JULY, 1941 BULLETIN 430

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

M. F. MILLER, *Director*

Controlling Bot and Warble Flies of Livestock in Missouri

LEONARD HASEMAN AND W. E. ROLAND

COLUMBIA, MISSOURI

Controlling Bot and Warble Flies of Livestock in Missouri

LEONARD HASEMAN AND W. E. ROLAND

Among the various insect pests of livestock, the family of two-winged flies, known commonly as the botflies, is of special importance. The maggots of these flies live as internal parasites in livestock and other animals. In this country, three different species of bots develop in the stomach of horses and mules, two species of warble flies develop in the bodies of cattle, and one species of nose bot develops in the upper nasal sinuses of sheep. These six species take an immense toll from the dairy and livestock industries in Missouri each year. For a number of years, the writers have been investigating these pests and they have prepared this report, hoping that it may be helpful to Missouri farmers and livestock men in their effort to protect their animals against these pests.

Historical

The original home of the different species of botflies or Oestridae attacking the horse, cow, and sheep in Missouri will never be known with certainty. However, the fact that they are largely restricted to their respective hosts indicates that they probably first appeared as pests in the ancient homes of these hosts. The bots of horses have been well known to workers for the last 150 years, and probably for a much longer time. The ox warbles were mentioned in literature 250 years ago, but were doubtless known to livestock men much earlier. The Greeks were acquainted with the sheep nose bot over 1,400 years ago. All of the six species under consideration, therefore, are of ancient origin. In each case, no doubt, they were brought into the United States with their respective hosts and they have now spread widely over the country. However, they are not all equally abundant and widely distributed. In Missouri, the lip botfly has apparently only recently arrived, and the northern ox warble fly has only occasionally been reported in this state. The sheep nose bot or "gid-fly" seems to be most abundant in the west and southwest part of the state.

THE FAMILY OF OESTRIDAE

This family of flies includes only about seventy-five known species, but it is of very great importance since the larvae of all the species studied, without exception, live as parasites in mammals. The adults resemble bees, both as regards their con-

spicuous hairy plumage and the bee-like buzz which they usually produce when they approach the host to oviposit. The adults are short-lived, do no feeding, and, under favorable conditions, soon deposit their supply of eggs. The species which attack livestock require one year to mature. Most of this time is spent in the larval stage within the host.

The larvae develop inside the host in one of three locations. Some enter by the mouth and develop in the digestive tract, as for instance the horse bots. Another group enters and develops in the nostrils or nasal sinuses, as is the case with the sheep nose bot. A third group may enter the host's body through the skin at the base of the hair, to which the eggs are attached, where they may develop or they may travel about in the host's body and come to the surface at some point remote from where they entered. This is the case with the ox warble flies. These larvae all seem well equipped to carry on respiration while submerged within the body of the host. After the larva escapes from the body of the host it pupates within the dried larval skin. Later, when conditions are favorable, the adult escapes, soon mates, and proceeds to deposit eggs on its host.

Kinds of Horse Botflies

There are three distinct species of horse botflies in this country. They are called the horse botfly, *Gastrophilus intestinalis* (De Geer), the throat botfly, *Gastrophilus nasalis* (Linne), and the lip botfly, *Gastrophilus haemorrhoidalis* (Linne). The common botfly is the largest and most abundant and widely distributed. It is the one so frequently seen laying its eggs especially on the hair of the legs, sides, and bellies of horses and mules. The fly is the size of a very small bumblebee, is clothed with bands of yellowish and black hair, and has dark mottling on its wings. It is the least annoying of the botflies to the host while ovipositing. The throat botfly is more active, less frequently observed, and annoys the host greatly when it darts up under the throat and clings, buzzing similar to a bee while attaching its eggs to the base of the hairs. It is about the size of a worker honeybee and has the typical slender tip to the turned-under abdomen (Figure 1). Its wings are clear and the abdomen has a reddish-orange band of hair. The lip or nose botfly is scarcely larger than a common blowfly, with clear wings, and a conspicuous orange band across the middle of the abdomen (Figure 2). It is very swift on wing and is even more frightening to the host than the throat botfly when it strikes the lips to attach its blackish eggs to the hair.

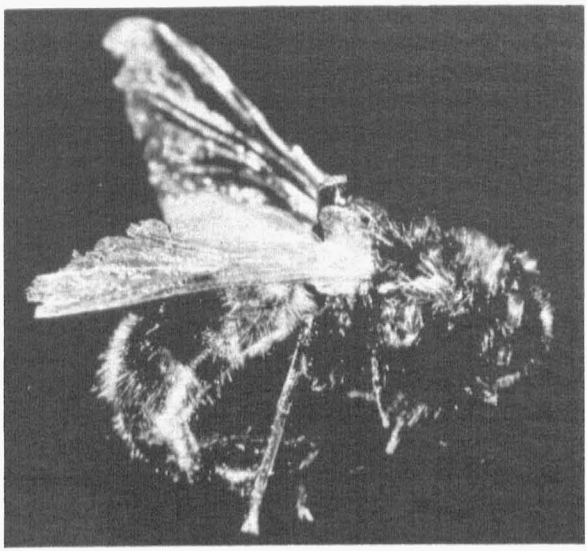

Fig. 1.—Adult throat botfly.

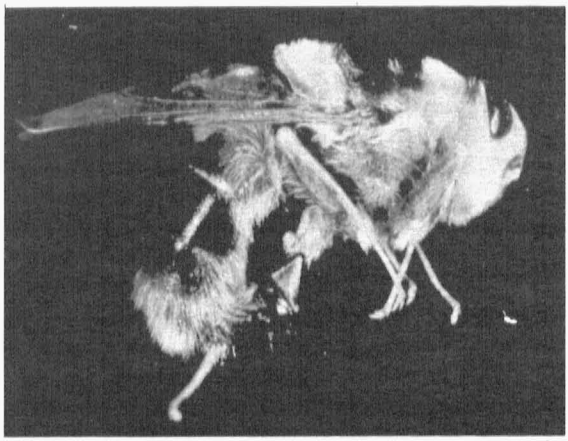

Fig. 2.—Adult lip botfly.

Nature and Extent of Damage.—There is a wide diversity of opinion on the part of research workers, veterinarians, and farmers regarding the actual damage bots cause to horses and mules. Some think that it is entirely natural for them to be in the animal's stomach, while others attribute all ailments, lack of flesh, and poor working ability in the spring to bots. Naturally, bots are not responsible for everything that may go

wrong with a horse or mule, but, on the other hand, a quart of bots developing in the animal's stomach is anything but natural. Farmers who regularly have their animals treated for bots have found that it pays well in reduced feed consumed, improvement in general health and flesh, and in the greater amount of work the animal is able to do.

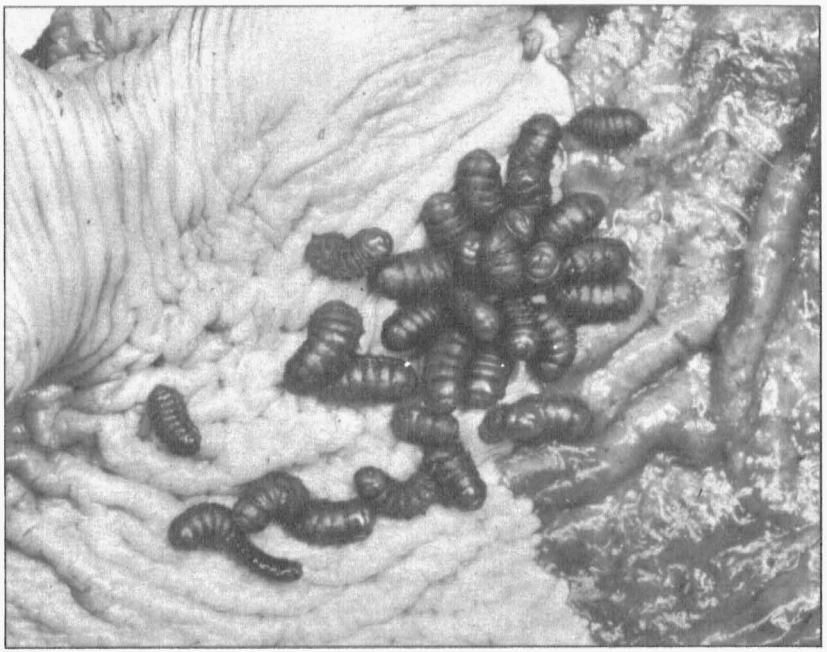

Fig. 3.—Bots attached to the wall of horse's stomach.

The presence of large numbers of bots in an animal's stomach may result in four definite types of injury. First, their attachment causes irritation to the stomach lining, which if severe may interfere with normal digestion (Figure 3). Second, they draw their nourishment, in part, from the food being digested and, in part, from the stomach wall which, as with any other intestinal parasite, constitutes a definite drain on the host. Third, in severe cases, at least, they may clog the passage from the stomach to the intestine, causing definite digestive upset if not actual death of the host. Fourth, they may set up irritation in the intestines as they move from the stomach to the anus to be discharged with the dung. Some consider this as perhaps the most serious injury they cause to the general health of the host.

The adult fly, in laying eggs on the hair of the host, causes no direct physical pain, but by frightening the animal the pest may cause it to run away or otherwise injure itself and possibly the driver. Young nervous animals, in particular, may seriously injure themselves due to the fright caused by the visits of the throat and lip botflies.

Life History of the Botflies

All three species of botflies spend most of the year as larvae in the stomach and intestines of the host. From our observations, the lip botfly and the throat botfly appear on wing earlier in the summer than does the common species. In 1937, the throat botfly was observed ovipositing at Columbia early in June, and in 1938 the lip botfly began to emerge in the laboratory by the middle of May from larvae collected in stable manure the last of April. As a rule, the earliest adults of the common species do not begin to appear in central Missouri before the first of July, and some adults may continue to oviposit as late in the fall as October. On warm days in early October, 1938 and 1939, they were observed ovipositing at Columbia. The lip and throat botflies have not been observed on wing so late in the year. With adult flies on wing ovipositing from late May or early June until October, and with the larvae of the common botfly remaining alive and active inside the egg shells for a few months after the eggs are laid, it is but natural to find bots in different stages of development in the stomach and intestines of the host at almost any time during the year.

Egg.—All three species of botflies fasten their eggs to the hair by means of a cement clasp. The size and shape of the eggs and their nature of attachment differ. The eggs of the common species are most often attached to the hair on the legs and, to a less extent, on the hair of the belly, sides, and higher on the body. The egg is about a millimeter long, thicker in proportion to length then in the other two species, light straw-colored, and is attached along its basal third with the free end of the egg directed away from the hair (Figure 4). The egg of the throat botfly is usually found attached along most of its length to the hair under the throat (Figure 5). The egg is more slender than that of the common species and is usually attached closer to the base of the hair. The egg of the lip bot is black and has a slender basal stalk. It is attached to the hair by this basal stalk, as well as along the side of the basal half of the egg proper. The basal part of the egg may fit down into the hair follicle.

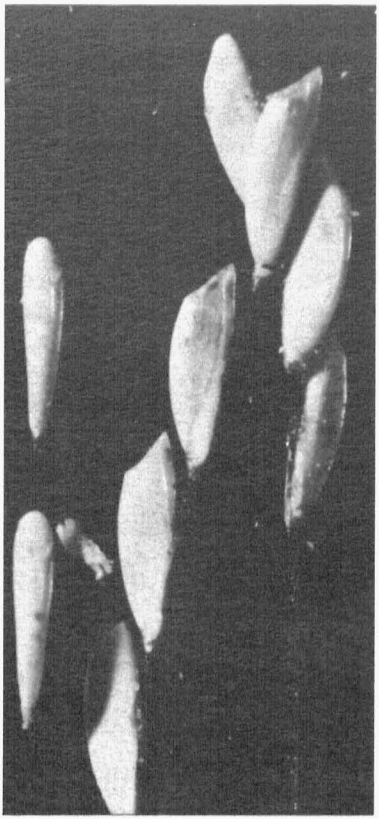

Fig. 4.—Eggs of common botfly showing attachment to the hair along only the basal part of the egg.

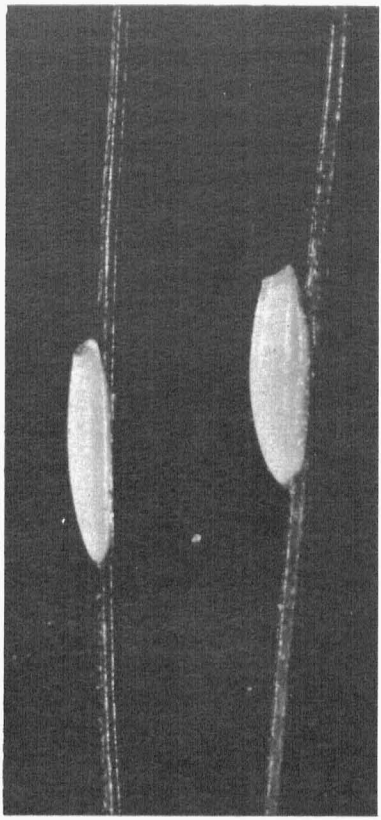

Fig. 5.—Eggs of throat botfly showing atachment to the hair along most of the egg's length.

Hatching of Eggs.—The larvae of the common botfly does not leave the egg until it is licked or brushed by the host or by some other moist object. It may be ready to leave the shell for weeks, but until moisture and friction aid it in removing the cap at the end of the egg the small, spiny, banded creature remains trapped in its own egg shell. When released by the host biting itself, the larva presumably becomes attached to the lips or tongue and later reaches the stomach.

The larva of the throat botfly does not seem to require licking or rubbing to escape from the egg shell. After escaping, it is not known with certainty just how it gets into the digestive tract. It has been observed to have the ability to bore into the membranes of the mouth and some think that the young larvae may bore through the skin of the throat and thus eventually reach the alimentary canal. The newly hatched larvae when

examined under the microscope (Figure 6) appear to have the boring instinct, and the writers have observed what appear to be small skin punctures near the base of hairs containing hatched eggs. Other workers are of the opinion that the larvae crawl to the mouth and enter the digestive tract in that way.

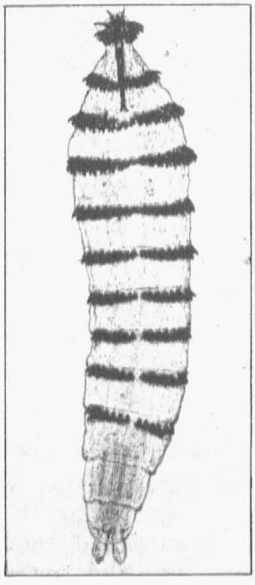

Fig. 6.—Newly hatched larva of the throat botfly, much enlarged.

The eggs of the lip botfly are usually kept moistened by saliva and on hatching the larva seems to enter the mouth with food and water and thus gains access to the alimentary canal.

Larvae and Attachment.—The full-grown larvae of the three species are quite different in size and general appearance and in the arrangement of the spiny armor. The larva of the common species is much the largest of the three and is heavily spined. It is about three-fourth inch long and one-third inch in diameter when full-grown, while the throat bot is only about one-half inch long. The lip species is longer and more slender in appearance than the throat species, and it is less heavily covered with the ringlets of spines. Except in case of the lip botfly larvae when attached in the anus, or when an animal dies and an autopsy is performed, the botfly larvae are seldom observed by farmers even though they may be passed with the dung in large numbers during the early part of the summer.

Most of the larvae of the common species become attached and continue to develop in the stomach of the host until they are full-fed and are ready to pass out. In severe cases, a considerable sized patch of the stomach lining may be completely encrusted with the spiny larvae. At the point of attachment a definite pit or scar develops.

The larvae of the throat botfly, on the other hand, are attached mostly in the front part of the intestine or at the outlet from the stomach. Here they remain until full-fed and ready to pass out. The larvae of the lip botfly may be found attached either to the lining of the stomach near the outlet or in the front part of the intestines. They have the habit of releasing their hold before they are full-fed and reattaching themselves for a time farther back, especially in the anus. The other two species normally pass directly out with the droppings once they release their hold.

Pupa.—As soon as they have escaped from their host the botfly larvae squirm about seeking shelter under litter, or they may bore beneath the surface of the ground. In a few days, the outer larval skin begins to dry and shrink and inside it the pupa forms. Under favorable temperature and moisture the adult soon emerges, escaping from the pointed end of the hard case through a horizontal slit which allows the two halves of the front end of the case to be spread apart.

Adult.—The adults soon spread their wings and take on their characteristic fuzzy, bee-like appearance. In due time, mating occurs, after which the females seek a host on which to deposit their eggs. While large numbers of the lip botfly were reared in the laboratory in the spring of 1938, none of them were observed to mate in captivity. The adult botflies attract most attention while depositing their eggs. The throat and the nose botflies may begin to oviposit early in June. The common species, as a rule, does not appear on wing until about hay harvest, but it may still be found ovipositing until late September and early October and its eggs containing live larvae may remain attached to the hair of the host until winter sets in.

Horse Bot Control

Horse bots are not equally abundant every year. A number of natural checks help with their control. Birds, poultry, mice, sowbugs, and other insect-feeding animals devour many of the larvae and pupae. Some of the larvae, after they leave the host, are destroyed by late spring cold or summer heat where they drop on hard, clean ground which furnishes no protective coverage. In breeding experiments, the pupae are frequently killed, apparently, by excessive moisture and by diseases.

The control of horse bots is really a community or regional

problem. Everyone in the neighborhood should cooperate, since the adults may fly from farm to farm and infested animals may drop them along highways or on nearby farms. Untreated animals, therefore, may keep the community stocked with botflies.

In the control of these pests, several lines of attack are open to man. These include: (1) the prevention of egg deposition through the use of protectors and repellents, (2) the prevention of the host from taking the young bots into their mouth, (3) the destruction of eggs on the host, and (4) the destruction of the larvae after they reach the stomach of the host. The first three controls can, at best, only help to reduce the number of bots, as it is not practical by those measures to completely eliminate the infestation. The fourth control measure is entirely effective, but only after the older bot larvae have already done much of their real harm since the treatment must be delayed until early winter in order to destroy all of the young late arrivals in the host's stomach.

Prevent Deposition of Eggs.—If it were possible by any simple means to completely prevent botflies from depositing any eggs on the hair of horses and mules that would be the logical way to control them. While it is possible to reduce egg-laying by the throat botfly and the lip botfly on animals in harness, no simple and effective means has been found for preventing oviposition by the common botfly, whether the host be in harness or on pasture.

For use against the lip botfly, one may fasten a strip of leather, belting, or automobile inner tube, 4 or 5 inches wide, across under the mouth and attached to the bit rings. Without seriously interfering with breathing, this makes it difficult for the fly to reach the lips for laying eggs. A strip of canvas or cloth sprinkled with creosote or carbolic acid and attached to the bit rings beneath the lip may help some to repel the adults, but a lip guard, as described above, has proven more effective.

As protection against oviposition by the throat botfly, a strip of canvas or a piece of automobile inner tube fastened to the throat latch and to the bit rings has proven very effective. Also, a piece of gunnysack or a leafy branch fastened to the throat latch will help to prevent the throat botfly from attaching her eggs.

Destruction of Eggs.—As protection against all three species of botflies, one can go over work animals at night when they are being unharnessed with a rag mop moistened in a two per cent phenol or carbolic acid solution and most of the eggs touched

will be destroyed. This is a very simple treatment, does not take much time to apply, and, if followed out regularly while botflies are laying eggs, will help greatly in preventing later bot trouble. The same treatment can be applied once a week to animals on pasture with good results. However, since egg-laying may take place from June until October the treatment should be repeated at least once a week throughout that period. In applying this treatment, do not rub the solution in as it may injure the animal's skin. Coal oil, once thought to be effective, has proven of little value in actually destroying the eggs or the larvae waiting to escape from the eggs.

A stiff brush, currycomb, or clippers, may be used to remove some of the eggs, but the mechanical removal of eggs requires more time and is less effective than mopping with a two per cent phenol solution.

Destruction of Bots in the Stomach.—With all of the botfly larvae attached for several weeks in the stomach and front end of the intestines it is possible to reach them there very effectively with a chemical treatment. For years, veterinarians and entomologists have known that carbon bisulphide can be quite safely and effectively used to rid an animal of bots if the treatment is carefully applied. However, except in the hands of a veterinarian or one skilled in drenching horses and mules, this treatment has its hazards, since the chemical may cause serious results if it is taken into the lungs.

For an animal weighing from 1,000 to 1,200 pounds, one dose of 6 drams is usually given. Some prefer to give two doses of 4 drams each with an interval of 1 or 2 hours between doses, but generally the single larger dose is considered more satisfactory. The animal should receive no feed for about 18 hours before being treated, and after the dose is applied it should not be fed or watered for about 3 hours. The above dose must be reduced when given to smaller animals or to colts, and may be increased for larger animals. Mares in foal may be safely treated, but they must be carefully handled to avoid causing them any physical injury. Carbon bisulphide is usually given in a gelatin capsule with a balling gun, or by inserting the capsule deep in the animal's throat by hand. Care should be taken to insure that the capsule is swallowed without being crushed or broken, for if the liquid or its fumes are taken into the lungs serious injury or even death of the animal may result. However, during the last ten years, several hundred thousand treatments of horses and mules for bots have been made in Missouri with but few accidents. In the winter of 1938-39 alone, over 100,000 animals were treated. A few cases have been reported where old, weak or sickly animals have died following treatment, but

no fatilities have been reported due to accidents where experienced veterinarians have given the treatments.

Some veterinarians, however, prefer to take no chances with the capsules being broken and administer the carbon bisulphide by means of a rubber tube introduced through the nostril directly into the stomach. This is a safer method but it requires more time especially with young or nervous animals. In giving the dose by this method one must make sure that the tube passes down the oesophagus to the stomach and not into the lungs. A little water may be poured through the tube first to make sure all is well, after which the measured dose of carbon bisulphide is given.

Organized Community Bot Control.—In the late twenties the lip botfly was reported to be approaching Missouri from the west and north, and the members of the entomology department began a botfly survey to determine if this new species had yet reached the state. Along with this survey they also started what has now grown into a statewide bot control program. It is organized as county units with the county agents, the local veterinarians, and the extension specialists in entomology, animal husbandry, and veterinary science in charge. In more recent years, this control program has been expanded to include, besides bots, also the various other internal parasites of livestock.

During December and January, the county agent contacts the farmers of the county and arranges with them to bring their animals to designated places on certain days, where a veterinarian, with the farmers' help, treats them at a cost of about fifty cents per animal. These treatments have been given mostly in January and February. This is a little late for best results, as much damage by the bots will already have been done, and it is more difficult to assemble the animals after severe winter sets in. However, if precautions are not taken later reinfestation may occur if the treatment is given too early. The ideal plan for the future would be to begin in November, after freezing weather has eliminated late botflies, and organize the work and then in December do all the treating. If each animal that is treated with carbon bisulphide for bots is carefully gone over and also given the treatment for botfly egg destruction with the phenol solution no reinfestation will occur, and the animal will then be rid of bots at the opening of winter. This plan can easily be followed out if the control program is started earlier.

At the present time, carbon bisulphide is the most effective chemical known for killing the bots in the animal's stomach, but, as pointed out, it has its drawbacks. In the first place, it requires the services of a veterinarian or someone else skilled in

treating animals, second, it puts the farmer to considerable trouble keeping the animals off feed and taking them to a central point for treatment, and third, its use involves some hazard. If the farmer had some cheap material which he could simply add to the feed which would not injure the animal and yet destroy the bots that would greatly simplify the treatment and should result in every farmer treating all his horses and mules.

Phenothiazine has been given with feed but it has not been found effective in killing the bots, though it works well for some of the intestinal worm parasites of livestock. The writers have tested derris powder and rotenone crystals given with feed, but the results as yet are not conclusive. When derris powder was used on botfly larvae, under laboratory conditions, it killed slowly and, in some cases, requires retreatment to secure a kill. Some effective chemical of this nature for use with the feed would revolutionize bot control, but until such a chemical is found carbon bisulphide will continue to be the standard treatment.

THE OX WARBLE FLIES

While every farmer is familiar with the common nit-flies or botflies which torment horses and mules throughout the summer, few have ever seen the heel fly which causes cattle to stampede soon after they are turned on pasture in the spring and which is responsible for the grubs which appear in tumors or warbles on their backs the following winter. Also, few farmers, livestock men and dairymen realize the amount of damage these warble flies really do. Studies made at the Chicago Stock Yards nearly seventy-five years ago showed that, on the average, over 50 per cent of the beef animals arriving at the stock yards from Missouri and the other Corn Belt States during the warble season were affected by this pest. Those studies also showed that the average loss to each infested animal was at least one dollar on the hide and as much more to the beef. The loss from the pest in those early days on beef animals alone, therefore, amounted to several million dollars a year, and that loss has continued down through the years. An equally heavy loss occurs in dairy herds. The writers' investigations indicate that today, while the abundance of warbles may vary greatly from year to year, on the average, more than 50 per cent of the cattle in Missouri herds are affected. An animal seldom dies from the effects of warbles so farmers are inclined to underestimate their damage, but they really constitute one of the greatest annual drains on both the beef and the dairy industries in Missouri.

Kind of Warble Flies

There are two distinct species of the ox warble flies in America, the so-called heel fly (*Hypoderma lineatum* De Villers) and the northern ox warble fly (*Hypoderma bovis* De Geer). Both species have been reported from Missouri, but this investigation indicates that the common heel fly is the only one that is of any importance in the state, and it is the one which is considered mostly in this report.

The common heel fly is smaller and less sturdy than the northern species, its thorax is less heavily clothed with yellow and black hair, and the tip of the abdomen is clothed with orange-yellow hair in contrast with the lighter yellow hair of the northern species. The northern species has a wing expanse of an inch, while the heel fly expands about three-fourths of an inch. In general appearance, both species resemble the common horse botfly and they have the same bee-like buzz and action. The northern species is swifter on wing and more frightening to cattle when it approaches to oviposit, though the heel fly may also stampede cattle, often resulting in serious injury to themselves. As a rule, however, the heel fly, on approaching to deposit eggs, has been observed to light on the ground or grass near the animal's heels and from this position extend its abdomen botfly fashion, cementing its eggs to the hair on the heels or on other parts of the host if the animal happens to be lying down.

Life History of the Heel Fly

As in case of the botflies, the warble flies require one full year or, in some cases, a little more to develop from the egg to the adult stage. The eggs are laid mostly on the hair of the heels and lower part of the legs during the spring and early summer. Under favorable conditions, these hatch in a few days and the tiny larvae bore through the skin near the base of the hair to which the eggs are attached. Then begins the long journey through the tissues of the body of the host. This journey is not an easy one to follow, by actual observations, but the uncharted portion of the journey ends with a gathering of the small larvae along the gullet and oesophagus during the fall and early winter. Animals slaughtered during November and December may have a number of the larvae imbedded in the gullet and other tissues in that region. After reaching the gullet the journey is really not over, for the larvae again scatter, moving backward and upward, the first or oldest of the larvae beginning to appear as small, hard lumps under the skin on the back by the last of December, or a little earlier some years. Here a small breathing hole is soon made in the hide of the host by each larva. In due time, the larvae become full-grown,

when they work their way through the small breathing hole in the hide and drop to the ground. Here they crawl under litter or just under the surface layer of the soil and pupate inside the darkened and shrunken larval skin. Later, when conditions, are favorable, the adults escape from the hard, dry cases, spread their wings, and go in search of mates and, in case of the females, a host on which to oviposit.

The Egg.—The eggs of the heel fly and their attachment to the hair are not greatly different from those of the common horse botfly. The eggs average about three-fourths millimeter in length, are yellowish-white in color with a smooth, shiny surface. From one to several eggs may be attached at an angle on a hair, usually near its base, by means of a stalk or clasp. The eggs hatch normally in from about three to seven days, and neither moisture nor friction seem necessary for aiding the small larva to escape through a transverse slit at the tip of the egg.

The Larvae.—While the writers have not made a careful study of the activities of the newly hatched larvae on the host it is now well known that, in place of being licked off and taken into the mouth, the larvae on hatching slowly bore directly through the skin near the base of the hair on which they hatched. Pimples, rash, or even small sores may appear where several larvae enter the skin close together. Frequently, an animal will be seen to stamp its feet or lick its heels in an effort to relieve the irritation caused by the entering larvae.

Larval Migration Within Host.—It is a long journey from the heels of a cow to the gullet where the larvae are first observed in any considerable numbers after they once enter the body of the host. The small size of the young larvae, together with the fact that they are of about the same color as the tissues through which they migrate, have made it difficult to find them on their journey from the hind portion of the host to the viscera and gullet. In two months or more after larvae begin entering the heels they may be found in great numbers in the gullet and nearby tissues of slaughtered animals (Figure 7). That they are not simply licked off the heels or taken with grass has been proven by Bishopp and his associates and by other investigators. They have actually fed newly hatched larvae to experimental animals without later evidence of warbles appearing. Similarly, they have proven that larvae will appear later in the backs of animals which were muzzled to prevent the possibility of their licking off larvae from their heels and legs. For unknown reasons the larvae of the heel fly seem to move upward and forward to the assembling place centered around the gullet region, where they remain for a time before moving rapidly to the back to form the characteristic warbles. It has also been

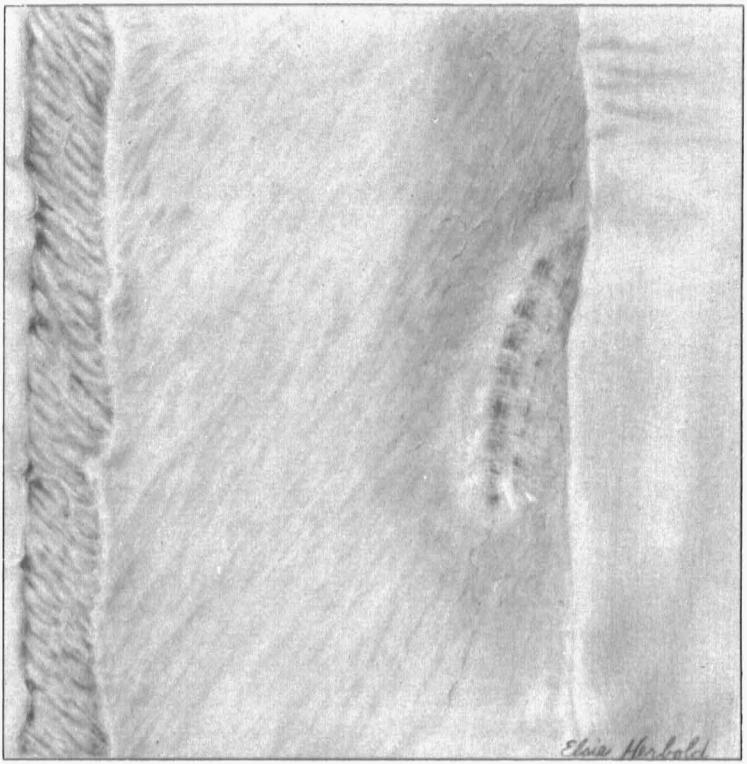

Fig. 7.—Ox warble fly larva embedded in the connective tissue of ox gullet.

found that larvae taken from the gullets of slaughtered animals (Figure 8) and placed under the skin of other animals at various places soon produced typical warbles near to or remote from the place they were introduced. Thus, it is seen that the young larvae after entering at the heels and elsewhere all gravitate to the gullet region where they remain for a time, after which they scatter again, reassembling to form the warbles in the back of the host. The large, black horseflies which suck blood from the backs of cattle during the summer do not cause the warbles as some seem to think. Their larvae or maggots develop in wet soil or water.

Very soon after each larva reaches the back (Figure 9) and forms a hard lump it makes an opening in the hide, usually near the center of the swelling. Some observers state that this opening is cut through the hide by the larva. The opening serves as a breathing hole and later as an exit for the full-grown larva.

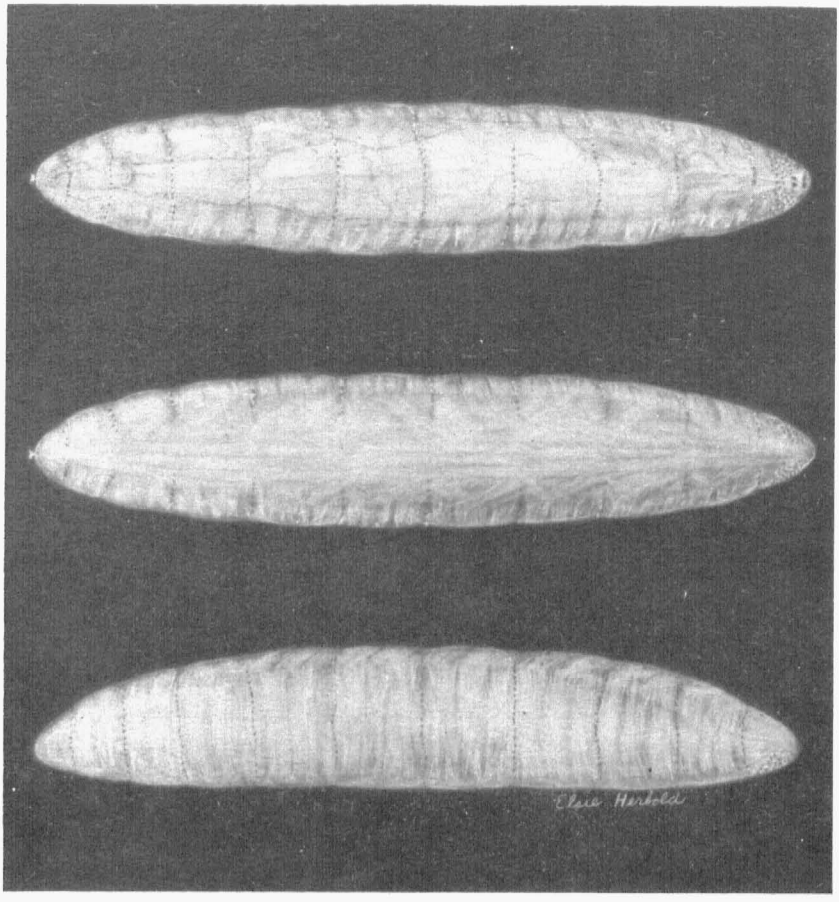

Fig. 8.—Dorsal, ventral, and lateral views of ox warble fly larva taken from connective tissue of ox gullet.

The larva may rest in the warble with its two caudal spiracles (Figures 12) exposed in the opening to facilitate respiration. On the average, it requires from 50 to 60 days after the larva reaches the back of its host before it is mature and ready to escape from the warble and drop to the ground.

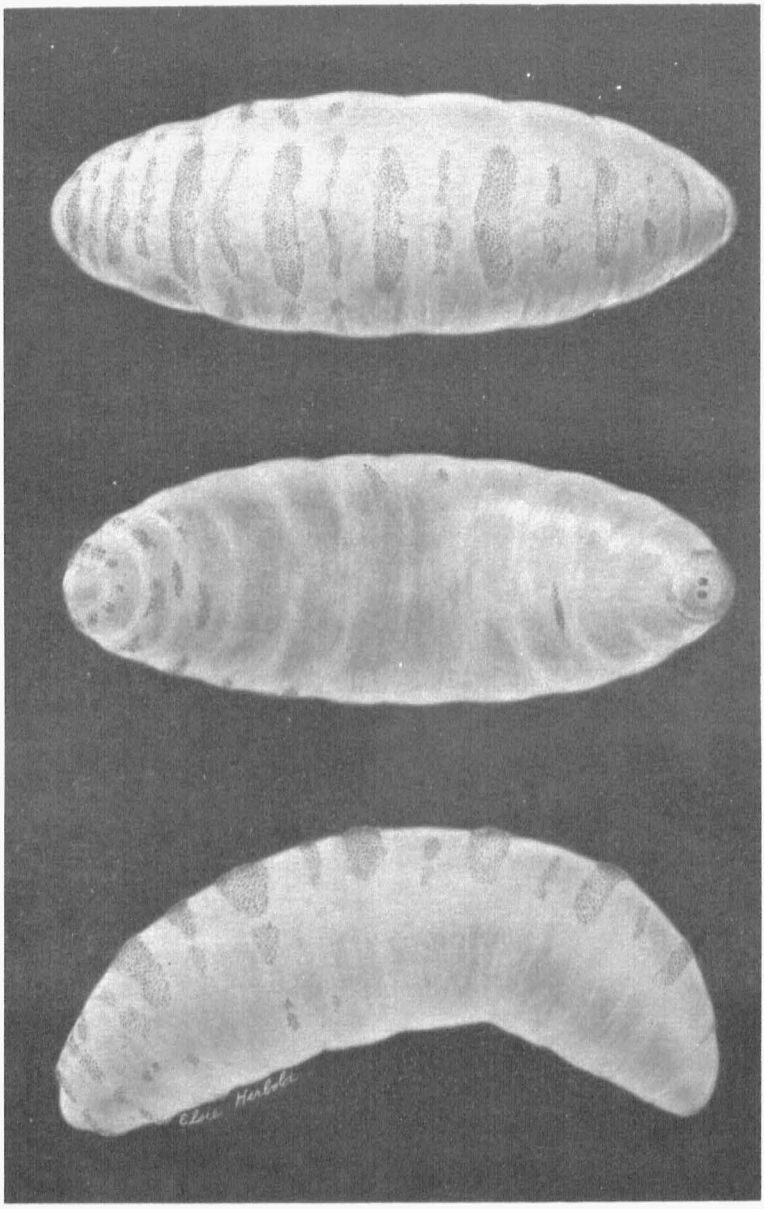

Fig. 9.—Ventral, dorsal, and lateral view of ox warble fly larva taken from small warble on back of host.

Number of Larval Stages.—The number of larval stages is still a disputed question, Knipling and others have maintained that there are only three stages, while other workers have concluded that there are five or, at least, four larval stages. The writers, from their study of larvae taken from the gullet region and from an analysis of the findings of others, are inclined to believe that, in spite of Knipling's findings, there are still grounds for questioning the three instar theory. It is generally agreed that the larva molts twice after it reaches the back of the host. If there are only three larval stages this would mean that the larva does not molt from the time it hatches until it first appears in the back some eight to ten months later and after it has increased from one-half millimeter in length to some sixteen millimeters in length. It seems strange that the larva should spend four-fifths of its larval life in the first larval stage and only one-fifth of it in the last two stages, or that it should attain two-thirds of its length and one-third of its width in the first larval stage.

If there are five larval stages, as some claim, the larva probably molts once between the time of hatching and the time it reaches the gullet region, and a second time sometime before it reaches the back, and a third and fourth time in the warble on the back of the host. While the number of larval stages are of interest to entomologists, it has no particular bearing on the damage the pest does or on the methods of control.

Pupa.—When the full-grown larva is ready to escape from the warble it forces its way, tail-end first, out through the small opening in the hide of the host by alternate expansion and contraction of its body segments (Figure 10). When it drops to the ground it crawls under litter or into the surface layer of the soil if it drops on loose ground. Bishopp and associates found that the majority of the larvae drop out when the host is most active during feeding periods. Soon after escaping, the skin of the larva begins to darken and to shrink and dry, entering what is spoken of as the prepupal stage (Figure 11). Inside the dried skin the larva changes to the pupa in a few days after it drops to the ground. With weather conditions favorable it remains in the pupa stage only about a month on the average.

Adult.—Soon after emerging, mating takes place and egg-laying begins on the first warm sunny days. Each individual fly lives for only a few days and does not feed. However, adults may continue to emerge and lay eggs on cattle in Missouri throughout March and April and, some years, early May. The stampeding of cattle in the spring is a sure sign that heel flies are on wing depositing eggs.

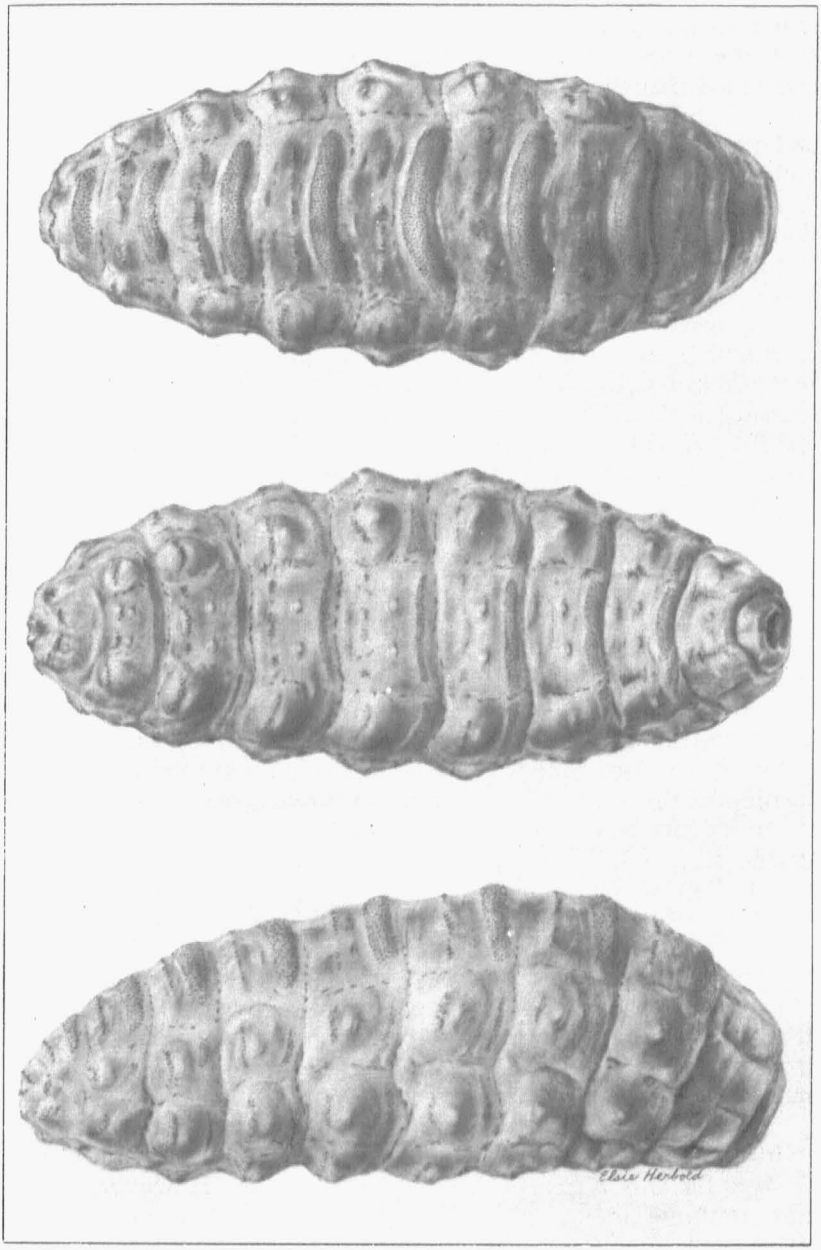

Fig. 10.—Ventral, dorsal, and lateral view of ox warble fly larva which was almost full-fed.

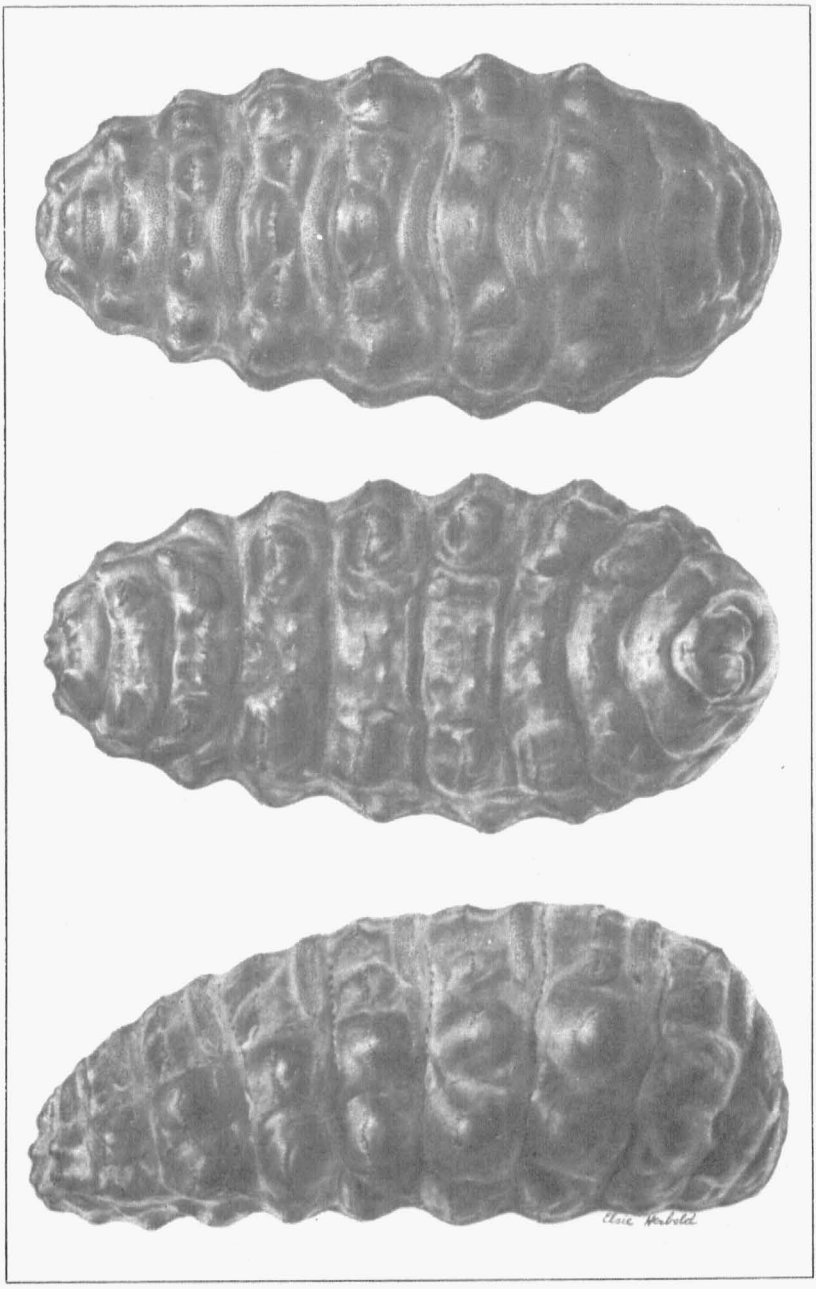

Fig. 11.—Ventral, dorsal, and lateral views of ox warble fly larva ready to pupate.

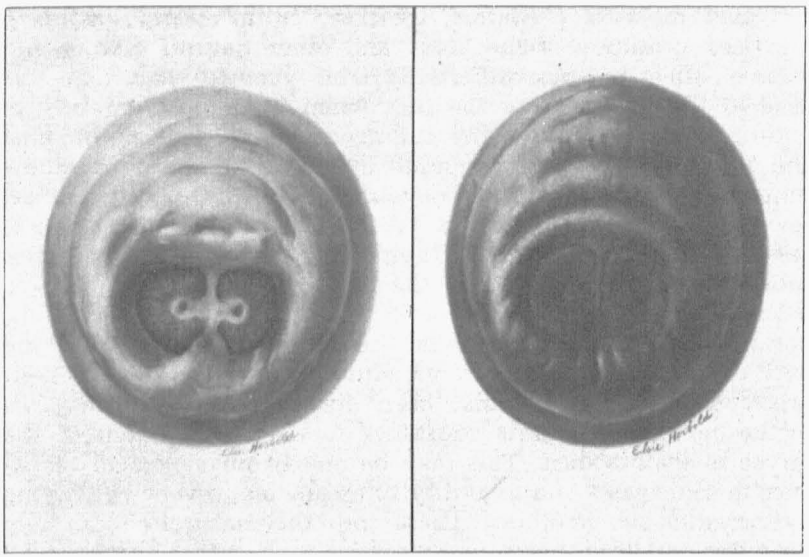

Fig. 12.—Caudal spiracles of larva ready to leave warble and of older larva ready to pupate, as shown in Figures 10 and 11.

Nature and Extent of Damage

No accurate method has been devised for determining the actual loss to the beef and dairy industries caused by the warble flies. That these losses are enormous seems self-evident from the fact that, on the average, half of all the cattle in Missouri are affected each year. The wild stampeding of herds during the spring when the flies are laying eggs and the large number of raw, festering tumors or warbles on the backs of cattle the following winter and early spring cannot help but result in definite drain on the hosts. Cattle heavy with calf and heavy milkers in particular are subject to injury by stampeding. The greater damage, however, results from the work of the spiny larvae in the backs of cattle. The damage to the hide for leather purposes is a definite one. Also, the injury to the tenderloin cuts of beef is evident to every butcher and meat inspector during the winter and spring months. A considerable though unmeasurable loss is that due to the irritation of the grubs, resulting in the host expending much energy, and therefore loss of milk secretion and fat, in the development of the festering tumors or warbles which encase the maturing larvae. An estimated annual loss of several million dollars a year in this country is conservative.

Enemies and Natural Checks

The degree of warble fly infestation on a farm will vary from year to year entirely independent of any control practices which the farmer or dairyman may apply. This is due to the

fact that diseases, predators, weather, cultural and pasturing practices, condition of the hosts, and other natural checks and enemies affect the pest differently from year to year. The one time in the life cycle of the pest when it is most exposed to natural controls is after the full-grown larva leaves the host and before it emerges as the adult fly. Many of the pupae show fungus infection, others are devoured by birds, poultry, mice, sow bugs, and other predators. Adverse weather, including excessive heat and cold, heavy tramping in feed lots and pastures, submersion in manure or in the soil by plowing, all help to destroy the full-grown larvae and pupae. As with other insects, normally comparatively few of the larvae escaping from the back of the host ever mature as adults to lay eggs for the next brood of larvae. It has also been observed that certain cows in the herd show definite resistance to the development of the larvae in their bodies. This may be due to physiological resistance in some cases and to ability to escape or prevent egg-laying by the adult flies in others. These and other natural checks help keep this pest from becoming excessively abundant every year.

Control

In man's protection of cattle from warble fly injury there are two possible lines of attack—first, the prevention of infestation, and second, the destruction of the larvae when they appear in the warbles on the back of the host. No effective method has been devised for destroying the young stages of the pest in the host before they appear in the warbles on the back. Also, the maturing stages after they are permitted to leave the host are largely beyond man's reach. In any systematic control effort, community cooperation is essential since the flies are able to move from farm to farm.

An abundance of deep shade or dark sheds and ponds or streams of water in which the cattle may stand during the hot part of the day when flies are most active will help to prevent infestation. While some egg-laying may occur in broken shade or on warm, cloudy, and cool, bright days, the flies are most active out in the open on warm, sunny days. Dairy herds can be largely protected from oviposition by the flies where it is possible to stable them during the hot part of the day and to run them on pasture at night and in the early morning and late afternoon. Also, the liberal use of one of the more effective fly sprays on the heels and lower part of the legs before dairy herds are turned on pasture in the morning is claimed by dairymen to help repel some of the flies trying to deposit eggs. Some also think that frequent mopping of the heels and lower parts of the legs of cattle with a 2 per cent phenol or creosote solution helps

to destroy heel fly eggs, similar to the destruction of horse botfly eggs. The work of Bishopp and others, however, showed that neither the use of fly sprays as repellents nor the treating of the heels at 4-day intervals with a 2 per cent commercial coal tar creosote dip in a wading vat reduced infestation and that, except for freshly laid eggs, dipping in a 2 per cent solution of coal tar creosote had little effect on the hatch of eggs in laboratory tests.

Aside from the possibility of keeping the cattle from open sunny pastures during the part of the day when flies are most active, there is little of a practical nature one can do to actually prevent infestation. Effective control, therefore, is largely restricted to the destruction of the maturing grubs in the warbles on the back of the host. This may be done either by removing the grubs or by killing them in the warbles by applying an insecticide.

Mechanical Removal of Grubs.—If the grubs are to be squeezed out care should be taken to avoid bursting them in the warbles, since the grubs may contain toxins injurious to the host. Various investigators and farmers have reported injury and some apparent cases of death of cattle resulting from the crushing of the grubs in attempting to remove them. However, if one is careful he can remove the grubs without bursting them in the warble and forcing their contents back into the tissues of the host. It is usually more difficult to remove the small grubs than the older ones where the escape hole in the warble is larger.

To squeeze out the grubs, some prefer to use both hands with the tips of the fingers on opposite sides of the opening in the warble (Figure 13). Then by pressing heavily and stretching the hide by drawing the hands apart the grub is slowly forced out through the hole in the warble. Another method is to use one hand cupped over the warble, pressing the tips of the fingers and thumb down under the warble and then applying pressure from underneath, forcing the grub out. One is more apt to burst the warble if the thumbs of both hands are pressed toward the grub from either side, and worse still if a pair of pliers are used to squeeze them out. To avoid bursting the grubs, some prefer to slightly enlarge the hole in the warble with a sharp knife and then remove the grub with a pair of tweezers. Another method which some workers use and which seems safe is to puncture the end of the grub and squeeze its body contents out through the opening in the warble after which its body wall can be easily removed with a pair of tweezers. In all cases, after the grub is removed the underlying pus in the warble should be pressed out and preferably a little disinfectant introduced to hasten healing (Figure 14).

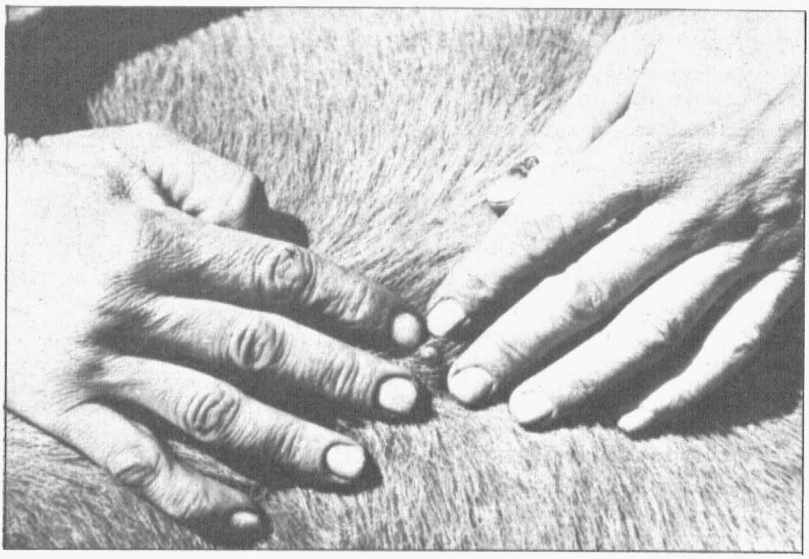

Fig. 13.—Squeezing out larva from warble with hand placed so as to avoid danger of bursting the larva.

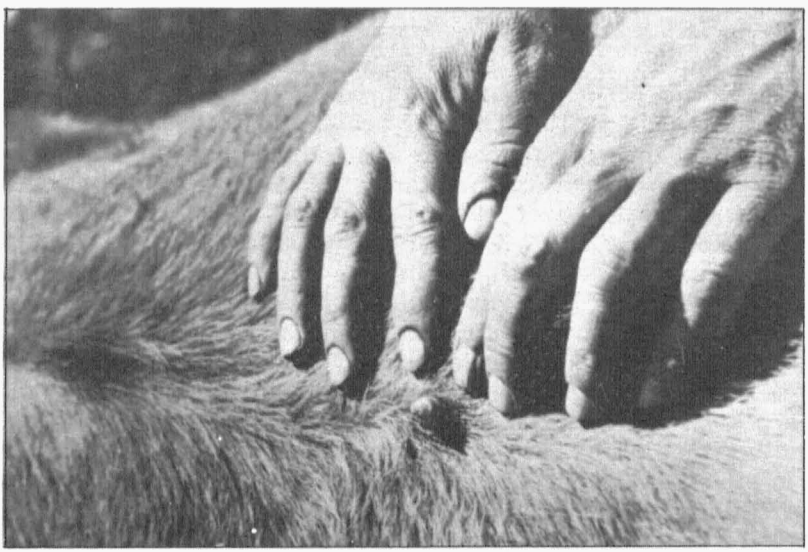

Fig. 14.—Removing larva from warble. After larva is removed, the pus should be pressed out and preferably the warble treated with a disinfectant.

Every farmer has his own method of squeezing out the grubs, but he should always keep in mind the fact that the operation is about as unpleasant to the cow as squeezing out the core of a boil on the back of one's neck. Such harsh treatments as the use of a pair of pliers is not recommended. Except where cattle are in stanchions or otherwise closely confined it is difficult to apply the old squeeze method of disposing of the grubs.

Killing the Grubs With An Insecticide.—More recent investigations have shown that it is both safer and more satisfactory to apply an insecticide to the backs of cattle, which kills the grubs in the warbles, after which they dry up and are forced out through the healing openings in the warbles. A number of different materials have been used with good results for killing the grubs in the warbles. Of these, derris powder alone, or in various combinations with either soap and water or with different grades of oil to form ointments or a salve, have come to be the most widely used insecticidal treatments.

Derris.—When combined with soap and water the wash is simply applied to the infested portion of the back and sides of the host and rubbed in vigorously with a stiff brush creating a lather. The scrubbing removes any dry matter plugging the openings in the warbles and also works the insecticide into the warble. This treatment, under the writers' supervision, has given very satisfactory control in a number of Missouri dairy herds (Figure 15). When combined with a light oil it is injected into the individual warbles with an oil can or similar convenient equipment. If combined with heavy paraffin oil, a small quantity of the mixture is either pressed into the individual warble opening with the finger tip after any dry matter is scraped out, or the writers have found that a large hypodermic syringe with the needle removed works very well for injecting the thick mixture down into the warbles. In all the herds so treated derris preparations have given the writers practically 100 per cent kill of grubs.

Where the derris wash is used and vigorously scrubbed into the hair and warbles there is less danger of missing some of the warbles, but after being killed the grubs tend to dry up and are not expelled from the healing warbles for several days. Where the heavy oil-derris mixtures are applied most of the dead grubs are forced out of the warbles in a few days, thus hastening healing of the openings. Commercial preparations of the derris powder for use as a wash, as well as its combination with heavy oil, are available at reasonable cost. For a few cents per cow, a dairy herd can be given preferably three treatments at one-month intervals, beginning as soon as the first grubs

appear in the backs of the cattle. These derris treatments are painless and harmless to the cattle, do not taint the milk, and if they are applied regularly by all farmers in a community should, in a few years, largely clear the region of warble flies.

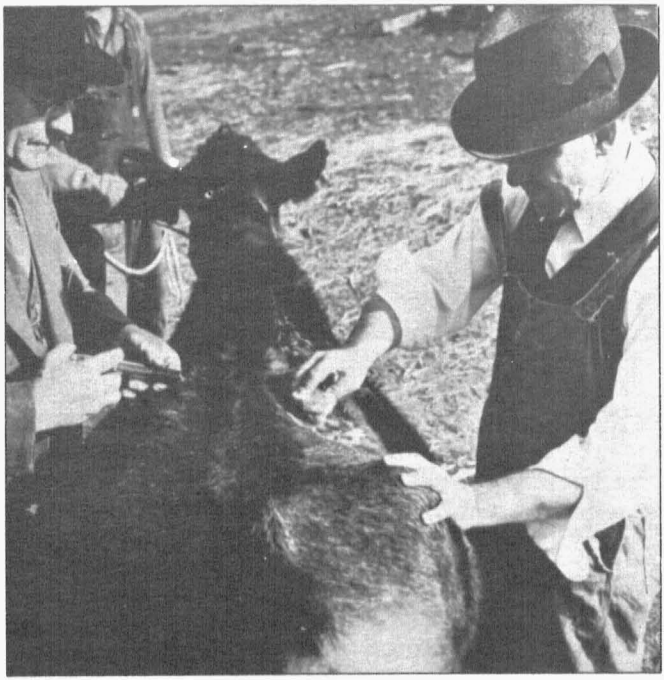

Fig. 15.—Treating with insecticide to kill larvae in warbles. On the right, the derris-soap wash is applied with a stiff brush; on the left, the derris ointment is being injected into the warble with a hypodermic syringe

Other Effective Chemicals.—Of the various other chemicals used to kill the grubs in the backs of cattle, the following have given fair to excellent results either in limited experiments or, on a larger scale, with farm herds: Pyrethrum, nicotine, benzol, chloroform, gasoline, iodoform, equal parts of pine tar and paraffin oil, potassium permanganate, silver nitrate, carbon tetrachloride, cresol, turpentine, and others. The effectiveness of some of these materials is increased when combined with a hard oil such as cup grease and applied as an ointment directly into the opening in the surface of the warble. An oil can with a slender curved spout works very well for applying the liquids directly into the warble.

Since the grubs may be found in the back of the host in Missouri from December until April or later, one single treat-

ment will not reach and kill all of the grubs. Two or, better still, three applications of the insecticide should be made, the first early in January as soon as holes in the warbles appear, a second a month later, and the third a month later. If only one treatment is to be made it should be given just before the first grubs are ready to leave the warbles. The average farmer or dairyman is likely to secure better control with a stiff brush and an effective wash, such as the derris-soap mixture, than with one of the ointments or liquid materials applied directly in the warble openings. The danger of missing some of the warbles with the spot treatment makes it less desirable unless the one applying the remedy works carefully and makes sure that each warble is treated.

The control for the heel fly is easier to apply on dairy herds than on beef cattle but where the latter are kept in barns and feed lots during the winter months, when the grubs appear in their backs, the destruction of the grubs by applying a chemical or by squeezing them out may not be so difficult even with beef cattle. In the effective control of the heel fly in Missouri cooperation is just as essential as with horse bot fly control. The only difference is that the farmers and dairymen themselves can apply the heel fly controls on their own farm, while the cooperation of a veterinarian is usually necessary with botfly control.

SHEEP NOSE BOT FLY

This is an old world pest of sheep and was undoubtedly brought to America when sheep were first introduced. It is now present throughout this country and, some seasons, is one of the most injurious parasites of sheep. Missouri farmers report very serious losses from the sheep nose botfly (*Oestrus ovis* Linne) some years. As with the other related botflies and warble flies it is not equally important every year since there are natural checks which help to keep it under control.

Every sheep raiser is familiar with the characteristic reaction of the sheep to the visitation of the fly when it is attempting to deposit its maggots in the nostrils. During the warm part of a mid-summer day when the botflies are busy the sheep may, individually, thrust their nostrils into vegetation or in the dust as protection. Frequently, several sheep will form a huddle, facing each other with their noses close together and pressed against the ground. They do not stampede as do cattle when the heel fly is ovipositing. When attacked they usually stand rigid with the nostrils protected as well as possible. If they move about while being attacked it is usually with a slow, stealthy motion with a fixed stare and with the head held low to protect the nostrils. Even in the shade they will continue to huddle and protect their nostrils as long as the flies stay near.

A flock of sheep on the University farm near Columbia one hot midsummer day in 1939, while being attacked by botflies, put on a perfect show for the writers. The flies, on the other hand, were less accommodating, for they eluded every effort to observe and capture them.

Life History and Description

The writers have done much less work with this species than with the other botflies, and there is much still to be learned regarding its life history and activities under Missouri conditions. Several years ago, one of the department assistants reared the adult from the larval stage in a cage carried under his clothing. Considerable data is available on its abundance and the damage it has caused in different parts of the state.

The adult fly is of a dull color and nearly as large as the horse lip botfly. Its general shape and form are not unlike that of a large house fly. It normally deposits the young larvae rather than eggs in the nostrils of sheep, usually without alighting. In some countries it is reported as also infesting goats and man in the same way as sheep. The small larvae work their way up into the nasal passages and the sinuses. Here they develop, feeding on the mucus secretions for from a few months to about nine months, according to different observers. The most destructive work of the larvae occurs during the winter months when the vitality of the host is naturally lowest. When they are full-fed the larvae pass down the nasal passages and escape to the ground, into which they crawl to pupate. Depending on temperature and other conditions, they remain in the pupa stage encased in the dry larval skin for six weeks or more, when the winged adult appears. The adults may appear from May until midsummer or later and, as with the related species, there is only one generation a year.

Nature and Extent of Injury

From the writers' observations the sheep are not stampeded by the flies while depositing their larvae, but they may interfere with their normal grazing. The real damage results from the activity of the spiny larvae in the tender nasal passages and in the sinuses. This irritation interferes with normal feeding and a nasal discharge appears as in case of a head cold. In severe cases, the host loses flesh, may stagger about, develop convulsions, and frequently die in a week or ten days after the severe symptoms show up. Farmers in Missouri have reported as high as 75 per cent of the flock affected some winters. Some call this pest the "gid fly", due to the resemblance of the symptoms of fatal cases to those of the gid disease.

Control

Of all the species of botflies attacking livestock, this is the most difficult one to reach and control. Repellents to prevent infestation have but little effect. The old practice of using pine tar around salt holes in logs or for smearing on the nose of the sheep has proven ineffective in giving the desired protection.

Better results generally may be expected by providing something which the sheep may use as a mechanical barrier to flies when they attempt to deposit their maggots in the nostrils. Patches of loose dirt or dust in dry lots, plowed furrows throughout pastures, windrows of loose straw, or buckbrush in the pasture all help to lessen the chance of severe infestation. Sheep instinctively thrust their nostrils into protection of these sorts when the fly appears to deposit maggots. An abundance of dense shade may also help. Aids along these lines should be given as long as the flies continue to attack sheep or from May into July, or later some years.

Once the maggots have established themselves in the nostrils or sinuses there is little real aid one can give sheep in dislodging them short of an actual operation, which is generally advisable only in case of valuable animals. Dusts used to cause sneezing may help to remove some grubs from the nostrils, and the careful use of a little carbon bisulphide mixed with mineral oil in the nostrils is thought by some to help dislodge the grubs. However, probing in the nostrils with a wire or the use of strong chemicals in the nostrils may prove more injurious than the work of the grubs. Prevention during the summer months to reduce infestation, coupled with good management, including proper housing and feeding during the winter, will do more to reduce losses from this destructive pest than anything else known at present. Further study directed at a more satisfactory solution of the problem is needed.

LIST OF REFERENCES

(1) Birkett, T. E. 1931.—The Morphology and Physiology of the Alimentary Canal of the Larva of the Ox Warble, *Hypoderma lineatum* De Villers. University of Missouri Thesis (Unpublished).

(2) Bishopp, F. C., E. W. Laake, H. M. Brundrett, and R. W. Wells. 1926.—The Cattle Grubs or Ox Warbles, Their Biologies and Suggestions for Control. USDA Dept. Bul. No. 1369.

(3) Bishopp, F. C., and W. E. Dove. 1932.—The Horse Bots and Their Control. USDA Farmers' Bul. No. 1503.

(4) Bishopp, F. C., E. W. Laake, and R. W. Wells. 1936.—Cattle Grubs or Heel Flies With Suggestions for Their Control. USDA Farmers' Bul. No. 1596.

(5) Case, L. F. 1929.—Study on the Ox Warble Flies, *Hypoderma lineatum* and *Hypoderma bovis*, With Special Reference to Economic Importance and Control. Va. Agr. Expt. Sta. Tech. Bul. No. 39, 12 p.

(6) Hadwen, Seymour. 1919,—Warble Flies, *Hypoderma lineatum* De Villers and *Hypoderma bovis* De Geer. Canadian Dept. of Agr., Health of Animal Branch, Sci. Ser. Bul. 27.

(7) ————————. 1924.—On the Migration of *Hypoderma lineatum* from the Skin to the Gullet. Parasitology, 16: 98-106.

(8) Knipling, Edward F. 1935.—The Larval Stages of *Hypoderma lineatum* De Villers and *Hypoderma bovis* De Geer. Jour. of Parasitology, Vol. 21, No. 2.

(9) Laake, E. W. 1921.—Distinguishing Characters of the Larval Stages of the Ox Warbles, *Hypoderma bovis* and *Hypoderma lineatum*, With Description of a New Larval Stage. USDA, Jour. Agr. Research, 21:439-457 ills.

(10) ————————. 1924.—Further Observations on the Molts of the Ox Bots, *Hypoderma bovis* De Geer and *Hypoderma lineatum* De Villers. USDA Jour. Agr. Research, 28:271-274.

(11) Mote, D. C. 1928.—The Ox Warble Flies, *Hypoderma bovis* De Geer and *Hypoderma lineatum* De Villers. Ohio Agr. Expt. Sta. Bul. 428.

(12) Riley, C. V. 1892.—The Ox Bot in the United States. Habits and Natural History of *Hypoderma lineata*. USDA Div. Ent. Insect Life 4:302-317.