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A Study of the Heel Flies, Hypodermia Lineatum Devillers and Hypoderma Novis DeGeer, in South Dakota

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A STUDY OF THE HEEL FLIES, *HYPODERMA LINEATUM* DEVILLERS AND *HYPODERMA BOVIS* DEGEER, IN SOUTH DAKOTA

By

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This is to certify that, in accordance with the requirements of South Dakota State College for the Master of Science Degree, Mr. John A. Lofgren has presented to this committee three bound copies of an acceptable thesis, done in the major field; and has satisfactorily passed a two-hour oral examination on the thesis, the major field, Entomology, and the minor field, Zoology.

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INTRODUCTION

The heel flies or ox-warble flies (*Hypoderma lineatum* DeVillers, and *H. bovis* DeGeer) and their larvae, commonly called cattle grubs or warbles, are among the most troublesome and costly insect pests of livestock producers in South Dakota. These parasites attack cattle almost exclusively although they may occur at times in other domestic and in wild animals. Infestations in man have been recorded, but these cases are quite rare. This work deals only with the occurrence of the parasites in cattle.

There have been several attempts to control cattle grubs in South Dakota and in other States. These attempts have been only partially successful. The problem is much more difficult than the control of horn flies, stable flies, or lice. In attempting to control the latter pests it is quite easy to determine the effectiveness of the treatments. With heel flies, however, the results are not so easily observed or quick to appear.

Up to the present time most of the control campaigns attempted consisted of treating the infested cattle only once, twice, or at the most, three times. Now it is evident that more treatments are essential in order to kill a greater percentage of the larvae in the cattle in areas where both species occur.

New materials and techniques are constantly being investigated in order to find more efficient means of control. Therefore, recommendations made one year may be replaced by better methods in following years.

The purpose of this paper is to present the results of two and one-half years of investigations dealing with the geographic distribution, abundance, and seasonal cycles of the two species of Hypoderma in South Dakota; to describe some attempts in community wide control programs; and to present some of the disadvantages of present methods of control. The work is based upon investigations conducted by the writer in conjunction with a research project of the South Dakota Agricultural Experiment Station.

ECONOMIC IMPORTANCE

A conservative estimate of the annual monetary loss caused by these parasites in the United States is one hundred million dollars. Because of the peculiarities of their life cycles, the damage arises from several sources. The most noticeable to the stockman is the running of the cattle caused by the adult flies. The egg depositing activity of the flies, mainly of H. bovis, drives the cattle into a frenzied attempt to evade them, probably causing a loss of weight. The possible discomfort and irritation caused by the larvae penetrating the skin and migrating through the connective tissues of the host is difficult to evaluate, but it should be considered in discussing the damage caused by them.

When the larvae reach the sub-dermal tissues of the back there is a noticeable reaction of these tissues to the invasion. The flesh becomes soft, slick, gelatinous, and in many cases, acquires a greenish coloration. At the time of slaughter all

this defective tissue must be trimmed and discarded. The result is a loss of meat and a less attractive carcass. The grubs finally appear along the center of the back about eight or ten inches on each side of the spine where they each make a small hole through the skin. From this portion of the hide comes the choice grade leather and when this part of the hide is full of holes produced by the larvae its value as leather is greatly reduced. Even if the holes in the skin do heal completely before the hide is removed, the healing produces scar tissue and the leather is inferior.

HISTORY OF PREVIOUS WORK

Heel flies, or ox warble flies, and the activities of these insects have been known for many years. As with so many parasites, a great many theories about life cycles and the effects of parasitism have arisen which take years of careful study, observations, and research to prove or disprove. The first records of observations on these insects were written by Vallisnieri (17)[1] an Italian naturalist, in 1710. Bracy Clark (5) in 1797, published an account of the Oestridae including his observations on Hypoderma. In 1863, Brauer (2) an Austrian, published an article in which he described a method of differentiating H. lineatum from H. bovis in the last larval stage.

One of the first erroneous conceptions of many early writers was that the flies deposit their eggs under the skin of the host, although in 1739, Linne' advanced the theory that the eggs of the related reindeer bot-fly were fastened to the skin or hair of the host.

1. Numbers in parentheses refer to literature cited.

For a number of years only the larvae under the skin of the host's back were known, and it was generally believed that the animal licked the eggs off the hair, thereby becoming infested with the maggots. In 1914, Carpenter, Hewitt, and Reddin (3) after a few years of conflicting reports conducted some experiments on muzzled calves and demonstrated that the larvae penetrated through the skin of the host. This work was done in Ireland where much important research was conducted from 1908 to 1922 by these investigators.

Interest in cattle grubs increased in America in the early '90s with publications by Riley in 1889 and 1892, Curtice in 1890 and 1891, and Marlatt in 1897. These workers assumed that the host licked the eggs from the hair and thus became infested. Hadwen (8) working in British Columbia, observed and described the method of oviposition of H. bovis and made other important investigations on the biology and economics of the parasite.

The first control work was attempted in Germany from 1912 to 1916 during which time a special commission was appointed to investigate the problem. From this work a great deal of information on losses due to the parasites, relative numbers of the two species, and control work was learned.

In 1920 and 1922 Carpenter and his associates reported successful grub control experiments in isolated regions of Ireland. In these investigations various materials, including tobacco powder, were used to kill the grubs.

Since early 1900 many valuable contributions have been made by workers in Denmark, England, Ireland, Germany, Canada, and the United States. One of the most complete investigations and

compilations of this period is the work of Bishopp, Laake, Brundrett, and Wells (1) published in 1926. At this time it was generally believed that the larvae passed through five stages but in 1935, Knipling (10) established the fact that there are three stages and two molts in the course of larval development.

More recent work has been done on seasonal occurrences and control practices by Mills, Marsh, and Willson (13) in Montana; L. I. Case (4) in Virginia; Knowlton and Sorenson (11) in Utah; Matthysse (12) in New York; Haseman and Roland (9) in Missouri; and Wells (18) of the U. S. Department of Agriculture.

Not much work is available on the anatomy and physiology of Hypoderma larvae although Ono (14), in 1932, published an account of morphologic studies of H. lineatum larvae. Simmons, (15 and 16) in 1939, published two articles, one of which dealt with the digestive enzymes of the grub, and the other with the histological reactions of the host caused by the larvae.

In 1948, Haberman, Morgan, and Dicks (7) reported on their studies of the migration of Hypoderma larvae in the hosts. They found that during the long period of migration through the hosts' bodies the larvae accumulate in specific tissues prior to appearing in the sub-dermal tissues of the backs. The larvae of H. lineatum normally are found in the sub-mucosa of the esophagus, while H. bovis accumulates in the fatty connective tissue of the spinal canal for a relatively short period of time.

GENERAL LIFE CYCLE[1]

Both species of heel flies are present in South Dakota. Their life cycles in general are the same, but H. bovis appears slightly later in all its stages than does H. lineatum.

The eggs of both species are deposited on the hair mainly on the legs below the knee and around the dew claws, although they may be laid almost anywhere on the body. The eggs of H. lineatum are laid in rows of usually four to eight in a row, although as many as fourteen or fifteen are sometimes found on a single hair. The eggs of H. bovis are almost invariably laid singly.

After about a week (two to eight days, depending on the temperature and moisture) the eggs begin to hatch. The young maggots or larvae crawl down the hair and enter the skin at the hair follicle. Upon entering the body the larvae migrate through the tissues of the host staying almost entirely in the connective tissues. Although little is known of the exact route or nature of the migration, considerable time is spent in the region of the gullet or spinal canal before the migration to the subcutaneous tissues of the back.

Haberman, et al, in making post mortem examinations of cattle in Wisconsin, found that H. lineatum occurs specifically in the esophagus and that H. bovis is found almost exclusively in the spinal canal before migrating to the back.

Several months are spent in the host before the larvae reach the back, at which time the grub begins to produce a hole through the skin of the host. The exact manner in which the perforation is

1. The life cycle is given as generally accepted in the literature.

produced is not known, although Ono (14) advanced the theory that a substance called dermatotoxin, a proteolytic material, produced in the midgut of the grub is used for this purpose. Ono believed that this enzyme digests or erodes the tissues of the skin thus producing or helping to produce a hole in the skin. Simmons (15) in 1939, wrote the following description: "The process of skin perforation is probably accomplished mainly through dissolution of the tissues by dermalytic enzymes." Very probably the perforation is caused by a combination of enzyme action and a mechanical rasping of the tissues by the mouth parts and (or) spines. Shortly after the grub appears under the skin of the back, the host produces a sac or cyst around the larva to isolate the parasite. One to five days after producing the hole through the skin, the grub molts for the first time and enters the second stage or instar. About twenty-five days later a second molt occurs and the grub is in its third and final stage. In all, a period of approximately twenty-five to seventy-five days is apparently required under the skin of the back for the complete larval development of H. lineatum and twenty-one to eighty days for H. bovis.

When the grub is mature it works its way out of the hole in the host's skin and falls to the ground. Here it takes advantage of whatever cover is available, such as leaves, grass, or loose dirt. One or two days later, the skin of the grub becomes black, hard, and wrinkled, forming a protective shell for the developing fly inside. This is called the puparium.

Inside of the integument of the puparium the transformation to the heel fly takes place. This change requires twenty to about

seventy-five days for the common grub and fifteen to twenty-five days for the northern grub. The speed of this development is dependent upon temperature and other weather conditions. When the fly is fully developed it pushes off a little flap, the operculum, at the anterior end of the puparium and emerges. A short time after emerging the fly is able to take to the air, mate, and lay its eggs. Each female fly is capable of laying about five hundred eggs, and lives for approximately one week. The eggs hatch in about a week and the cycle starts anew.

The egg laying activity of the flies, especially H. bovis causes the characteristic running and stampeding of the cattle. The causes for this action of the host are not thoroughly understood. The fly has no sting, as has the honey-bee, and no functional mouth-parts, for it does not feed. It is, therefore, anatomically impossible for the fly to bite or sting the animal upon which it is ovipositing.

DESCRIPTIONS

Hypoderma lineatum DeVillers

Adult or Fly: The adult is a fly about twelve to thirteen millimeters in length with a wing span of about twenty-four millimeters. The general color of the fly is black with transverse bands of yellowish white hairs and the posterior portion of the abdomen is clothed with distinctive reddish orange hairs. The thorax is quite bare dorsally, with four noticeable, shiny, longitudinal lines. The femora are black and the tibiae and tarsi brownish, all of which are well covered with black and orange colored hairs. The wing veins are dark brown to black and the alulae uniformly white. The average distance between the eyes is

1.9 millimeters. The ovipositor of the female is about four millimeters long when fully extended.

The Egg: The eggs are smooth and dull yellowish white in color. The shape is narrowly ovoid, slightly larger at the base than at the distal end. The average length is 0.76 millimeters and the average width at the widest point is 0.21 millimeters. The egg is equipped at the end of a short petiole with a clasping device which is clamped around the hair.

The Larva: When the larva first hatches from the egg it is generally cylindrical, tapering toward the anterior end. The average length is 0.60 millimeters and the average width is 0.16 millimeters at its widest point. It is creamy white in color and densely covered with spines, the anterior border of each segment bearing the heaviest spines in transverse rows. The anal segment bears the posterior spiracles which are two yellowish, apparently sclerotized, atria leading into the dorsal tracheal trunks. In newly hatched larvae these spiracles measure about ten microns and in older first stage larvae they are up to thirty-six microns in diameter. This increase is due to a deposit of a brownish formation, probably sclerotic material, as the larva grows older. These spiracles are protected by two or three stout triangular spines near their borders.

After the first molt, the larva is about 15 millimeters long and about 4.5 millimeters wide. The spiny armature varies greatly with different specimens; however, most of the spines are arranged in bands on the anterior borders of the ventral portions of the body segments. The posterior spiracles, or stigmata, appear as

a number of ring like sclerotized discs, yellowish-brown in color. The number of these openings or pores varies considerably, but in most larvae they number from twenty to twenty-five, and are loosely grouped together.

The third or last stage larva varies from 15 to 25 millimeters in length and 6 to 11 millimeters in width. The spiny armature varies dorsally and laterally, but is constant ventrally on the posterior borders of segments II to and including X. This arrangement of the armature has been widely used as a distinguishing characteristic of the species. The posterior stigmata are kidney shaped and quite flat or very slightly excavate. They enclose the ring like openings of stage two, but these pores are now more numerous and arranged in branching rows radiating from the pseudostigmatal orifice, or "button". The newly molted grubs are creamy white in color and become dark to almost black at maturity.

The Puparium: The puparium has the characteristics of the third larval stage except that it is more or less comma-shaped, hard, wrinkled, and very dark in color, being almost black. The dorsal side is flat and the operculum is plainly visible on the anterior end. The flat, kidney-shaped posterior stigmal plates remain visible.

Hypoderma bovis DeGeer

Adult or fly: The fly of the northern grub, sometimes called "Bomb fly", is larger and more robust than H. lineatum and measures 14 millimeters in length. The anterior part of the thorax is covered with pale yellow hairs which somewhat obscure the shiny

longitudinal lines. The abdomen of H. bovis is colored about the same as that of H. lineatum except that the posterior band of yellow hairs is considerably paler in color and wider. The wing veins are reddish brown and the alulae bordered with brown. The femora and tibiae are black and the tarsi brown and much less hairy than H. lineatum.

The Egg: The eggs are very similar to those of H. lineatum except in size. They are about 0.80 millimeters long and 0.29 millimeters wide. The petiole is attached to the center of the base of the egg and is sharply elbowed, whereas in H. lineatum the petiole is attached to the side of the base of the egg and is less bent.

The Larva: The first stage larva of H. bovis is very similar to H. lineatum except that it is slightly larger.

After the first molt, the larvae of H. bovis are more easily distinguished from H. lineatum. The posterior stigmal plates enclose the same type of ring-like, sclerotized pores, but are dark brown to black and are closely fused together. The number of rings is greater, averaging about thirty-five. In other respects the larvae are very similar.

The third stage H. bovis larvae are slightly larger than those of H. lineatum but are similar in shape. Ventral segments II to IX are armed with transverse bands of spines, but segment X is unarmed. The posterior stigmal plates are deeply excavate or funnel shaped in H. bovis and are a reliable characteristic of the species in the third stage.

The Puparium: The puparium is similar to that of H. lineatum except for the deeply excavated stigmal plates which are still plainly visible.

SEASONAL HISTORY, GEOGRAPHIC DISTRIBUTION, AND ABUNDANCE IN SOUTH DAKOTA

To obtain sufficient material for the seasonal history study and for the geographical distribution work, aid was solicited from the county extension agents, 4-H club members, and interested ranchers and farmers in South Dakota. These cooperators were asked to collect grubs from their native cattle throughout the season and send them in to the laboratory at Brookings, South Dakota. In addition, trips to the field were made at intervals to collect specimens and data during the period when the grubs were in the backs of the cattle. Much of the seasonal history data was obtained from some feed lot experiment cattle at Sioux Falls.

The times of the year during which the various stages of the insect occur vary from year to year. In the 1946-47 season the study had not started early enough to determine the earliest date of appearance or the date of the peak of abundance of larvae of H. lineatum in the backs of cattle. However, in the 1947-48 season the first larvae of this species appeared under the skin of the backs of South Dakota cattle about December 20, built up to a peak of abundance between the end of February and the middle of March, then declined through March, and disappeared by the first week of April. In 1948-49 the first appearance was during the first week of January. The peak was in mid February and the latest date of occurrence was the fifth of April.

In the 1946-47 season, H. bovis was present when the studies started the first of April. The larvae increased in number, reaching their peak between the middle of April and the first of

May and gradually disappeared by July 3. During the 1947-48 season the northern grubs first appeared at the March 11 inspection of the Sioux Falls cattle. No earlier specimens of H. bovis were obtained in other collections in the state. By the end of April the peak of abundance was reached and the larvae decreased in numbers, gradually disappearing by the end of June. During the following season H. bovis first appeared on March 3. The peak was reached about the first part of May, and all specimens had emerged by the end of June. There are isolated instances in some years in which the larvae may be found in the backs of cattle later in the year; however, by the fore part of July the grubs have usually all emerged from the backs of the cattle.

The length of time spent under the skin of the hosts' backs appears to be quite variable, judging from preliminary observations. The cattle in feed lot experiments at Sioux Falls were examined every two weeks. At each examination the larvae were located and plotted on a chart for each steer. Random samples of each species of grubs from five different steers in each of two untreated lots yielded the following data:

Lot I

Steer No.	Larva No.	Species	First Date Present	Last Date Present	Approximate Time in Back
	1	lineatum	2/15	3/21	5 weeks
	2	lineatum	2/3	2/15	3
154	3	bovis	3/8	5/5	8.5
	4	bovis	3/8	5/5	8.5
	5	bovis	3/8	4/5	4.5

Lot I (Continued)

Steer No.	Larva No.	Species	First Date Present	Last Date Present	Approximate Time in Back
164	1	lineatum	1/15	2/15	4.5 weeks
	2	lineatum	2/3	2/15	3
	3	lineatum	2/3	2/15	3
	4	bovis	4/5	4/21	3
	5	bovis	3/8	3/21	3
139	1	lineatum	2/3	3/21	6.5
	2	lineatum	2/3	3/21	6.5
	3	lineatum	2/3	4/5	9
	4	bovis	3/8	3/21	3
	5	bovis	3/8	3/21	3
158	1	lineatum	2/3	3/21	6.5
	2	lineatum	1/15	2/15	4.5
	3	bovis	4/21	5/5	2.5
	4	bovis	3/8	3/21	3
	5	bovis	3/8	3/21	3
133	1	lineatum	1/15	2/15	4.5
	2	lineatum	2/3	3/8	5
	3	lineatum	1/15	2/15	4.5
	4	bovis	3/8	4/5	4.5
	5	bovis	4/5	5/5	5

H. lineatum 3 to 9 weeks, av. 5.04 weeks

H. bovis 2.5 to 8.5 weeks, av. 4.21 weeks

Lot II

Steer No.	Larva No.	Species	First Date Present	Last Date Present	Approximate Time in Back
123	1	lineatum	1/15	2/15	4.5 weeks
	2	lineatum	2/3	3/8	5
	3	lineatum	2/3	3/8	5
	4	bovis	3/8	4/5	4.5
	5	bovis	3/8	4/21	6.5
7	1	lineatum	1/15	3/8	8
	2	lineatum	2/15	3/21	5
	3	bovis	4/5	5/5	5
	4	bovis	4/5	4/21	3
	5	bovis	4/5	5/5	5
57	1	lineatum	2/3	3/8	5
	2	lineatum	2/3	3/8	5
	3	lineatum	1/15	3/8	8
	4	bovis	3/21	4/21	5.5
	5	bovis	4/5	5/5	5
157	1	lineatum	1/15	3/21	9.5
	2	lineatum	2/3	3/21	6.5
	3	bovis	4/5	5/25	7.5
	4	bovis	3/8	4/21	6.5
	5	bovis	3/8	3/21	3

Lot II (Continued)

Steer No.	Larva No.	Species	First Date Present	Last Date Present	Approximate Time in Back
	1	lineatum	2/3	3/8	5 weeks
	2	lineatum	2/3	3/8	5
136	3	bovis	3/8	4/21	6.5
	4	bovis	3/8	4/5	4.5
	5	bovis	3/8	3/21	3

H. lineatum 4.5 to 9.5 weeks, av. 5.96

H. bovis 3 to 7.5 weeks, av. 5.08

SUMMARY OF DATA

s = standard deviation

H. lineatum		H. bovis	
Lot I	Mean = 5.04 weeks	Lot I	Mean = 4.21
	s = 1.72		s = 2.12
	Mean ± s = 3.32 to 6.76		Mean ± s = 2.09 to 6.33
Lot II	Mean = 5.96	Lot II	Mean = 5.08
	s = 1.94		s = .69
	Mean ± s = 4.02 to 7.90		Mean ± s = 4.39 to 5.77
Both Lots		Both Lots	
	Mean = 5.48		Mean = 4.70
	s = 1.84		s = 1.56
	Mean ± s = 3.64 to 7.32		Mean ± s = 3.14 to 6.26

These data cannot be regarded as final or as accurate measurements of the length of time the larvae spend under the skin; however, an indication of the variation in time needed to mature larvae is evident. More accurate observations are planned as the study continues, to determine whether or not the time differences are caused by seasonal variation of the external environmental conditions.

There is only meager information available on the earliest and latest dates of appearance of the adult heel flies in South Dakota. In order to obtain one lot of cattle which was relatively grub free for the feeding trials at Sioux Falls, ten head were removed from the range in northern Sully County on May 1 and brought to Brookings, which is in a practically grub free area. On August 23 these steers were returned to their range and when they were examined the following Winter and Spring a relatively grub free condition was found (Fig. 1, Page 21). Some reports of heel fly activity as early as the latter part of February have been made in Ziebach County; however, the greatest activity of the adults observed has been from the middle of May until the middle of July with scattered activity before and after this period.

SEASONAL HISTORY DATA, 1947-48

Showing percentages of each species in each collection of larvae taken throughout the state during the period December 20 to July 2

Place, County	Date	% H. lineatum	% H. bovis
Sioux Falls, Minnehaha*	Dec. 20	100	
"	Dec. 31	100	
"	Jan. 15	100	
"	Jan. 30	100	
"	Feb. 12	100	
"	Feb. 26	100	
Rockham, Hand	Feb. 26	100	
Cresbard, Faulk	Feb. 29	100	
Sioux Falls, Minnehaha	March 11	80	20
Cresbard, Faulk	March 13	100	
Brookings, Brookings**	March 16	90	10
Dupree, Ziebach	March 17	85	15

SEASONAL HISTORY DATA, 1947-48 (Continued)

Showing percentages of each species in each collection of larvae taken throughout the state during the period December 20 to July 2

Place, County	Date	% H. lineatum	% H. bovis
Artesian, Sanborn	March 20	100	
Spearfish, Lawrence	March 23		100
Artesian, Sanborn	March 23	66.65	33.35
Woonsocket, Sanborn	March 23	87.5	12.5
Woonsocket, Sanborn	March 25	80	20
Cottonwood, Jackson	March 25	19	81
Sioux Falls, Minnehaha	March 27	30	70
Woonsocket, Sanborn	March 28	50	50
Scotland, Bon Homme	March 28		100
Harrold, Hughes	March 31		100
Brookings, Brookings	April 2	6.5	93.5
Spearfish, Lawrence	April 2		100
Ree Heights, Hand	April 3	75	25
Elkton, (south), Moody	April 5		100
Woonsocket, Sanborn	April 5		100
Artesian, Sanborn	April 8		100
Rockham, Hand	April 8		100
Sioux Falls, Minnehaha	April 9		100
Deadwood, Lawrence	April 14		100
Woonsocket, Sanborn	April 15		100
Rockham, Hand	April 17		100
Sioux Falls, Minnehaha	April 23		100
Scotland, Bon Homme	April 25		100

SEASONAL HISTORY DATA, 1947-48 (Continued)

Showing percentages of each species in each collection of larvae taken throughout the state during the period December 20 to July 2

Place, County	Date	% H. lineatum	% H. bovis
Buffalo, Harding	April 27		100
Sisseton, Roberts	April 30		100
Cresbard, Faulk	May 1		100
Brookings, Brookings	May 3		100
Sioux Falls, Minnehaha	May 7		100
Sioux Falls, Minnehaha	May 21		100
Sioux Falls, Minnehaha	June 18		100
Sioux Falls, Minnehaha	July 2	0	0

*The data from Sioux Falls were taken from the cattle that were on feeding trials and that were infested in Sully County.

**The data from Brookings were taken from experimental cattle shipped to Brookings from Cottonwood, Jackson County.

GRUB COUNTS OF SIOUX FALLS CATTLE 1947-48 SEASON *

Date examined	Average number of grubs per head		
	10 head grub-free	10 head grubby check	9 head grubby sprayed
Dec. 18, 1947	0.00	0.90	0.11
Dec. 30, 1947	0.00	0.50	0.22
Jan. 15, 1948	0.00	2.60	1.11
Jan. 30, 1948	0.00	12.40	8.33
Feb. 12	0.00	11.30	1.55
Feb. 26	0.00	14.20	0.22
March 11	0.30	17.00	1.33
March 27	0.70	6.50	1.66
April 9	0.40	3.30	0.44
April 23	0.30	3.10	0.44
May 7	0.50	2.10	0.33
May 21	0.30	1.20	0.00
June 4	0.10	0.40	0.00

* These cattle were infested in Sully County and shipped to Sioux Falls for the experiment in November.

Note: Species differentiation was not considered in these data.

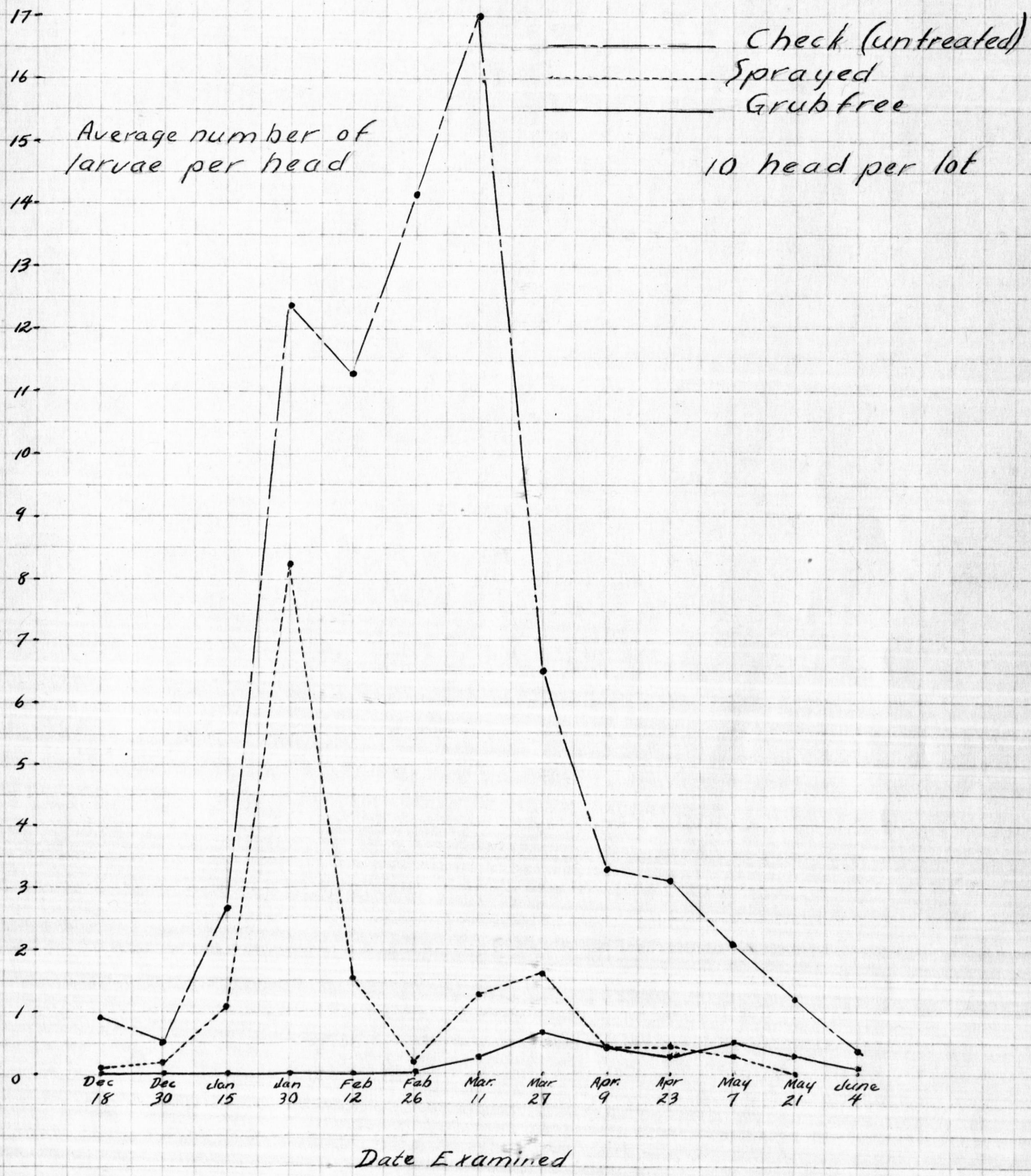


Fig. I

Average grub populations in lots of yearling steers 1947-48

GRUB COUNTS OF SIOUX FALLS CATTLE 1948-49 SEASON *

Date examined	Average number of grubs per head	
	10 head grubby sprayed	10 head grubby check
Jan. 15, 1948	3.50	5.40
Feb. 3	10.40	12.50
Feb. 15	4.20	14.70
March 8	3.30	9.80
March 21	1.60	5.00
April 5	1.20	3.50
April 21	0.00	1.70
May 5	0.00	0.80
May 25	0.20	0.10
June 8	0.00	0.00

* Cattle shipped to Sioux Falls from Sully County

Note: Species differentiation was not considered in these data.

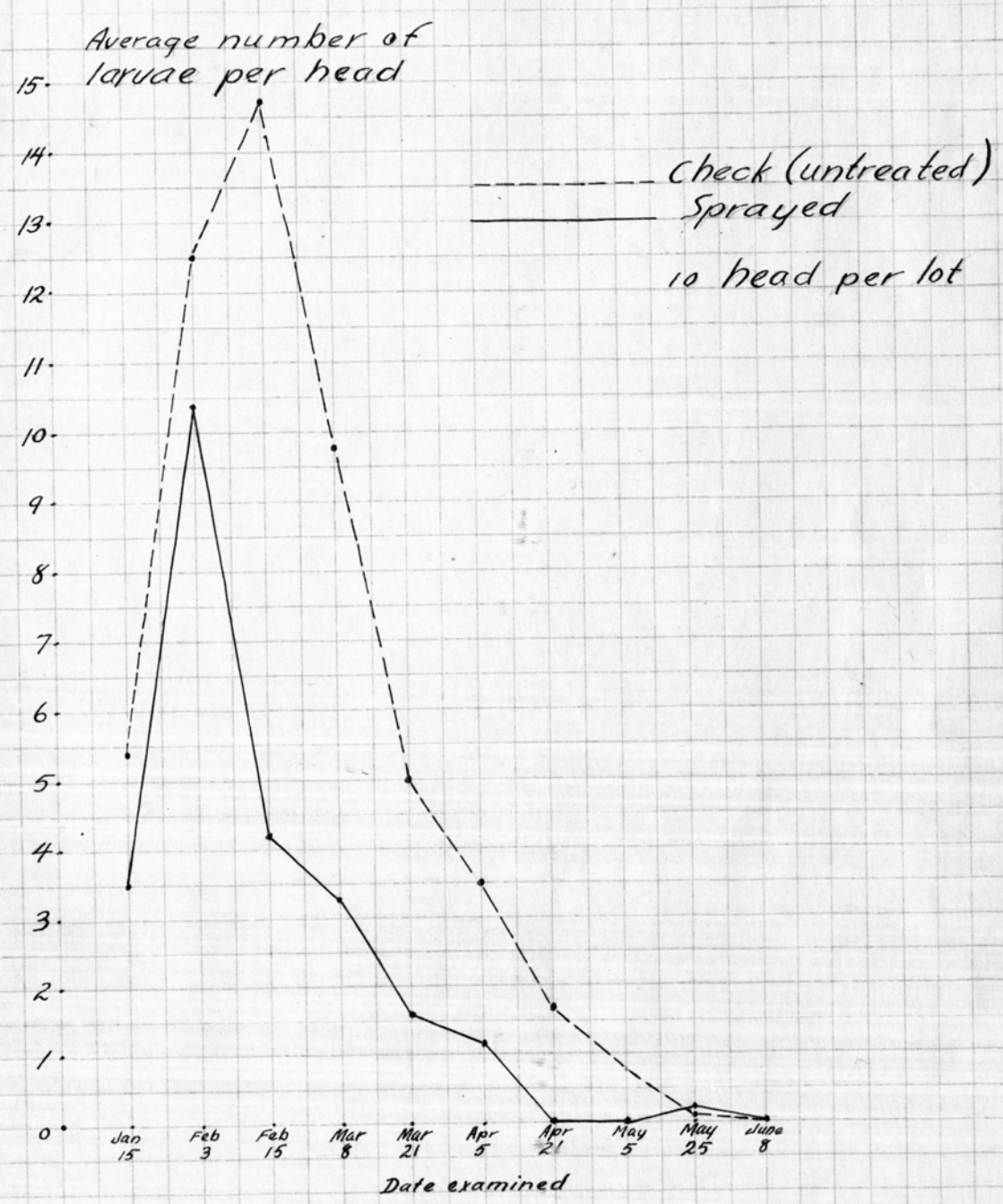


Fig. II

Average grub populations in lots of yearling steers 1948-49

GEOGRAPHICAL DISTRIBUTION

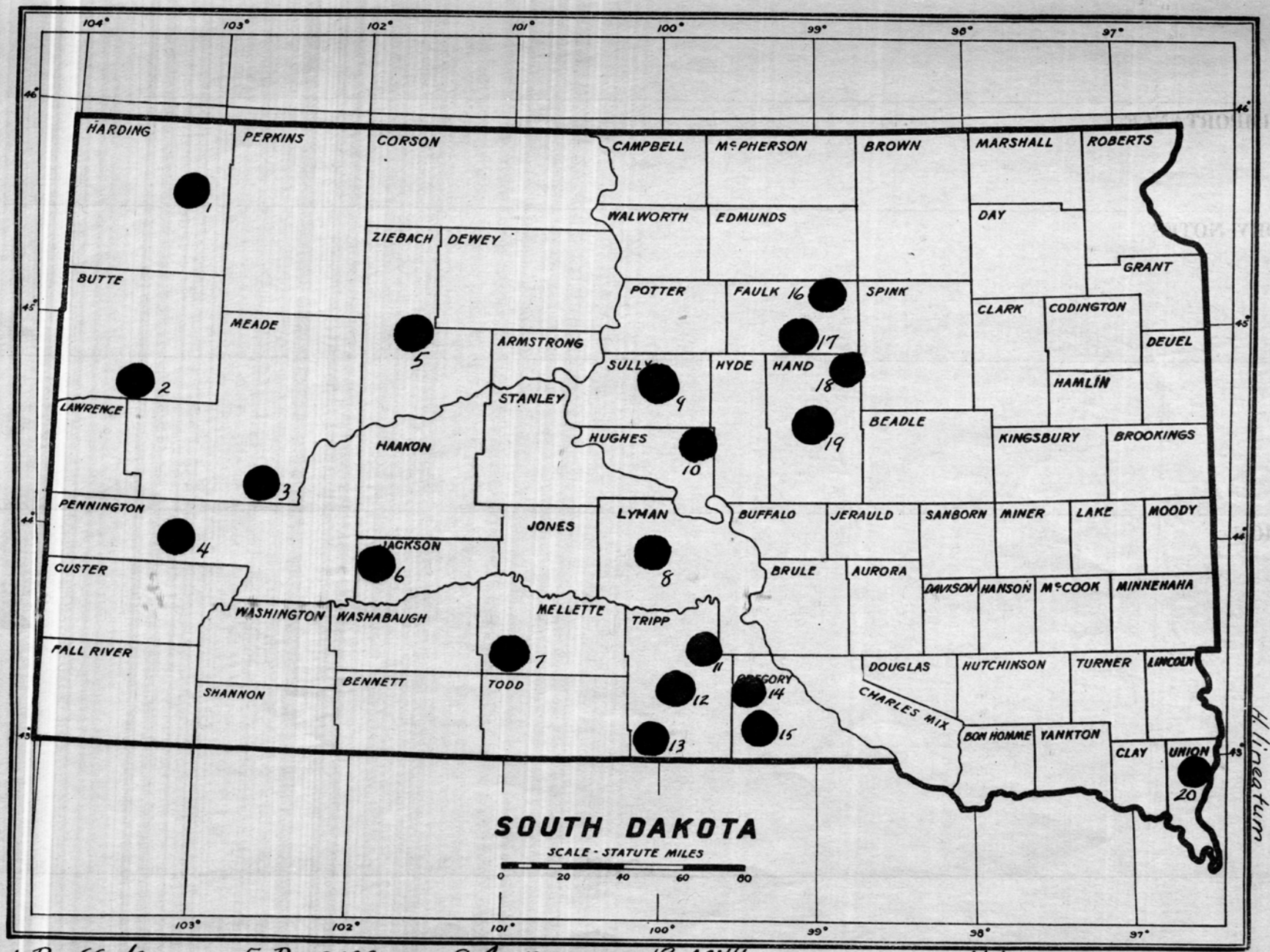
Heel flies and cattle grubs are distributed generally over the entire United States. H. lineatum may be present in all sections while H. bovis is usually encountered only in the northern part of the country. In South Dakota both species are practically statewide, although there are spotted areas which are practically free of grubs. The most noticeable of these is the area along the eastern edge of the state, extending westward into Clark and Kingsbury Counties and thence south through Miner, Hanson, Hutchinson and Bon Homme Counties. Another isolated apparently grub free area is eastern and central Douglas County, and there may be others in the state. Although the eastern edge is considered grub-free, moderately light infestations of H. bovis were noted in southern Brookings and northeastern Moody Counties in the 1947-48 season and heel flies were noticed in Kingsbury County, near DeSmet, in the Summer of 1949. There are also spotted areas in the Black Hills region in which H. lineatum apparently did not occur, but in which infestations of H. bovis were quite heavy. In all it appears as though H. bovis is adaptable to a wider range of ecological conditions in South Dakota than is H. lineatum; however, where the latter occurs, the infestation is usually heavy, and it is the predominant species.

DISTRIBUTION OF H. LINEATUM IN S. DAK.

County	Place	Date	No. of Specimens
Butte	Nisland	March 9, 1949	2
Faulk	Faulkton	March 18, 1949	1

DISTRIBUTION OF H. LINEATUM IN S. DAK. (Continued)

County	Place	Date	No. of Specimens
Faulk	Cresbard	February 29, 1948	6
Gregory	Gregory	March 7, 1949	6
	Gregory	March 10, 1949	13
	Dixon	March 21, 1949	4
Hand	Miller	April 17, 1948	2
	Rockham	February 26, 1948	6
Harding	Buffalo	February 12, 1948	7
Hughes	Harrold	March 17, 1949	4
Jackson	Cottonwood	March 24, 1948	6
	Cottonwood	February 27, 1948	4
	Cottonwood	March 4, 1949	10
Lyman	Presho N.	March 25, 1948	5
Meade	Wicksville N.	February 10, 1948	3
Mellette	Norris	March 9, 1949	4
Pennington	Rapid City	April 3, 1947	1
Sully	Agar	January 29, 1948	11
	Agar	February 12, 1948	8
Tripp	Winner	March 3, 1949	23
	Hamill	March 7, 1949	3
	Millboro	March 8, 1949	1
	Millboro	March 19, 1949	1
	Winner	March 20, 1949	2
Union	Alcester	February 28, 1949	2
	Alcester	March 16, 1949	2
Ziebach	Dupree	March 17, 1948	20



1 Buffalo
2 Nisland
3 Wicksville, N.
4 Rapid City
5 Dupree
6 Cottonwood
7 Norris
8 Presho, N.
9 Agar
10 Harrold
11 Hamill
12 Winner
13 Millboro
14 Dixon
15 Gregory
16 Cresbard
17 Faulkton
18 Rockham
19 Miller
20 Alcester

H. Lineatum

DISTRIBUTION OF HYPODERMA BOVIS IN S. DAK.

County	Place	Date	No. of Specimens
Beadle	S. Carpenter (Lake Byron)	April 17, 1947	2
Bon Homme	Tyndall	April 22, 1947	1
	Scotland	March 28, 1948	2
	Scotland	April 25, 1948	9
Brookings	Brookings	April 8, 1948	4
Brule	Chamberlain	April 15, 1948	6
Corson	Watauga	April 24, 1947	3
Custer	Fairburn	April 20, 1947	6
	Custer	June 5, 1947	1
	Custer	July 3, 1947	2
Davison	Mitchell	May 27, 1947	2
Day	E. Conde	May 2, 1947	2
	E. Conde	May 20, 1947	5
	Waubay	April 25, 1947	3
	Bristol	April 21, 1947	1
Dewey	Timberlake	April 20, 1947	6
Faulk	Cresbard	May 12, 1947	11
	Cresbard	March 13, 1948	5
	Cresbard	May 1, 1948	6
	Cresbard	April 8, 1949	6
	Cresbard	April 20, 1949	1
	Chelsea	April 25, 1949	5
	Faulkton	March 18, 1949	4
	Faulkton	April 18, 1949	3
	Faulkton	April 1, 1949	4
	Norbeck	May 17, 1947	1

DISTRIBUTION OF HYPODERMA BOVIS IN S. DAK. (Continued)

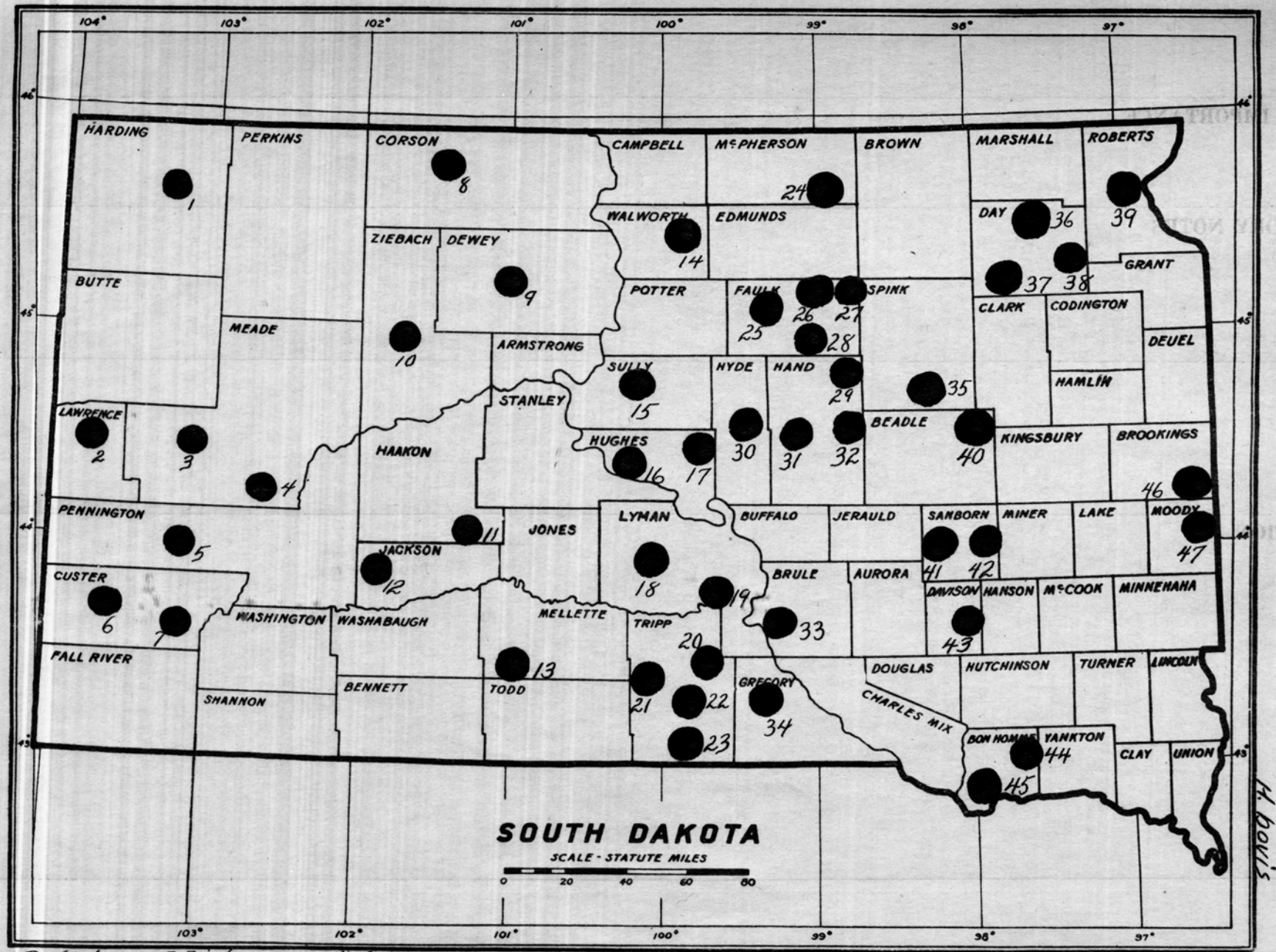
County	Place	Date	No. of Specimens
Gregory	Dixon	March 21, 1949	3
Haakon	Nowlin	May 27, 1948	5
Hand	Miller	April 7, 1947	7
	Miller	April 17, 1947	1
	Ree Heights	April 3, 1948	3
	Rockham	April 12, 1947	3
	Rockham	April 30, 1947	1
	Rockham	June 1, 1947	1
	Rockham	April 8, 1948	7
	Rockham	April 17, 1948	5
Harding	Buffalo	April 27, 1948	26
Hughes	Harrold	March 21, 1948	6
	Harrold	March 17, 1949	4
	Pierre	June 26, 1947	1
Hyde	Highmore	April 10, 1947	6
Jackson	Cottonwood	March 24, 1948	13
	Cottonwood	April 20, 1948	10
	Cottonwood	May 16, 1948	8
	Cottonwood	June 15, 1948	2
	Cottonwood	March 4, 1949	10
Lawrence	Spearfish	March 23, 1948	6
	Spearfish	April 2, 1948	8
Lyman	Kennebec	April 23, 1947	4
	Presho N.	March 25, 1948	10
	Presho N.	April 21, 1948	4
Mellette	Norris	March 9, 1949	10

DISTRIBUTION OF HYPODERMA BOVIS IN S. DAK. (Continued)

County	Place	Date	No. of Specimens
McPherson	Leola	June 2, 1947	5
	Leola	April 28, 1947	4
	Leola	April 19, 1947	36
Meade	Sturgis	May 11, 1948	2
	Wicksville (4N)	May 17, 1949	12
Moody	S. Elkton	April 5, 1948	4
Pennington	Rapid City	April 3, 1947	10
	Rapid City	April 18, 1947	18
Roberts	Sisseton	April 30, 1948	2
Sanborn	Artesian	March 20, 1948	3
	Artesian	March 23, 1948	3
	Artesian	April 8, 1948	1
	Woonsocket	March 20, 1948	8
	Woonsocket	March 25, 1948	5
	Woonsocket	March 28, 1948	10
	Woonsocket	April 5, 1948	5
	Woonsocket	April 15, 1948	8
Spink	Tulare	May 16, 1948	18
Sully	Agar	March 21, 1949	5
	Agar	April 23, 1948	14
	Agar	May 21, 1948	3
Tripp	Hamill	March 7, 1949	1
	Millboro	March 8, 1949	5
	Millboro	March 19, 1949	5
	Winner	March 3, 1949	4

DISTRIBUTION OF *HYPODERMA BOVIS* IN S. DAK. (Continued)

County	Place	Date	No. of Specimens
Tripp	Winner	March 20, 1949	5
	Witten	April 6, 1949	6
Walworth	Selby	May 6, 1949	1
Ziebach	Dupree	March 17, 1948	25



1. Buffalo
2. Spearfish
3. Sturgis
4. Wicksville, N.
5. Rapid City
6. Custer
7. Fairburn
8. Watauga
9. Timber Lake
10. Dupree
11. Nowlin
12. Cottonwood
13. Norris
14. Selby
15. Agar
16. Pierre
17. Harrold
18. Presho, N.
19. Kennebec
20. Hamill
21. Witten
22. Winner
23. Millboro
24. Leola
25. Norbeck
26. Cresbard
27. Chelsea
28. Faulkton
29. Rockham
30. Highmore
31. Ree Heights
32. Miller
33. Chamberlain
34. Dixon
35. Tulare
36. Bristol
37. Conde, E.
38. Waubay
39. Sisseton
40. Lake Byron
41. Woonsocket
42. Artesian
43. Mitchell
44. Scotland
45. Tynall
46. Brookings
47. Elkton, S.

H. Bouis

ABUNDANCE

The number of grubs in cattle varies greatly in any one year and the degree of infestation in an area may vary a good deal from year to year. In one herd there may be animals totally free from grubs and other animals with 50 to 100 grubs in the backs at one time. The heaviest infestation found in this study was 175 third stage larvae in a yearling steer from Ziebach County. Apparently, there is a wide range in the number of grubs present at one time in the backs of the cattle in the same herd. At the peak of abundance in the experimental cattle at Sioux Falls, in 1948, the range was 0 to 50 with an average infestation of 17 grubs per head, based on ten head of untreated cattle (Feg. 1-Page 21). It is rather generally believed that the average number of grubs per head on the range is much greater than this, but it is doubtful if the average infestation in any particular herd in the state is more than 20 or 25 grubs per head at any one time. Matthysse (12) states "Because of the extreme variations of grub populations it is necessary to use large numbers of cattle and grubs in experiments."

The severity of an infestation varies considerably with the type and condition of the host. For example, a fat steer does not seem to be as heavily infested as a thin unthrifty steer on the range, and a herd of choice fat cows will have fewer grubs than a herd of poor emaciated cows. The infestation varies somewhat between breeds, but more so within one breed between hosts in good condition and poor. Whether this is due to the fact that the cattle in poor condition try less to evade the ovipositing flies or whether the larvae meet less resistance in the body of the host is not known. It is

generally accepted that hosts in poor condition are more heavily infested with other parasites than are animals in good condition. In some cases severe attacks of a parasite or parasites will cause the poor condition and unthrifty appearance of the host. It is doubtful if this is the case of Hypoderma larvae except in rare, very extremely heavy infestations.

The age of the host seems to have a considerable effect on the severity of the infestation. Generally, the young animals, calves and yearlings, are much more heavily infested than are the older cattle. In the 1946-47 season, accurate counts were made on one herd of old cows and two year old heifers grazing together at the Experiment Station's ranch south of Fort Pierre (Reed's Ranch). The results of this examination are recorded below:

Date examined	Two year old heifers		Old Cows	
	Total Grubs	Av/head	Total grubs	Av/head
March 27	170	8.50	40	2.00
April 24	70	3.50	9	.45

It is interesting to note that in the cattle on feeding trials at Sioux Falls there was no definite peak of abundance for H. bovis. A peak for H. lineatum was apparent, but the population of larvae diminished gradually to the end of June (Figures 1 and 2, pages 21 and 23). These steers were two years old at the end of the feeding period and were quite heavily infested with H. lineatum, but not with H. bovis. This agrees with the findings of Mills, Marsh, and Willson (33).

Mills, et al, working in Montana report, "Calves, then, were most heavily infested by both species; cows were the least infested.

Yearlings resembled calves in their infestation with the common cattle grub and were similar to aged stock in their reaction to the northern species."

From observations in the field, it is believed that the grubs emerge from the younger animals earlier than from older cattle. The younger animals seem to "clean up" and be free from the grubs rather early, while an occasional grub or two will continue to appear in the older cattle later in the Spring.

CONTROL MEASURES

Up to the present time the most practical method of controlling heel flies is to destroy the larvae after they have reached the subcutaneous tissues of the host's back and before they emerge from beneath the skin. This may be accomplished by squeezing the grubs from the cysts or by killing them in the cysts with some larvacide.

Squeezing the grubs out by hand is not very efficient except for cases in which just a few head of stock are involved. Care must be exercised in removing the grubs so that the larvae and cyst walls are not broken, forcing the contents into the tissues of the host. This action may cause anaphylactic shock.

The most practical method of destroying the larvae is by means of an insecticide. Rotenone bearing powders have proven to be the most efficient materials for this purpose and they may be applied as dry dusts, or in water suspensions. In cases where just a few head of cattle are involved a derris or cube' dust containing about 1.5% rotenone can easily be applied by hand at the rate of three or four ounces per animal and rubbed in well with the fingertips.

In the event large herds are to be treated, the best way to apply the insecticide is in the form of a water suspension with a power sprayer. A wettable powder containing five per cent rotenone in used at the rate of seven and one-half pounds in one hundred gallons of water. The suspension must be well agitated and applied at a pressure of about five hundred pounds per square inch. An area twelve to fourteen inches on each side of the spine from the withers to the tail head should be covered with a coarse driving spray. The nozzles should be held nearly vertical ten to sixteen inches from the back. One hundred gallons of the spray suspension is sufficient to treat about one hundred-fifty head.

The cattle should be treated about a month after the first warbles appear under the skin and thereafter at monthly intervals until no more larvae appear. Under South Dakota conditions this entails at least four, and sometimes five treatments from February until June. In most areas the first treatment should be applied from the first to the fifteenth of February and the last treatment from the middle of May to the first of June.

AREA CONTROL PROGRAMS

In January, 1948, one area in each of five counties was selected in which to carry on an intensive campaign of cattle grub control on an area or community basis. The Agricultural Experiment Station in cooperation with the Extension Service was instrumental in getting the program underway and in seeing that the control measures were carried through. In order to obtain the best cooperation from the farmers and ranchers a spray program of four treatments

was adopted. The plan called for the farmer or rancher to pay for the first two treatments and to receive the third and fourth free of charge, the cost to be paid from a grant-in-aid furnished by commercial donors. In some cases, in which few animals were involved and in which the operator wanted to dust his cattle, the prepared rotenone dust was furnished him with instructions or demonstrations on its correct application.

The program involved a total of 10,300 head of cattle and 115 operators.

The location and size of these areas were as follows:

Area 1. In Hughes County, Central S. Dak. about 35 miles east of Pierre, 35 operators, and about 3500 head of cattle. R. J. Fineran, County Agent.

Area 2. In Haakon County, about 20 miles east of Philip, 18 operators, and 1700 head of cattle. Elbert Bentley, County Agent.

Area 3. In Lawrence County, western S. Dak. near Spearfish, 25 operators and about 2200 head of cattle, T. H. Young, County Agent.

Area 4. In Meade County, western S. Dak. east of Sturgis, 32 operators, and about 2000 head of cattle, Kenneth Lesli, County Agent.

Area 5. In Harding County, northwestern S. Dak., near Buffalo, 5 operators and 900 head of cattle, Fredrick Wilson, County Agent.

The first treatment was applied about the middle of February and three applications followed at monthly intervals, with almost all the treatments having been completed by May 25. Bad weather

hampered some of the communities so the regular spray schedule was, in some cases, disrupted somewhat. However, excellent results were obtained in killing grubs in all five areas. In one herd in the Hughes County area a kill of 88.8% was obtained; in the Harding County area a kill of 94% was reported and the kill of grubs in the other areas was reported to be 90% or better. By the 15th of May, when untreated herds were being run by heel flies, the herds in the treated areas were bothered very little. There was some running of the cattle, especially around the edges of the area, but the molestation as observed by the ranchers and county agents was reduced considerably over previous years.

However, due to unfavorable weather conditions and to the reluctance of some ranchers to spray during calving season, a few herds received only two or three treatments. In these herds more heel fly activity was observed the following Spring than in the herds which received the four treatments.

Many farmers and ranchers living outside of the control areas after seeing this reduction in fly population became interested and treated their herds just as thoroughly as did the operators in the area. This condition was particularly true in Meade County. It is hoped that in the future 100% cooperation in the four treatments may be obtained in all the herds in these areas. The area phase of grub control research needs further study before the advisability of a county wide or state wide control program can be evaluated.

It is interesting to note that in a few cases, one in Pennington County and two in Meade County, for example, ranchers have reported lower grub infestations and less heel fly activity in seasons following a thorough Spring and Summer DDT spray program for horn fly and stable fly control. No experiments or accurate observations

have been conducted in South Dakota to substantiate this report. However, Matthysse working on dairy cattle in New York, states, "Sprays containing DDT applied to the legs and undersides of the bodies...were found to be of no value (in reducing cattle grub infestations)." And Mills, et al, in Montana found, "....the treated group averaged 8.2 grubs and the untreated 8.8. Therefore, under the conditions of this experiment, the attempt to control cattle grubs by treating cattle with DDT during the fly season was unsuccessful."

PROBLEMS OF CONTROL PROGRAMS

Many difficulties are encountered in attempting to carry on a grub control program. Theoretically, after studying the life history, it would seem possible to almost eradicate heel flies and cattle grubs from our range land. In practice, however, many problems present themselves. Weather conditions in South Dakota during February and March are very unpredictable. Heavy snows, extended cold periods, or rapid thawing sometimes makes the roads impassable or in other ways delay some of the spraying operations. This may allow some of the larvae to live and emerge for pupation.

Many ranchers will not spray their cattle when it is quite cold for fear of harming them, although there have been no first hand reports of any sickness or death resulting from spraying in below freezing temperatures. Farmers and stockmen are also reluctant to spray pregnant cows because of the dangers of possible abortion. However, if the holding pens and chutes are constructed properly and the cows are handled carefully without crowding them into corners there is little danger.

Treatments for grubs can be applied quite readily to smaller herds of cattle, but when a herd of 1000 to 2000 or more are to be treated and these are scattered over a very large range, a complete roundup, requiring extra riders and labor, is needed. There are many stock raisers who feel that the time and expense of performing this operation on their herds four or five times per season is not worth the results obtainable with present materials and techniques.

There is a question of the effectiveness of present control methods. Previous writers have claimed kills of 90 to 100 per cent of the larvae present at the time of application of the insecticide. It is doubtful if such high percentages of mortality are actually obtained.

During the 1949 season accurate counts of larvae were made on fifty head of yearlings. Charts of each animal's back were made and the position of each larva was indicated. The treated lots were sprayed or dusted every twenty-eight days and the animals were examined fourteen days after each treatment (figure 2). The highest per cent of kill was 84% after the third treatment. Most of the mortality percentages ranged from 55% to 75%. Furman and Douglas 1948 obtained by careful statistical analysis, a mortality of 64% of the larvae treated, which was the highest percentage obtained in a series of tests.

Many cattle raisers and feeders see no value to be had by treating the larvae after they have reached the subdermal tissues. It is becoming evident that treating feed lot cattle for grubs has little or no effect on the rate of gain. (Reinertson 1948, S. Dak. Agr. Expt. Station 1949). Ranchers see their cattle running from the heel flies after they have treated their herds for grubs, so

they decide the attempt is of no value. Only in communities wherein all the ranchers have made a cooperative effort for control have any results been obtained. Even in these communities the effort must be continued every year to hold the gains already made.

It is evident that a new approach must be made if eradication of heel flies is to be the goal. New techniques, new methods, and new materials must be investigated in order to find the most practicable means of control.

SUMMARY

1. Both species of heel flies or cattle grubs, Hypoderma lineatum and H. bovis are present and statewide in distribution in South Dakota. There are areas which are practically free from both species of heel flies and other areas in which only one species is prevalent.

2. The abundance of grubs in the backs of cattle varies widely and generally they are present from late December until the latter part of June.

3. The most effective control measures available to date are treatments with rotenone applied when the grubs are in the backs of the cattle. An excellent means of applying rotenone under South Dakota conditions is with a power sprayer at about 500 pounds pressure at monthly intervals as long as the larvae are present under the skin.

4. The results of the area treatment program, judging from observations carried on for two years, indicated a marked reduction of heel fly activity in herds treated four times as compared with untreated herds in the same area or with herds treated two or three times within the area.

SUMMARY (Continued)

5. Control measures as practiced at the present time have many shortcomings. There is a need for the development of new techniques and materials to use in controlling heel flies and cattle grubs in South Dakota.

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