies on all parts of the body. They seldom remain on the host long without inserting the beak. Before blood is extracted they are easily disturbed and often move about several times before settling down for final engorgement. After the beak is well inserted and the blood begins to flow they usually become engorged in from two to five minutes. During feeding the abdomen becomes greatly distended (see fig. 5) and often of a distinctly reddish color. When the appetite of the fly has been satisfied it withdraws its beak and flies rather sluggishly to some near-by object, where it rests while digesting its meal. During this process numerous drops of clear liquid excrement are voided. This also takes place while the fly is feeding. The insertion of the beak is accompanied by a rather severe, sharp pain. This accounts for much of the worriment caused to the host by this species. After blood extraction has begun little or no pain is felt. When the proboscis is withdrawn a drop of blood usually exudes from the wound. Numerous small flies have been seen to frequent the blood which exudes in this way, and it is not improbable that the screw-worm fly may deposit its eggs on these spots and thus cause infestation of the host with these maggots.

During warm weather the blood is digested rapidly and the flies may feed again the same day. When the weather is cooler they usually require about a day for the digestion of the blood. After partaking of a meal the flies, during hot weather, ordinarily alight on the walls of buildings or on foliage of plants in shady situations. When the temperature is lower they remain in the sunlight, but in all cases they tend to avoid strong wind.

Adults frequently follow for considerable distances teams traversing roads and, when engorged, settle on near-by objects. Other teams which pass along the same highways are thus frequently attacked by flies which have completed the digestion of their previous meal, and this has given rise to the idea that the flies are breeding in weeds, grass, and hedges along the highways. This is also a means by which the flies invade territory beyond that in which they develop. Adults have also been observed to travel many miles in the passenger coaches of railways. Few individuals are carried in this way, but doubtless the spread of the species is aided and, what is more important, diseases might be spread in this way by infected flies.

FIG. 6.—Legs of a steer attacked by the stable fly. (Author's illustration.)

Feeding may take place a number of times. Experimentally, individual flies have been induced to engorge as many as 14 times. Flies have been observed to partake of water and to feed to some extent on succulent fruit. They commonly feed on the moisture on fresh manure and on rotting straw. Although man is occasionally bitten by these flies, horses and cattle seem to be preferred as hosts.

REPRODUCTION.

Mating of the flies takes place while they are not on hosts, and egg laying soon follows, provided the flies have fed a sufficient number of times. It seems that at least three feedings on blood are necessary for the production of eggs. After the third meal is digested the flies seek suitable places for deposition. When the weather is cool additional feedings are often necessary before eggs are produced. The adults appear to have a keen sense of smell and are able to detect moist straw and suitable manure very quickly. This is especially noticeable when a straw stack which is dry on the outside is opened up so as to expose the moist and rotting interior.

Very soon after a stack is opened flies are seen to come to the moist straw in numbers and begin depositing eggs. They usually crawl into the loose straw, sometimes going to a depth of several inches. When laying eggs the fly greatly extends the ovipositor and uses it as an organ of touch in locating a suitable spot in which to deposit. The eggs are laid in irregular masses, although occasionally single ones are deposited. The female usually moves several times during deposition so that each mass contains from a few to as many as 25 or more eggs. The greatest number of eggs which has been observed to be deposited before another meal of blood is taken is 122. After all of the eggs have been deposited the female again seeks a host, and this feeding is again followed by deposition. Three of such depositions commonly take place in this species. It is sometimes necessary, especially during cool weather, for a fly to become engorged twice before each deposition following the first. The greatest number of eggs which has been seen to be deposited by a single female during her life is 278.

LENGTH OF LIFE OF THE ADULT.

A considerable number of experiments have been made to determine the length of life of the adult fly. A knowledge of the longevity of the adult is important in order that its possibilities as a pest may be determined and that we may ascertain whether the species may act as a true host of disease organisms; that is, whether disease germs can multiply within the fly before being capable of producing the disease in a higher animal. Individuals kept in small tubes without food or water during hot weather died within two days. When water and sugar sirup were supplied to flies, in a screen cage about 1 foot square, one specimen out of a large number of males and females lived for 23 days. Individuals which had access to blood at frequent intervals lived 17 days, and a few specimens, among a considerable number which were kept in large cages with cattle and suitable material in which to deposit eggs, lived for 29 days. When flies had been supplied with fruit and moist straw, but had not had access to host animals, they frequently lived for 10 days.

THE LARVA AND ITS HABITS.

The larvæ begin feeding as soon as they hatch from the eggs and continue to do so throughout their growth. Portions of moist straw or other material in which they are breeding are torn off by their mandibles, which are located on the narrow or head end of the maggot. When very small they frequently penetrate between the layers of the stalk or leaves of grain when moistened in the straw stack. When larger they frequently feed within the straws, and transformation to the resting state sometimes takes place in this protected situation.

The duration of the larval stage has been found to vary from 11 to 30 days. During very cold weather this stage is probably considerably longer than one month. The character and abundance of food as well as the amount of moisture present have an important influence on the development of the maggots. The larvæ follow the moisture inward as the material in which they are breeding becomes dry on the surface. Pupation occurs anywhere in the breeding material; however, it frequently happens that the larvæ, when breeding in small masses of straw or manure, work downward as the material dries and pupate at the surface of the soil.

LIFE CYCLE.

It has been found that the complete development from the deposition of the egg to the emergence of the adult fly may be completed in 19 days. On the average the period is somewhat longer than this, generally ranging from 21 to 25 days where conditions are very favorable. The longest period observed for complete development was 43 days, although it is certain that in the late fall and during the winter months a much longer period is often necessary. The finding of full-grown larvæ and pupæ in straw during the latter part of March, 1913, in northern Texas shows that development may require about three months, as these stages almost certainly developed from eggs deposited the previous December.

SEASONAL HISTORY.

The stable fly is particularly abundant and injurious in the late summer and fall. This is especially true in the Northern States, where development begins later in the spring. Mr. C. T. Brues states that the flies first appear in noticeable numbers about June 1, in the vicinity of Boston, Mass. The fly has been observed to be sufficiently numerous to annoy cattle considerably at Dallas, Tex., as early as March 1, and in the western part of Texas it has been observed feeding on live stock in considerable numbers early in May. At Batesburg, S. C., Mr. E. A. McGregor found the adults to be commonly attacking live stock about the middle of March in 1913. In the extreme southern part of the United States, however, there is no month during the year in which flies are not annoying to horses and cattle.

The number of generations of this insect annually has not been determined, but it is estimated that seven broods may readily develop in one year in the Southern States. In the Northern States probably five broods is about the usual number.

HIBERNATION.

In the southern part of the United States there is no true hibernation of this insect. The adults have been found to emerge at various times throughout the winter, and during warm periods at Dallas, Tex., they have been observed to feed on animals. Mr. W. V. King reports that considerable numbers of adults were present throughout the winter of 1912–13 at New Orleans, La. In fact, they appeared to be even more numerous in midwinter than during the previous fall. At Victoria, Tex., Mr. J. D. Mitchell found them to annoy stock throughout the winter. Although no egg laying appeared to take place during the winter of 1912–13 at Dallas, Tex., it may sometimes occur at that latitude and probably occurs throughout the winter in the extreme southern part of the United States. It would seem that most of the individuals which pass the winter successfully hatch from the eggs laid in the fall and continue development slowly during winter, emerging in early spring when conditions are favorable for further reproduction. Examinations of straw stacks in northern Texas, made during the latter part of March, 1913, showed a few full-grown larvæ and large numbers of puparia. These almost certainly developed from eggs deposited the previous December. In the northern part of the United States it is doubtful if many flies emerge during the winter months, the winter being normally passed in the larval and pupal stages. Near Boston, Mass., Mr. C. T. Brues observed adults to be active in heated stables in the dead of winter. These individuals probably bred out in refuse within the warm barns and were not hibernating adults. In 1913, at Clarksville, Tenn., Mr. D. C. Parman found that the adults began emerging about March 30.

AGRICULTURAL PRACTICES IN RELATION TO FLY ABUNDANCE.

A number of agricultural practices which are commonly in vogue in the United States are calculated to favor greatly the development of this species. As has been stated, this species breeds most commonly in straw and horse manure or a mixture of these two substances. The usual custom of allowing the manure from the horse stable to accumulate just outside of the stable doors absolutely insures the presence of a considerable number of stable flies at all times when climatic conditions are suitable for breeding. Allowing barnyards, especially around dairies, to become knee-deep in manure is also calculated to produce flies in abundance.

In the grain belt it is the general practice for farmers to thrash the grain in the fields by means of self-stacking thrashing machines. The individual stacks cover much ground and the straw is very loosely piled. In many cases for convenience a large number of stacks are formed in various parts of a field. This condition, when followed by more or less heavy summer and fall rains, is certain to produce great numbers of flies. In fact, this is precisely the condition which occurred in 1905 and in 1912, when the serious outbreaks of the fly occurred in Texas. In many instances straw stacks are not protected from live stock. The animals soon scatter the straw about and by adding manure to the straw still further favor the breeding of flies. These straw stacks are usually allowed to remain from one year to the next without any attention whatever. When the succeeding crop is planted the area occupied by the stacks is simply left uncultivated. In a number of instances 50,000 square feet have been found occupied by a single stack, and in many cases several of these stacks occurred in a field of 60 or more acres. A railroad official recently computed that the area covered by wheat stacks in Kansas alone is no less than one-fourth of a million acres. Such stacks are usually allowed to remain throughout the fall and winter and in a few cases are burned the following spring. More frequently, however, they are left from year to year and the new straw added to the old stacks, destruction only taking place when the stacks become exceedingly large. It will be seen that these practices not only encourage the breeding of the stable fly, but when the straw becomes sufficiently rotten and compact the house fly as well breeds in it in abundance. Throughout the grain belt a very considerable amount of valuable land is untilled and the full manurial value of the straw is lost. Of course the stacks serve some purpose as shelter and food for live stock kept in the fields during winter. In fact, this is the only legitimate reason for not scattering them or burning them in the late summer or fall.

NATURAL CONTROL.

CLIMATIC EFFECT.

The adults feed when the temperature is very high and the sun bright and hot as well as during cool and cloudy weather. They have also been observed to attack animals during drizzling rain, and when somewhat protected by sheds and stables they often feed during heavy rain. The lowest temperature at which flies have been observed to partake of blood was 55° F. When the temperature goes below 60° F. their desire to feed is less marked. Between 40° and 48° F. they lose their ability to fly, and complete inactivity occurs

when the temperature ranges between 31° and 45° F. This range of activity is due to variation in individual flies, to the rapidity of the decline or rise in temperature, and to the minimum temperature experienced by the individuals. No adults appear to be killed when the temperature does not go below 27° F., and some at least are able to survive temperatures considerably below this point. All of the adults at Dallas, Tex., seem to have been killed when the temperature reached 8° F. As has been stated, the flies always seek shady places during hot weather, but when the temperatures are low they delight to dart about in the sun in a manner very similar to that of the house fly.

The maggots, or larvæ, are very susceptible to drying. This is particularly true soon after they are hatched. Excessive moisture is also detrimental to their development, and flooding kills them in a few hours. They appear to be able to endure rather high temperatures when abundant moisture is at hand, although the heat produced in manure and straw stacks is often sufficient either to kill them or to drive them outward. No doubt the generation of heat within the breeding places stimulates the development of the immature stages during the fall and winter months. Light is detrimental to the development of the larvæ. When placed in bright daylight, even though sheltered from the sun, larvæ have never been known to complete development. These facts make it possible successfully to destroy the pest in this stage of its life.

The pupæ of the insect, being in the resting stage, are much less susceptible to all climatic extremes. They appear to be able to withstand low temperatures and are not very susceptible to heat or drying, especially after development of the fly has proceeded for some time.

PREDACEOUS ENEMIES.

Hogs, as well as chickens and other poultry, are capable of destroying great numbers of the immature stages of the stable fly. They are attracted to the straw stacks and manure piles partly by the grain to be found, but incidentally they destroy the maggots and pupæ which they find. A number of insects are also important destroyers of these stages. Certain beetles devour them in considerable numbers. The adult flies fall prey to numerous enemies. Among the more important enemies of the adults are the large robber flies, which may be seen in great numbers around straw stacks, pouncing upon flies which are depositing eggs or resting upon straw. A number of wasps capture the flies that are attacking stock or flying about. When filled with blood the adults are comparatively sluggish and much more easily caught by these enemies. When in this condition spiders often devour numbers of them.

PARASITES.

Two species of small wasplike insects have been found to breed within the pupæ of the stable fly. These insects deposit their eggs through the hard puparium, and instead of an adult fly the little parasite emerges. In some cases, where the immature stages of the fly were concentrated in great numbers, as high as 40 per cent of the pupæ were found to be destroyed by these parasites. At least one of these parasites, known scientifically as *Spalangia muscidarium* Richardson, appears to have a wide distribution in this country. It has been found in Massachusetts, Washington, D. C., southern Kansas, southern Louisiana, and a number of points in northern Texas.

ARTIFICIAL CONTROL.

As is the case with most insects, the destruction of the stage which is actually doing the injury is most desired by those concerned. With this species, as with many others, this is very difficult of accomplishment, and we must determine some more easy way of securing the desired end. With the stable fly the natural point of attack is found in the immature stages, and there is every reason to believe that by properly caring for substances in which it breeds the insect may be kept well under control.

PROTECTION OF LIVE STOCK FROM ATTACK OF THE STABLE FLY.

When adult flies are present in great numbers it is necessary to devise some means of protection against them, especially since we know that every individual is capable of feeding a number of times before it dies. During the recent outbreak in Texas many different substances were tried with a view to repelling the flies from live stock. Most of the materials used were found to be ineffective, and although some gave a measure of protection for a time, none had a lasting effect. In addition to the temporary value of these substances, in many cases injury was produced by their application, especially if persisted in often enough to keep the flies away.

Many malodorous mixtures, particularly of an oily nature, have some value as repellents, but in preparing these care should be taken that they are not made too strong, particularly when animals are being worked in the hot sun, as they are likely to cause overheating and often produce shedding of the hair. A mixture of fish oil (1 gallon), oil of pine tar (2 ounces), oil of pennyroyal (2 ounces), and kerosene (½ pint) was found to be very effective in keeping the flies off live stock when applied lightly, but thoroughly, to the portions of animals not covered with blankets or nets.

Work animals may be largely protected from the pest by means of coverings. One type which was found very effective and inexpensive during the recent outbreak in Texas consisted of a blanket made of double thickness of burlap so arranged as completely to cover the back, sides, and neck of the animal (fig. 7). The legs are then covered by means of old trousers slipped on over the feet and tied over the back. Leather nets or strips of leather attached to the bridle also aid in keeping the flies from the head. The ordinary flynet has been found to be of little value as it only tends to displace the flies temporarily and cause them to settle in places not covered by the net.

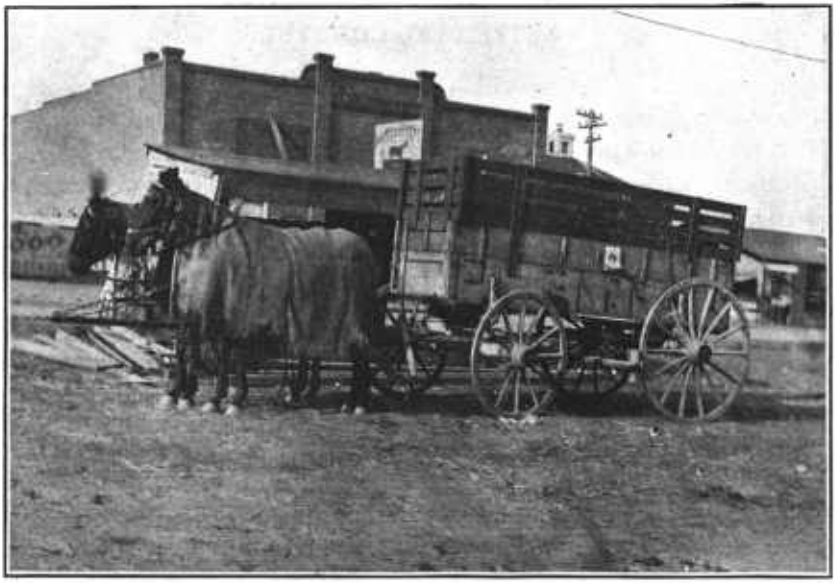

FIG. 7.—Horses with one form of covering used to protect them from the stable fly. (After Felt.)

Completely darkened stables offer much protection from the flies. The lack of ventilation resulting from such an arrangement is very objectionable, however. The thorough screening of all windows and doors is, therefore, much more desirable. When screened barns are used care should be taken to brush the flies from the animals, when they are about to enter, by means of nets over the doorway, or with sacks. Little can be done to protect range stock from the flies. On hog farms a freshly plowed trench offers considerable protection to the swine. The sides of these trenches may be smeared with petroleum which is rubbed off on the animals and acts as a repellent. The trench may be used also for protecting sheep, but the petroleum in their case is unnecessary.

TRAPPING THE FLIES.

It is impossible successfully to capture adult flies by means of the traps ordinarily used for the house fly. However, a trap has been designed by Prof. C. F. Hodge which may be utilized in capturing adults as they enter or leave barns. This trap is undoubtedly very effective under certain conditions and has the advantage of catching not only the stable fly but the house fly and other obnoxious species. In order to employ the trap for the stable fly it should be built in a frame so as to fit closely in a window, preferably on the brightest side of the barn and close to the cows or horses which are kept within. Other windows should be darkened by hanging gunny sacks over them. This may be done so as not to interfere with ventilation, and by flapping in the wind and darkening, both drive and cause the flies to be attracted to the light trap-window.

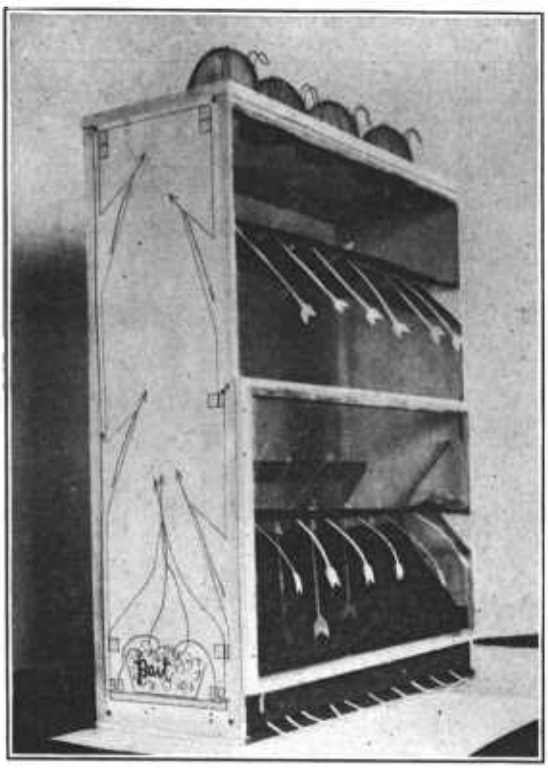

Fig. 8.—The Hodge flytrap, showing where the flies enter. (After Hodge.)

Prof. Hodge has very kindly permitted the use of some of his illustrations of this trap (figs. 8, 9, 10), and his description of its construction has also been followed. At the bottom of the trap a space about one-fourth of an inch wide running entirely across the window is left on both sides of the frame. This crack admits the flies beneath a roof or ridge of screen wire having holes large enough for flies to go through punched along its top at 2-inch intervals. In order to capture the house fly, bait consisting of any material which is attractive to them is placed in pans beneath this ridge. The flies enter this space and then ascend through the holes and are unable to escape. The sides of the trap, also, are made of ordinary screen wire bent inward and upward in two horizontal folds running

aeross the window, one toward the bottom and one toward the top. The ends of the sereen are then seeurely taeked and a series of small holes punched along the inner edge of each of the folds. The trap-folds and ridge must not be too sharp or flies will not go up to the angle. They should not be less than 45°. The flies, in trying to go in and out through the window, crawl into the folds and enter the holes at the apex, but never escape, as on the inside the holes are along the projeeting ridge. Prof. Hodge states that a trap set in a window in a basement barn near a cow within eaught nearly 5 quarts of flies from July 1 to November 1. The stable fly constituted 90 per cent of these flies, this being practieally all that appeared on the place.

FIG. 9.—The Hodge fly trap fitted to a barn window. (After Hodge.)

This trap is inexpensive and can be made by anyone with a box, or box lumber, and screen wire. It is espeeially well adapted to well-made barns where the flies do not have numerous places for entrance and exit. It is also more applieable to small barns in whieh animals are kept more or less eonstantly than to large dairy barns where the cows are brought in only at milking time. Under the latter conditions the flies enter the barns on the cows and many remain on the walls of the barn until after the eattle have been turned out. In some cases where flies are eoncentrated in dairy barns in this manner they have been driven out by forcing live steam into the building from the boilers used for sterilizing purposes. Where such arrangements are made the flies may be caught in such traps as the one described, as they are endeavoring to escape from the barn, which should first be tightly closed.

If such barns are tightly closed, as above, during the light part of each day, the flies will practically all "catch themselves" in trying to escape through the trap-window or windows.

DESTRUCTION OF IMMATURE STAGES AND PREVENTION OF BREEDING.

Since straw stacks have been found to be the principal breeding places of this insect in the grain belt, the proper care of the straw is by far the most important step in control. The straw should be stacked more carefully than is ordinarily done, when it is desired to keep it for protection and food for live stock. This may be accomplished by making the sides of the stack nearly vertical and rounding it up well on top, in order the better to shed the rain.

So far as possible, all straw which is not required for winter feed for stock should be disposed of immediately by burning, or by scattering it over the land soon after thrashing and subsequently plowing it under, or by burning the stacks. The plowing under of the straw is the most advisable method of procedure, as by this practice large amounts of humus are added to the soil. Oat straw is most generally used for feeding purposes, and it is this straw which forms the principal

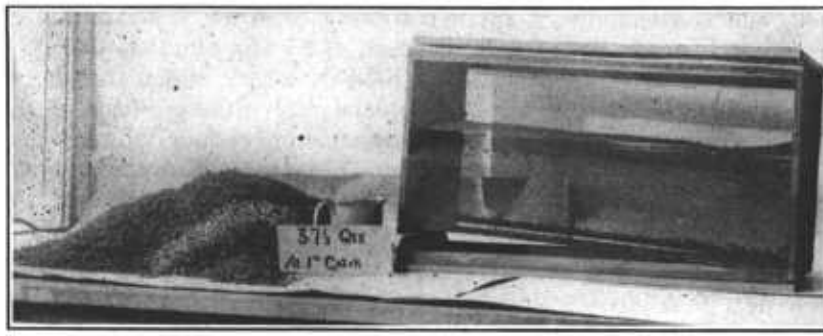

FIG. 10.—Pile of flies caught in a Hodge flytrap. (After Hodge.)

breeding ground for flies. It is therefore important that all of the oat straw needed for feed or bedding be baled and stored under cover and that the remainder be promptly burned or scattered.

All straw stacks not consumed by stock during the winter should be promptly disposed of in the early spring, as these stacks furnish flies continuously during spring and summer. Often the flies reared in such situations are abundant enough to cause great annoyance to live stock during early spring, and by multiplying throughout the summer an almost incredible number of flies are produced by fall. An examination of an oat-straw stack at Gainesville, Tex., in March, 1913, showed a very large number of pupæ, from many of which flies were emerging. In portions of this stack it was estimated that 300 pupæ were present in each cubic foot of straw. This illustrates the importance of disposing, in spring, of straw which has been carried over the winter. Disposition of the stacks in spring may be accomplished in the same way as has been suggested to be followed in the fall.

The conditions which produced the unusual outbreak in 1912, that is, the heavy rainfall on the freshly thrashed straw, rendered the straw

largely unfit for food for live stock, as the stacks in many cases were wet through and soon became heated and rotten. In such instances, where the flies are already breeding in these stacks, their immediate destruction by burning or scattering is necessary to relieve the conditions. When stacks are scattered the work should be done thoroughly, so as to expose the straw completely to the influence of the sun, wind, and light. By this procedure practically all of the larvæ and many of the pupæ are destroyed.

It is best to plow under the scattered straw soon after it has become well dried out. In many sections of the grain belt plowing is not generally practiced, the land being simply shallowly disked prior to seeding. The scattering of straw over the ground in such cases is less practicable than where the land is plowed. Of course, the practice of disking land is not a commendable one, and wherever plowing can be done it should be adopted.

In sections of the country where headers instead of binders are used, and consequently a smaller amount of straw is accumulated, the straw is much more easily disposed of by the methods just outlined. The general adoption of the field thrashers, which thrash the grain without cutting it, would completely solve the question of the straw stack. It is reported that this machine reduces the expense of harvesting from 14 cents to 2 cents per acre. The straw is left standing in the field and the chaff scattered over the ground, the entire refuse being turned under at plowing time.

The use of poisons or other substances, with a view of destroying immature flies in the substances in which they are breeding, is neither practicable nor advisable. Enormous quantities of these materials would be required to permeate the straw or manure piles to kill the flies, and, even though the flies were destroyed, the straw would be rendered dangerous to live stock.

Although straw is the principal breeding place for flies within the grain belt, there is no doubt that thousands of stable flies develop in manure piles. Moreover, such material is utilized extensively as a breeding place for the house fly and horn fly. Hence the proper care of all sorts of animal refuse is essential for successfully combating the pest. Manure should be hauled out and scattered at regular intervals, as is recommended for the control of the house fly, and any accumulations of straw or hay, especially adjacent to stables, should be disposed of, as these are often utilized for the breeding of the stable fly when larger accumulations of horse manure and straw are not available.

The need of properly caring for stable refuse is still further emphasized by the fact that there are far more manure piles than straw stacks. Furthermore, the stable manure is usually in close proximity to the habitations of man and thus furnishes flies which have freer access to man, with consequent greater potentiality as disseminators of human diseases.